



Ulster County 2021 Climate Smart Communities Recertification Documentation

PE3 Action: Government Building Energy Audits

10 POINTS DOCUMENTED

Background: In the past 7 years, Ulster County has completed energy audits at two County-owned facilities consisting of 39% of all conditioned floor area.

- Ulster County Office Building:
Heating and Cooling Master Plan: An energy audit was paired with feasibility studies of available heating and cooling technologies to develop a heating and cooling master plan.
The subsequent Geothermal Clean Energy Challenge energy audit and geothermal design provided additional energy audit detail.
- Ulster County Law Enforcement Center (UCLEC):
Heating and Cooling Master Plan: An energy audit was paired with feasibility studies of available heating and cooling technologies to develop a heating and cooling master plan.

Documentation:

- Listing of total conditioned floor area
- Summary calculations of floor area audited
- Heating and Cooling Master Plans at the Ulster County Office Building and UCLEC
Available here: <https://ulstercountyny.gov/environment/sustainability-energy/building-energy-benchmarking>
- Geothermal Clean Energy Challenge study at the Ulster County Office Building
Available here: <https://ulstercountyny.gov/environment/sustainability-energy/building-energy-benchmarking>

Property Name	Property GFA - Self-Reported (ft²)	Address 1	City	Energy Audit?
Accord Substation - Office	1,343	456 Granite Road	Rochester	N
Boiceville Garage and Office	5,506	8 Cabin Hill Road	Olive	N
Carr Building	5,438	1 Pearl Street	Kingston	N
Community Corrections	7,700	63 Golden Hill Drive	Kingston	N
Department of the Environment	4,229	17 Pearl Street	Kingston	N
DSS	74,000	1 Development Court	Kingston	N
Emergency Management	3,537	238 Golden Hill Dr	Kingston	N
Family Court	43,977	1 Development Court	Kingston	N
Golden Hill Office Building	39,600	239 Golden Hill Drive	Kingston	N
Heavy Vehicle Maintenance	35,000	Shamrock Lane	Kingston	N
Highway Substation - New Paltz	13,697	246 Libertyville Road	New Paltz	N
Highway Substation - Plattekill	2,265	227 Fosler Road	Plattekill	N
Highway Substation - Saugerties	3,552	344 Harry Wells Road	Saugerties	N
Highway Substation - Shawangunk	4,433	40 King's Lane	Shawangunk	N
Hutton Building	3,386	234 Golden Hill Lane	Kingston	N
Information Services	13,174	25 South Manor Avenue	Kingston	N
Old Jail Storage Garage	5,000	63 Golden Hill Drive	Kingston	N
Old Ulster County Jail	53,391	63 Golden Hill Drive	Kingston	N
Persen House	6,405	74 John Street	Kingston	N
Probation Campus	17,594	733 Broadway	Kingston	N
Public Safety Training Center	6,804	250 Ulster Landing Road	Kingston	N
Public Works Building	10,740	313 Shamrock Lane	Kingston	N
Shandaken Garage	3,020	7336 State Rt. 28	Shandaken	N
Sheriff's Substation - Warwarsing	1,534	155 Airport Road	Ellenville	N
Sojourner Truth Ulster Landing Park	3,198	916 Ulster Landing Road	Saugerties	N
Sundown Garage & Office	3,040	30 Greenville Road	Denning	N
Trudy Resnick Farber	20,732	50 Center Street	Ellenville	N
UCAT	23,413	1 Danny Circle	Kingston	N
Ulster County Courthouse	43,650	285 Wall Street	Kingston	N
Ulster County Law Enforcement Center	277,000	380 Boulevard	Kingston	Y
Ulster County Office Building	62,396	244 Fair Street	Kingston	Y
Ulster County Pool	7,126	241 Libertyville Road	New Paltz	N
Ulster County Records Center	22,550	300 Foxhall Avenue	Kingston	N
Ulster Heights Substation Garage & Office	2,146	229 Ulster Heights Road	Wawarsing	N
Van Dale Garage - Fabrication Shop	15,146	316 Van Dale Road	West Hurley	N
Veterans Transitional Housing Facility	6,656	67 Wurts St	Kingston	N
Total	852,378			

	Column Labels		
	N	Y	Grand Total
Sum of Property GFA - Self-Reported (ft²)	512,982	339,396	852,378

	Column Labels		
	N	Y	Grand Total
Sum of Property GFA - Self-Reported (ft²)	60.2%	39.8%	100.0%



FLEXTECH STUDY AND HEATING/COOLING MASTER PLAN

For

**Ulster County Law Enforcement Center
380 Boulevard
Kingston, NY 12402**

**New York State Energy Research and
Development Authority
17 Columbia Circle
Albany, New York 12203-6399**



Final Report Date: 09-17-2019

For questions regarding this report, please contact FlexTech@nyserda.ny.gov.

We hope the findings of this report will assist you in making decisions about energy efficiency improvements in your facility. Thank you for your participation in this program.

NOTICE

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State of New York
Andrew Cuomo, Governor

New York State Energy Research and Development Authority

FLEXTECH ENERGY STUDY

Ulster County Law Enforcement Center

**380 Boulevard
Kingston, NY 12402**



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Ulster County

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ABSTRACT

Ulster County has a strong track record of being a leader in green power use and environmental sustainability. Ulster County has demonstrated its commitment to clean energy by participating in the New York State Energy Research and Development Authority (NYSERDA) Clean Energy Communities Program and was the first County in New York State to achieve the designation of a Clean Energy Community.

Pursuant to Executive Order Number 1-2016, Ulster County is required to decrease greenhouse gas emissions associated with its operations (through conservation, efficiency, and on-site renewable generation) by 25% by 2025 and 80% by 2050, using the County's 2012 greenhouse gas emission inventory as a baseline.

The purpose of this study was to investigate and report on near term heating needs, using energy efficient equipment, and clean alternatives to natural gas combustion equipment for long-term energy reduction plans at the Ulster County Law Enforcement Center - Kingston, NY.

Data was gathered by an experienced team of HVAC and energy engineers during on-site surveys through the visual observation of the building and its energy consuming systems, interviews with operating personnel, and analysis of energy records pertaining to electricity and fuel oil.



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PROJECT TEAM AND INFORMATION

The follow table presents the individual professionals that lead and participated in the energy study activities. The name, certifications, and qualifications of the Consultants' staff that performed and were involved with the energy study are:

Role and Name	Contact Information	Certifications & Experience	Applicable Experience
Lead Engineer Daniel Hampson GPI	DHampson@gpinet.com (518) 453-9431	PE	37 years
Project Manager Brendan Kelly L&S Energy Services	BKelly@LS-Energy.com (518) 383-9405 x 214	PE, CEM, LEED® AP, CGI	21 years
Project Manager Tom Lamb GPI	TLamb@gpinet.com (518) 453-9431		30 years
QA/QC Ron Slosberg L&S Energy Services	RSlosberg@LS-Energy.com (518) 383-9405 x 216	CEM, CMVP, LEED AP, EBCP	30 years
HVAC Engineer Daniel Ryan GPI	DRyan@gpinet.com (518) 453-9431		22 years
Energy Engineer Mike Stiles L&S Energy Services	MStiles@LS-Energy.com (518) 383-9405 x219	CEM, PhD	30 years

We would like to thank the staff at Ulster County, especially Nick Hvozda and David Gruskiewicz, for their time and effort during our site visits and with subsequent information requests. Should you have any questions, please do not hesitate to contact Daniel Hampson (518) 453-9431 x 1519 or Brendan Kelly (518) 383-9405 x 214.

Sincerely,

GPI

Daniel Hampson, PE
Vice President and Director of MEP-FP

EXECUTIVE SUMMARY

DESCRIPTION OF STUDY

The focus of this Energy Study was to evaluate the replacement of boiler equipment, while simultaneously developing an implementable strategy for reducing energy use through the application of best-available clean heating and cooling technologies in both the near and long-term at the Ulster County Law Enforcement Center - Kingston, NY.

Interviews with County personnel and equipment surveys of the Ulster County Law Enforcement Center - Kingston, NY were conducted by GPI and L&S Energy Services on February 8th, 2019. The purpose of the interviews and equipment survey were to assess the existing heating and cooling systems, energy savings goals, and the operation of the existing Building Automated System (BAS). Historic design documents, energy bills, and BAS trend data were provided by the site contact and were reviewed.

Interviews and walk-through audits were performed to gather equipment nameplate data, review operational schedules, and procure annual electric and fossil fuel consumption schedules. The layouts and general conditions of the existing HVAC heating and cooling systems were compared to the plans and documentation received. System operation schedules were obtained from the Direct Digital Control (DDC). The goal of these activities was to calculate the building load coefficient (BLC) and the balance point temperature for heating as the basis for recommending energy efficiency improvements.

For the one year period from January 2018 through December 2018, the Ulster County Law Enforcement Center used a total of 4,634,829 kWh at a cost of \$559,577.

Over the same time period, 97,570 gallons of fuel oil #2 were consumed at a cost of \$212,015 and used for heating and domestic hot water. Propane deliveries totaled 12,828 gallons at a cost of \$17,162, but not considered further because it supplies kitchen cooking and a minimal terminal unit. The emergency generators utilize diesel.

A utility bill summary is included in Appendix A. Energy use, costs and rates are based on values provided by the County through Energy Star Portfolio Manager.

The cost per million Btus (\$/MMBtu) was calculated for each fuel type below.

<u>Utility Type</u>	<u>Avg. Unit Cost</u>	<u>\$/MMBtu</u>
Electric Energy (Central Hudson)	\$0.102/kWh	\$29.84/MMbtu
Electric Demand (Central Hudson)	\$9.69 /kW	--
#2 Fuel Oil (KoscoHeritage/Paraco and Bottini)	\$2.17/ gallon	\$15.57/MMbtu
Natural Gas Interruptible (Central Hudson)	\$0.570/therm	\$5.70/MMbtu

3,413 Btu = 1 kWh; 139,600 Btu = 1 gallon #2 fuel oil; 100,000 Btu = 1 therm

Note: Natural gas rates from Central Hudson Gas & Electric Corporation Service Classification 8 / Rate G-3, as provided by the customer.

A pre-feasibility study (PFS) was conducted for the following clean heating & cooling technologies:

- Solar Thermal DHW
- Cooling Energy Thermal Storage

The following energy conservation measures (ECMs) were evaluated as feasible options:

- Condensing Natural Gas Boiler
- Decoupled DHW Natural Gas Boilers
- Biomass Boiler and a Condensing Natural Gas Boiler (also with decoupled DHW)

For each qualified measure, energy use and projected cost savings were calculated using spreadsheet analysis. ECM analysis, life-cycle cost and calculation data are included in Appendix B. The cost estimate for each ECM is included in Appendix C. The simple payback period for each measure was calculated. A description was prepared for each ECM which details baseline and proposed equipment.

Pre-feasibility measures were evaluated using screening level vendor tools or simple spreadsheet calculations. These preliminary studies were also detailed with savings, costs, and paybacks. Life-cycle cost analysis was not completed at the screen level.

The Technology Evaluation section of this study only takes into consideration energy cost savings. Incentives were not incorporated into the economic evaluation of technologies because they may change, or be eliminated by the time the final selected equipment is determined. Incentives should be re-evaluated when the final selected system/technology is selected.

The final section of this report details the selected course of action for the Heating/Cooling Master Plan, supported by detailed (specification-level) cost estimation and economic analysis.

Additionally, NYSERDA CHP pre-feasibility model results and NYSERDA/NYPA Geothermal Clean Energy Challenge Stage 1 and 2 reports were provided by the County and summarized. Detailed results are included in Appendix D.

A summary of preliminary energy conservation measures evaluated and those selected for further analysis as part of the HVAC Master Plan are shown in Figure 1 below.

Figure 1

Ulster County Law Enforcement Center

Energy Conservation Measure Energy Savings Summary - 380 Boulevard, Kingston NY 12402

	Measure Description	Measure Status (See Notes)	kWh Savings	kW Savings	NG mmBtu Savings	Oil mmBtu Savings	Total mmBtu Savings	Annual Cost Savings	Project Cost	Payback (Years)
PFS 1	Install Solar Thermal DHW	NR			1,086		1,086	\$9,356	\$406,817	43.5
PFS 2	Install Cooling Energy Thermal Storage	NR		817			0	\$8,032	\$300,000	37.4
ECM 1	Install a HHW Condensing Boiler	ME			-6,047	6,791	744	\$71,256	\$439,100	6.2
ECM 2	Install Natural Gas DHW Boilers	NR			-4,895	5,557	662	\$58,618	\$243,600	4.2
ECM 3	Install Biomass Boiler with HHW Condensing Boiler	NR			-3,456	9,701	966	\$22,258	\$440,200	19.8
FA PFS 1	Install Solar Thermal DHW	RS			95	48	143	\$1,286	\$58,117	45.2
FA PFS 2	Install Cooling Energy Thermal Storage	RS	No change from PFS 2 above							
FA ECM 1	Install a HHW Condensing Boiler	RME			-8,411	9,838	1,427	\$105,230	\$1,010,200	9.6
Totals (All Measures)			0	817	-16,667	25,144	3,198	\$195,425	\$2,052,117	10.5
Totals R, I, and RNE Only			0	0	-8,411	9,838	1,427	\$105,230	\$1,010,200	9.6

Measure Status: Recommended (R); Not Recommended (NR); Further Study Recommended (RS); Recommended for Non-Energy Benefits (RNE);

Implemented (I); Recommended Mutually Exclusive; Mutually Exclusive

FA measures were selected by the customer for further analysis by the customer as part of the Heating/Cooling Master Plan.

1 MMBtu = 1,000,000 Btu

ECM 3 Total mmBtu Saving includes 5,279 mmBtu is biomass fuel use.

PFS 1 assumes solar will displace natural gas usage

PFS 2's kW savings is cumulative annual

Annual cost savings for R/I/RNE measures:	\$105,230	Base year costs - proposed annual cost savings	\$666,362
Base year energy costs		% savings	13.6%
Electric	\$559,577		
#2 Fuel Oil	\$212,015		
	<u>\$771,592</u>		

GENERAL NOTES:

1. Savings round to nearest whole number.
2. A description of each measure and associated savings are included in the Energy Conservation Measures section.
3. ECM supporting calculations and cost estimates are included in Appendices B and C, respectively.
4. Savings are based upon 2018 utility rates (Appendix A) and rates provided by the customer for natural gas.
5. Interactivity among the individual ECMs was not considered (unless where noted), so the savings may change depending on the combination of improvements implemented.
6. Incentives and O&M costs are not considered.

Based upon full implementation of all ECMs selected by the County for further analysis in the HVAC Master Plan (and recommended in Figure 1), the annual savings currently projected in this analysis are \$105,230 per year. This would reduce the annual energy costs by approximately 13.6% from the base amount of \$771,592 to a proposed amount of \$668,362. The estimated capital cost associated with implementing all recommended energy conservation measures is \$1,010,200 with a simple payback period of 9.6 years.

This report is the final deliverable under the project's statement of work. Savings assumptions are based on the conditions present at the site at the time of the initial audit.

ASSESSMENT OF SITE CONDITIONS

BUILDING OVERVIEW

The Ulster County Law Enforcement Center is a 277,000 square foot Law Enforcement Center located in Kingston, NY. The building is occupied by the Ulster County Jail and also serves as headquarters for the Sheriff's Patrol and Civil Divisions and is therefore occupied all hours of the year. The two story building with basement was constructed in 2007 and contains inmate cells, visitation, kitchen, cafeteria, meeting rooms, offices, mezzanines, mechanical areas, corridors, storage, and restrooms. The facility is elaborate and has experienced very little change of use since opening.

Architectural Features

The Ulster County Law Enforcement Center is a masonry and steel framed structure. The roof is built up with flat black EPDM. The staff stated during the interview that the roof has both structural and water penetration issues. In addition, areas of the building shell were noted as porous, which results in moisture permeation through the wall. Insulation values are assumed to match the performance defined in the construction design documents. The windows are original to the building, are non-operable, and have insulated glazing with aluminum frames.

Heating, Air Conditioning, and Controls

The boilers are the primary focus of this study. The following description emphasizes their performance, existing conditions, and control parameters.

Cooling is supplied by (2) VSD water cooled centrifugal chillers, coupled with a pair of cooling towers. Staff noted during the interview that the cooling towers are unable to keep up with load at peak cooling. They also indicated that the towers provide free cooling, but this was not found in the design drawings. Chilled water distribution is provided by a variable-flow primary/secondary system with lead/lag pumps. The condenser water pumps also operate lead/lag but are constant speed.

Heating is provided by three 3-pass, dual fuel (natural gas & #2 oil), water-backed, horizontal firetube boilers manufactured by Sellers Engineering Co. These boilers are used for both building heat and domestic hot water generation. They are non-condensing boilers which were installed in 2006. These boilers use propane as an ignition source but maintain firing with #2 oil.



The boilers heat a propylene glycol/water mix that heats the spaces through terminal equipment. Domestic hot water is generated by this same glycol/water mix piped into vertical tank/heat exchangers located in various locations in the building.

The boilers are piped in a primary/secondary arrangement with a duplex secondary pump setup distributing glycol/water mix past the boilers and out to the building and back. The secondary pumps operate in a lead-lag arrangement and are variable-speed pumps controlled to maintain a set pressure at the far limits of the piping system.

There are three primary pumps piped in parallel drawing water from the secondary piping loop, to the boilers and back to the secondary loop. The primary pumps are not dedicated to any boiler, but instead operate on a one-for-one basis with the boilers. Two-way control valves open at each boiler to allow flow through the boiler when it is called to operate and one of the primary pumps is commanded on.

Each of the boilers has experienced tube failures with all of them having to be retubed three times each. There is no expectation to retube any of the boilers more than four times. Depending on the amount of welding done during previous repairs, it is possible none of the boilers can be retubed a fourth time.

Boiler control was added to the existing Automated Logic system two years ago and allows a warm up cycle during rotation. Previously, when a boiler was called upon to operate, the associated two-way control valve was commanded open and a primary pump started. The boiler would then begin operating at a high-fire rate for a period of time before modulating down.

Now the lag boiler continues to operate until the new lead boiler reaches operating temperature and the burner starts at low-fire instead of a high-fire rate before modulating up. Boiler rotation is presently scheduled via the BAS for every Wednesday.

Only one boiler is typically needed to meet the building load. The burners are dual fuel, so natural gas can be utilized when service is made available. A recent boiler efficiency test was not provided for this study, but the boilers are serviced semi-annually.

The boilers also supply hot water to 14 domestic hot water storage tanks with internal heat exchangers. This arrangement requires the boilers to be enabled year-round. The domestic hot water is stored at 130-140°F and recirculated at 110°F to support sinks, showers, laundry, and kitchen activities.

The hot water supply set point for each boiler is linearly scaled as a function of outside air temperature (OAT) as follows: 180°F HWS @ 40°F OAT and 160°F HWS @ 80°F OAT. This schedule is constrained to meet the domestic water requirements. De-coupling domestic water heating from the main boilers would decrease non-heating season energy usage.

Table 1

Boiler Schedule						
B-	Manufacturer	Model Number	Input MBH	Output MBH	Design Thermal Efficiency	Fuel
1	Sellers	SY-300-W	12263	10043	81.9%	Oil #2
2	Sellers	SY-300-W	12263	10043	81.9%	Oil #2
3	Sellers	SY-300-W	12263	10043	81.9%	Oil #2

HVAC in the facility includes (40) AHUs, (2) RTUs, (94) exhaust fans, and an assortment of electric, gas, and HW terminal units. AHU characteristics are as follows:

- All AHUs have hot water (HW) coils, and:
- (32) have chilled water (CW) coils
- (10) have air-to-air heat exchangers with re-heat coils
- (7) serve as MUA's
- (12) have air-side economizers
- Fan VSD's are installed on variable volume systems
- Systems operate 24/7/365

Electrical Systems

Interior and exterior lighting systems were recently upgraded with LED. Lighting sensor upgrades are planned.

Staff mentioned during the interview that they're strategizing to reduce Excess RKVA (power factor) charges.

Process and Plug Loads

Process and plug loads include equipment and systems typically found in Law Enforcement Centers and office environments.

Building Control System

The building has an Automated Logic building automation system (BAS), maintained by Eastern Heating and Cooling. The system is accessible remotely and has trending capabilities which are not utilized to their fullest extent by the County. The staff expressed interest in learning about software that overlays the BAS to provide ongoing energy analysis, commissioning, and monitoring/verification of system upgrades.

As part of its evaluation of the BAS, L&S attempted to correlate trend data with boiler room logs, fuel oil delivery records, and other sources of information. Impediments to this process included lack of clear labeling of the data fields, ambiguity as to the physical units of the quantities recorded, and lack of documentation including calibration records.

The BAS's trending capabilities are a valuable resource not only for continuous commissioning of the HVAC plant but also for measurement and verification of equipment upgrades. L&S strongly recommends that the facility work with Eastern Heating and Cooling to bring the BAS to its full potential.

BUILDING BALANCE POINT TEMPERATURE AND LOAD COEFFICIENT

The balance point temperature and load coefficient are two metrics used to estimate the heating and cooling requirements of a building. Both metrics were computed using historical utility data and weather (temperature) data. Because boiler replacement is the primary focus of this project, calculations were for the heating season only. The following high-level summary assumes that the reader is familiar with regression statistics as applied to building energy analysis.

The balance point temperature is the temperature below which a building requires active heating. It is a function not only of the size and composition of a building but also of internal, solar, and other gains. There are several ways to estimate it. For purposes of this report it was based on a heating degree day (HDD) analysis.

The number of heating degree days for a given day is (average daily temperature – degree day base temperature) when that number is greater than zero. A regression analysis is performed on utility heating fuel data as a function of heating degree days for the billing periods¹.

The objective is to select the degree day base temperature that maximizes the correlation coefficient of the regression. By the definition of correlation coefficient, this minimizes the regression's ratio of unexplained variation to total variation with respect to degree day base temperature. The base temperature that maximizes the correlation coefficient is then taken as the balance point temperature of the building.

The results were as follows for the fuel oil data:

- HDD base temperature = 57° F giving R^2 (squared correlation coefficient) of 0.953
- Slope = 23.45 therms/day / HDD57/day
- Intercept = 152.25 therms/day

The process is completed by multiplying the regression parameters (slope and intercept) by the estimated efficiency of the heating system – to get an estimate that is independent of the HVAC system. The seasonal efficiency of the heating system was estimated at 78%. Note that this procedure does not change the HDD base temperature or correlation coefficient of the data set.

The results that describe the heating load of the building independently of the heating system were found to be:

- Slope = 18.29 therms/day / HDD57/day
- Intercept = 118.75 therms/day

The intercept describes daily usage that is independent of weather conditions. For this facility, it has a large value and is associated with the production of domestic hot water (DHW). To de-couple DHW usage from heating hot water (HHW) usage, the intercept was used in calculations for the

¹ See ASHRAE Guideline 14-2002 pgs 139-140, which includes a description of eliminating *sample interval bias* from the data.

former and the slope was used for the latter. This was the basis for evaluating a proposed DHW system that does not rely on the HHW boiler (ECM 2).

These results were used to model proposed boiler energy usage (ECMs 1 and 3) as detailed in Appendix B. The models were based on projected fuel use in a year of typical weather (using TMY3 data). The model calculations were cast in a form that does not require the use of the building load coefficient. However for sake of completeness the load coefficient was calculated using the information outlined above.

Recall that the building load coefficient is defined as the quantity UA in the conductive heat transfer formula $\text{Btu/hour} = UA \Delta T$. The load coefficient may be derived from the utility data regression slope in the following way:

1. The physical units of the load coefficient are Btu/hour °F
2. The physical units of the regression slope are therms/HDD, that is, therms/day °F
3. The conversion of the utility data regression slope to load coefficient is:

Utility regression therms / day deg F * 10^5 Btu/therm * 1 day/24 hours * heating efficiency \equiv Btu / hr deg F

The building load coefficient was thus found to be 76,209 Btu/hr °F.

PRELIMINARY ENERGY USE ANALYSIS (PEA)

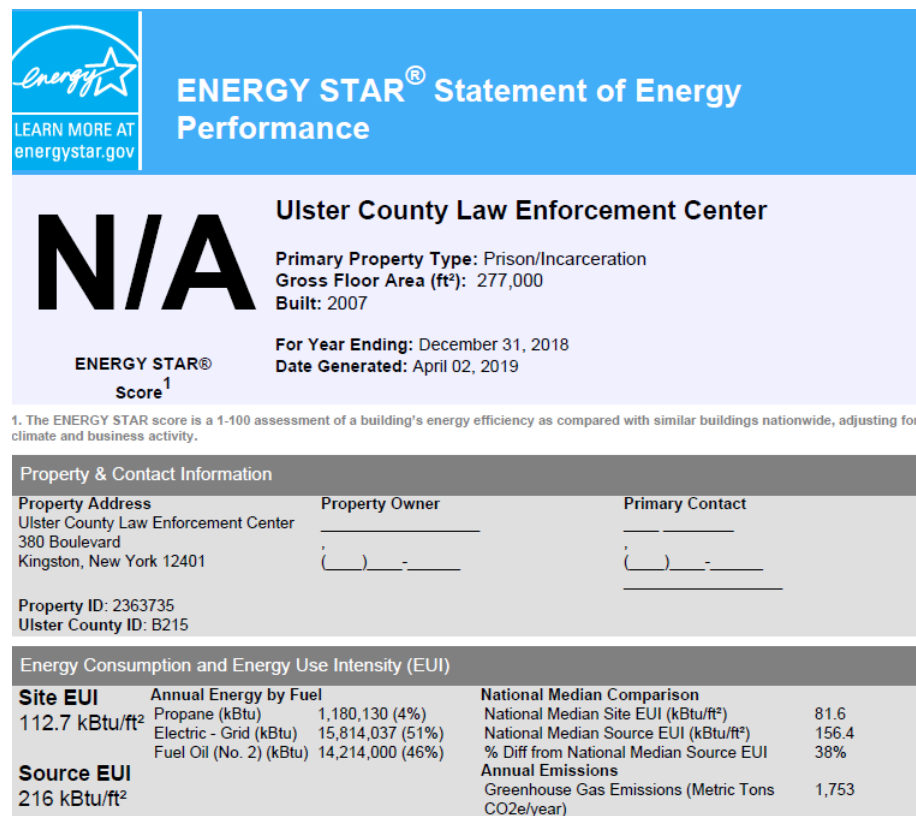
Data and Building Characteristics for EPA Portfolio Manager

The utility data used for energy and cost savings analysis for ECMs is listed in Appendix A. Also included in Appendix A is the Energy Star Data Verification Checklist (DVC). The DVC lists its version of the utility data as well as building age, gross floor area, and other relevant information.

EPA Portfolio Manager Results

Figure 2 shows the Energy Star's score card and the building's Energy Usage Intensity (EUI). Due to the lack of a sufficient data base for this type of property, Energy Star was unable to compile a score.

Figure 2



The EUI is a building's energy use normalized to floor area. Based on 12 months of energy consumption history the site EUI is 112.7 kBtu/ft². According to Energy Star's Portfolio Manager, the EUI of comparative sites (Prison/Incarceration) is 81.6 kBtu/ft², or 38% more efficient than this site.

TECHNOLOGY EVALUATION

The supporting calculation data for the following Energy Conservation Measures (ECMs) can be referenced in Appendix B.

ECM No.	Energy Conservation Measure Description
PFS-1	Install Solar Thermal DHW
PFS-2	Install Cooling Energy Thermal Storage
ECM-1	Install a HHW Condensing Boiler
ECM-2	Install Natural Gas DHW Boilers
ECM-3	Install a Biomass Boiler and a HHW Condensing Natural Gas Boiler

Supporting Information

- The Law Enforcement Center is slated for a fuel switch from #2 oil to natural gas. Savings for each type of fuel are listed for the boiler and DHW measures. The solar DHW measure assumes that the facility has switched to natural gas. The County communicated the terms associated with natural gas extension to the UCLEC facility from the utility as an interruptible rate structure and implementation the responsibility of the County.
- Heating hot water and DHW measures (ECMs 1 & 2): To cover all options, savings calculations would be given using both a baseline of existing conditions and a baseline based on code-minimum equipment. However, the existing #2 fuel oil boiler's nameplate efficiency is 82%, which is identical to the minimum code efficiency for a natural gas-fired boiler of the same capacity². In the narratives below, incremental implementation costs are compared with absolute costs for these measures given that there would be no energy savings from installing code-minimum equipment.
- ECM 3 (Install a Biomass Boiler and a HHW Condensing Natural Gas Boiler): There is not sufficient supporting information in the industry to estimate CO2 emissions reductions for biomass boilers. For example, Energy Star Portfolio Manager lists CO2 emissions for #2 fuel oil as 74.21 kg/MBtu and wood is listed as 95.05 kg/MBtu, a 28% increase. High efficiency biomass boilers are advertised to reduce CO2 emissions as compared to fuel oil by varying amounts (56% in one study, 1.5 tons of CO2 per ton of pellets in another), however we had a low confidence in using these references for this study due to high variability. Ultimately, low emissions are achieved in high efficiency biomass boilers by installing controls and thermal storage that allow for long on-cycles followed by long off-cycles.

² IECC 2015, page C-47, Table C403.2.3(5)

PFS-1: Install Solar Thermal DHW

Project Cost:	\$406,817	
Simple Payback:	43.5	Years
Electricity Savings:	0	kWh /Year
Peak Demand Savings:	0	kW
Gas Heating Savings:	1,086	mmBtu/Year
Annual Energy Cost Savings:	\$9,356	

EXISTING CONDITIONS:

Presently, the HHW boilers also supply hot water to 14 domestic hot water storage tanks with internal heat exchangers (ECM-2 calls for installing gas-fired units at 7 of these 14 stations). The DHW load was estimated to be 4,334 mmBtu/year; the present #2 fuel oil-fired boilers use 5,557 mmBtu/year to meet this load.

ECM SPECIFICATIONS:

Install solar-assisted domestic hot water heating. A pre-feasibility study was applied to this measure. An on-line calculator maintained by energy.gov determined there to be energy savings (1,086 mmBtu/year). The simple payback was calculated assuming that ECM 2 has been implemented, and with natural gas cost savings payback is about 44 years.

This analysis has not been updated to reflect the interrupted natural gas tariff, or changes to ECM-2. A rate of \$0.86/therm (referenced from the UC Office Building) was utilized for natural gas. Please see Further Analysis for PFS-1, on page 24, for further analysis of the selected option.

ACTION ITEMS:

Due to the long payback, this measure is not recommended. The solar benefit will only be useful from about April through October in upstate NY. There are not incentive available for solar DHW in NYS that we're aware of at this time.

PFS-2: Install Cooling Energy Thermal Storage

Project Cost:	\$300,000	
Simple Payback:	37.4	Years
Electricity Savings:	0	kWh /Year
Peak Demand Savings:	817	kW
Annual Electric Demand Cost Savings:	\$8,032	

EXISTING CONDITIONS:

The existing chillers cool the building with no thermal storage.

ECM SPECIFICATIONS:

Install ice-based storage for cooling. A pre-feasibility study was applied to this measure. The cooling requirements for this building were estimated from electric utility data. The savings calculations were based on the potential of this technology to shave peak electric demand. Using typical equipment and performance specs for this technology, it was determined that for seven months of the year chiller electric demand could be shaved by 50% resulting in a total annual reduction of 817 kW.

ACTION ITEMS:

This measure is not recommended due to its long payback.

ECM-1: Install a HHW Condensing Natural Gas Boiler

Project Cost:	\$439,100	
Simple Payback:	6.2	Years
Electricity Savings:	0	kWh /Year
Peak Demand Savings:	0	kW
#2 Fuel Oil Savings:	6,791	mmBtu/Year
New Gas Heating Usage:	- 6,047	mmBtu/Year
Net Fuel Savings:	744	mmBtu/Year
Net Annual Energy Cost Savings:	\$71,256	
% Reduction in CO2 Emissions:	25%	

EXISTING CONDITIONS:

Heating is provided by three inefficient oil-fired fire-tube hot water boilers that were installed in 2002. The hot water supply set point for each boiler is linearly scaled as a function of outside air temperature (OAT) as follows: 180°F HWS @ 40°F OAT and 160°F HWS @ 80°F OAT. This schedule is constrained to meet the domestic water requirements.

ECM SPECIFICATIONS:

Install a natural gas fired high efficiency condensing boiler. Retain (or replace in kind) at least one of the existing boilers as a backup for when the condensing boiler is down or natural gas is interrupted. The natural gas boiler is assumed to be interruption 30% of the time (estimated by the customer) and the oil fired boiler takes over.

After deducting the DHW load, one condensing boiler was modeled with a full load capacity of 7,797 MBH and a maximum efficiency of 94%. The existing boilers are modeled with a system efficiency of 78%, to count for losses associated with distribution and potentially high glycol concentrations (the actual glycol levels were not tested and frequency that glycol is added is unknown). The boiler capacity was verified by GPI through a Trane Trace building load simulation. It is assumed that hot water is supplied from the boiler on the OAT same reset schedule as existing. As indicated above, this analysis also assumes that the DHW load is supplemented by another system, so a lower return temperature can be used that will allow for longer periods of condensing (below 140°F). In addition, it is assumed that gas is interrupted 30%

ACTION ITEMS:

This ECM is recommended based on the assumption that DHW load can be decoupled, the condition of the existing boilers and on the payback.

It may also be beneficial to understand the savings associated with the fuel switch as compared to the efficiency improvement:

- Fuel switch: \$59,684
- Efficiency improvement: \$11,572

A comparison of an in-kind code-minimum oil fired boiler to condensing natural gas boiler was requested by the customer. The boiler cost estimate for a code-minimum (non-condensing) in-kind oil fired boiler is \$143,000³. The incremental cost of the proposed energy-efficient option over the code-minimum option is \$296,100, which results in a simple payback of approximately 4.6 years. The % Reduction in CO2 Emissions = 21 %.

³ RSMeans 2018 Mechanical 23 52 23.20 3400; cost for two (2) 3996 MBH boilers + \$6K demo & \$2k venting.

ECM-2: Install Natural Gas DHW Boilers

Project Cost:	\$243,600	
Simple Payback:	4.2	Years
Electricity Savings:	0	kWh /Year
Peak Demand Savings:	0	kW
#2 Fuel Oil Savings:	5,557	mmBtu/Year
New Gas Heating Usage:	- 4,895	mmBtu/Year
Net Fuel Savings:	662	mmBtu/Year
Net Annual Energy Cost Savings:	\$58,618	
% Reduction in CO2 Emissions:	36%	

EXISTING CONDITIONS:

Presently, the HHW boilers also supply hot water to 7 locations, each with two hot water storage tanks with internal heat exchangers, for a total of 14 units. The DHW load was estimated to be 4,334 mmBtu/year; the present #2 fuel oil-fired boilers use 5,557 mmBtu/year to meet this load.

ECM SPECIFICATIONS:

Install a natural gas fired high efficiency boiler (approximately 319 MBH) at each of the 7 locations to replace one of two storage tanks. The second tank would remain coupled to the HHW boiler plant for back-up for when gas is interrupted or a heater fails.

ACTION ITEMS:

The customer did not select this measure for the HVAC Master Plan due to logistical issues associated with the existing building infrastructure, so it is not recommended.

It may also be beneficial to understand the savings associated with the fuel switch as compared to the efficiency improvement:

- Fuel switch: \$48,312
- Efficiency improvement: \$10,306

ECM-3: Install a Biomass Boiler and a Condensing HHW Natural Gas Boiler

Project Cost:	\$440,200	
Simple Payback:	19.8	Years
Electricity Savings:	0	kWh /Year
Peak Demand Savings:	0	kW
#2 Fuel Oil Savings:	9,701	mmBtu/Year
New Biomass Pellet Usage:	- 5,279	mmBtu/Year
New Gas Heating Usage:	- 3,456	mmBtu/Year
Net Fuel Savings:	966	mmBtu/Year
Net Annual Energy Cost Savings:	\$22,258	
% Reduction in CO2 Emissions:	See discussion in Supporting Information above	

EXISTING CONDITIONS:

Heating is provided by three inefficient oil-fired fire-tube hot water boilers that were installed in 2002.

ECM SPECIFICATIONS:

Install a biomass hot water boiler system sized to handle about 60% of the peak heating load (~ 4678 MBH) in the building and a condensing gas fired boiler for auxiliary heat (~ 3119 MBH). These systems would be sized to replace the existing boiler capacity after deducting the DHW load (see ECM 2).

Biomass is any plant-derived organic matter available on a renewable basis, including dedicated energy crops and trees, agricultural food and feed crops, agricultural crop wastes and residues, wood wastes and residues, aquatic plants, animal wastes, municipal wastes, and other waste materials⁴.

The building heat load was calculated via the methods described above. The existing systems were modeled as meeting the load at an average seasonal efficiency of 78%. The fuel requirements for meeting the load with the proposed systems were then calculated. The proposed biomass boiler was modeled at a 100% firing rate with efficiency of 86% based on typical product literature. The proposed condensing boiler was modeled with an efficiency that varied linearly between 85% at outdoor temperature of 20° F and 94% at outdoor temperature of 58° F.

The model projected that in a year of typical weather, the biomass boiler would use 52,791 equivalent therms (330 tons of pellets) annually and the condensing boiler would use 34,555 therms. The resulting 87,346 therms consumption represents a 10% savings over the existing system under the same conditions.

This analysis has not been updated to reflect the interrupted natural gas tariff, as oil use was assumed

⁴ <https://www.nyserdera.ny.gov/Researchers-and-Policymakers/Biomass>

to be eliminated. Therefore, a rate of \$0.86/therm (referenced from the UC Office Building) was utilized for natural gas.

ACTION ITEMS:

As detailed in Appendix B, the energy savings would not be advantageous due to the present disparities in fuel prices between biomass pellets and natural gas. There should also be additional evaluation by an installer of the logistics of installing a pellet silo at this facility and securing a pellet supplier. L&S contacted several pellet suppliers in New York State and Pennsylvania; however none would have vacuum delivery services available for Ulster County. Further, L&S contacted NYSERDA's Renewable Heat New York program management, who also could not identify a supplier. Although not ruled out by payback alone, this measure is recommended for further study if the facility wishes to pursue a biomass option. The County should also review available incentives through NYSERDA's Renewable Heat New York (RHNY) Biomass Program, upon further evaluation.

Discussion of CHP pre-feasibility model results

ERS completed a CHP pre-feasibility model for the Ulster County Law Enforcement Center and a summary of the results was provided by the County for integration into this study. The summary reports energy savings, NYSERDA incentive and simple payback for numerous scenarios associated with: Variable Implementation Cost, Fixed Implementation Cost and energy rates.

At the time of writing this report, NYSERDA's solicitation for the Combined Heat and Power Program (PON 2568) is closed, so no direct incentives are available. NYSERDA is currently exploring programs that will help to promote distributed energy resources (DER), which are technologies that generate or manage the demand of electricity at different points of the grid, such as at homes and businesses, instead of exclusively at power plants. They allow owners to reduce their facilities' carbon footprints, rein in energy costs, and improve utility grid power-outage resiliency.

ERS provided an updated summary table showing simple payback without the incentive for each scenario and is shown in part below. The rates used in this model are based on the utility information provided to ERS at the time of the screening, so they do not align with the rates used in this FlexTech study. If rates that used in this report were used in the analysis, the simple payback would increase by about one year. The full savings summary table and model results can be found Appendix D.

Table 3

Variable Cost	Fixed Cost	Total Cost	kWh Rate	Summer kW Rate	Winter kW Rate	Gas Rate	CHP Gas Rate	Annual kWh	Peak Demand	Annual MMBtu	Optimal Size	Payback
\$4,500	\$100,000	\$550,000	\$0.083	\$8.68	\$8.49	\$11.84	\$7.50	4,929,057	948	16,311	100-125	13.5
\$4,000	\$75,000	\$475,000										11.6
\$4,500	\$100,000	\$550,000	\$0.083	\$9.16	\$9.16	\$9.77	\$7.00	4,929,057	948	16,311	100-125	16.0
\$4,000	\$75,000	\$475,000										13.9
\$4,500	\$100,000	\$550,000	\$0.090	\$9.50	\$9.50	\$10.50	\$7.00	4,929,057	948	16,311	100-125	12.4
\$4,000	\$75,000	\$475,000										10.7

The CHP pre-feasibility model shows that LEC is a good candidate for CHP based on an overall system efficiency of 77.6%, so the County may choose to pursue a more detailed CHP study with the assistance of FlexTech, or wait to see if NYSERDA issues another solicitation that includes incentives associated with the DER initiative discussed above. A detailed analysis of CHP was not part of the scope of work for this FlexTech study; however L&S can complete this work through a separate application.

Discussion of NYSERDA/NYPA Geothermal Clean Energy Challenge Stage 2 Report

The County is participating in the NYSERDA/NYPA Geothermal Clean Energy Challenge. At the onset of this study, the County was in Stage 1 (Summary Report) of the Geothermal Clean Energy Challenge, and we were only tasked with providing insights associated with this stage. In the meantime, the County had a Stage 2 (Advanced Report) completed, so we expanded our efforts to include insights for Stage 2 below. The complete Advanced Report is included in Appendix D.

The Stage 2 building energy model (BEM) analysis of LEC was completed with the whole building energy simulation program Energy Plus, through Open Studio software. The estimated energy use was simulated for the single closed loop ground source heat pump (GSHP) system. Energy Plus includes a library of typical loads and system performance characteristics that were likely used to fine tune the energy load patterns, in addition to input parameters provided by the County. The study cautions that the results are still considered preliminary and a detailed feasibility assessment (Stage 3) should be pursued, if the County finds the results of the Stage 2 favorable.

In summary, the Stage 2 report does not specify how the GSHP would be integrated with the existing LEC HVAC systems, or the type of GSHP system that should be considered, i.e. air to water or water to water. The payback with incentive is estimated to be 22-25 years, which is on the higher end of the range from our experience. The County was approved for Stage 3, which may give an opportunity to flush out some more of the assumptions and look for opportunities to reduce the implementation costs. The assumptions and energy rates used in the GSHP study may be different from the parameters used in this FlexTech study and may be too extensive to list in detail here. However, if the rates in this report were used, the simple payback may drop significantly.

HEATING/COOLING MASTER - FURTHER ANALYSIS (FA)

GPI/L&S meet with the County on May 16, 2019 to review the technologies evaluated in the section above from the draft Flex Tech Study. On July 10, 2019, the County provided guidance to L&S/GPI on a selected course of action to integrate into the final Flex Tech Study and Heating/Cooling Master Plan. The County, GPI and L&S completed a conference call on July 22, 2019 to review the guidance document.

The County selected the following measures for detailed (specification-level) cost estimation and economic analysis for the Ulster County Law Enforcement Center. Adjustments to energy analysis may also be completed when deemed appropriate and within the project scope of work.

- PFS-1: Install Solar Thermal DHW
- PFS-2: Install Cooling Energy Thermal Storage
- ECM-1: Install a HHW Condensing Natural Gas Boiler

FA PFS-1: Install Solar Thermal DHW

Project Cost:	\$58,117	
Simple Payback:	45.2	Years
Electricity Savings:	0	kWh /Year
Peak Demand Savings:	0	kW
Gas Heating Savings:	95	mmBtu/Year
Oil Heating Savings:	48	mmBtu/Year
Annual Energy Cost Savings:	\$1,286	

COUNTY SELECTED COURSE OF ACTION:

Assess solar thermal DHW in further detail as a system to be integrated into the heating loop in the future.

EXISTING CONDITIONS:

Presently, the HHW boilers also supply hot water to 14 domestic hot water storage tanks with internal heat exchangers (ECM 2 calls for installing gas-fired units at 7 of these 14 stations).

COUNTY SOW SPECIFICATIONS:

Work to include the installation of new solar thermal collection system with collectors to be installed on the roof of the existing Boiler Plant section with a new storage tank installed within the existing Boiler Room. System shall interface with existing Kitchen/Laundry water heaters WH-7 and WH-7A. Prior to sizing of system, coordinate with the County to install a water meter on the cold water feed to the water heaters. Usage data from this meter shall be used to size collector and storage system. Design basis shall be Viessmann model Vitosol 200-FM with ThermProtect switching absorber layer. Collector controls shall interface with existing Building Management System.

Trend temperatures and flow rates from the HHW boilers to the storage tanks for an appropriate period of time to capture a typical load cycle.

This measure was reassessed using the energy.gov on-line calculator for just the 2 domestic hot water storage tanks at a pre-feasibility level, to keep within the project scope of work. No further action was taken to assess integrating into the heating loop or implementation with a roof replacement, as prices may change in time. Detailed implementation costs and energy analysis should be pursued in further detail when the County decides to pursue this measure.

The solar benefit will only be useful from about April through October in upstate NY. There are not incentive available for solar DHW in NYS that we're aware of at this time.

FA PFS-2: Install Cooling Energy Thermal Storage

Project Cost:	\$300,000	
Simple Payback:	37.4	Years
Electricity Savings:	0	kWh /Year
Peak Demand Savings:	816.6	kW
Annual Electric Demand Cost Savings:	\$8,032	

COUNTY SELECTED COURSE OF ACTION:

Assess integration of cooling energy thermal storage.

EXISTING CONDITIONS:

The existing chillers cool the building with no thermal storage.

COUNTY SOW SPECIFICATIONS:

A SOW was not developed by GPI or requested by the County, as it required further evaluation as an as a valuable option.

Further energy analysis beyond pre-feasibility is outside the project scope of work and the installation cost should be reevaluated when the County decides to pursue this measure

FA ECM-1: Install a HHW Condensing Natural Gas Boiler

Project Cost:	\$1,010,200	
Simple Payback:	9.6	Years
Electricity Savings:	0	kWh /Year
Peak Demand Savings:	0	kW
#2 Fuel Oil Savings:	9,838	mmBtu/Year
New Gas Heating Usage:	- 8,411	mmBtu/Year
Net Fuel Savings:	1,427	mmBtu/Year
Net Annual Energy Cost Savings:	\$105,230	
% Reduction in CO2 Emissions:	24%	

COUNTY SELECTED COURSE OF ACTION:

Replace the three existing "Sellers" boiler with one natural gas fired condensing boiler, and two "Cleaver-Brooks" dual fuel (gas, #2 F.O.) boilers. Include any alternative recommendations on how to configure dual fuel boilers to achieve maximum efficiency (i.e. alternate make/model/sizing/quantity) while still meeting the building load with redundancy.

EXISTING CONDITIONS:

Heating and DHW is provided by three inefficient oil-fired fire-tube hot water boilers that were installed in 2002. The hot water supply set point for each boiler is linearly scaled as a function of outside air temperature (OAT) as follows: 180°F HWS @ 40°F OAT and 160°F HWS @ 80°F OAT. This schedule is constrained to meet the domestic water requirements.

COUNTY SOW SPECIFICATIONS:

Work to include replacement of the three original 300 HP Sellers wetback firetube boilers with two 300 HP non-condensing firetube boilers and one 300 HP condensing boiler. Non-condensing boilers shall operate on No.2 fuel oil or natural gas with automatic change-over based on input from the Building Management System. Burners shall be modulating. The condensing boiler shall be placed first in line on the return water system and operate on natural gas. The design basis for both will be Cleaver Brooks. Modify or replace existing systems as needed. Modify the existing Building Management System control sequences to operate the heating system to take advantage of condensing mode as frequently as possible and schedule operation of boilers in lead-lag arrangement. Automatically reset the supply water temperature in accordance with the New York State Energy Code.

In concert with the selected course of action, the economic analysis has been updated to reflect the replace of all three boilers. Although outside the scope of work, the energy analysis was updated to reflect the assumption that the DHW load will remain on the hot water loop. The DHW operation will require higher supply water temperatures to be maintained and result in less efficient operation of the condensing boiler.

It may also be beneficial to understand the savings associated with the fuel switch as compared to the efficiency improvement:

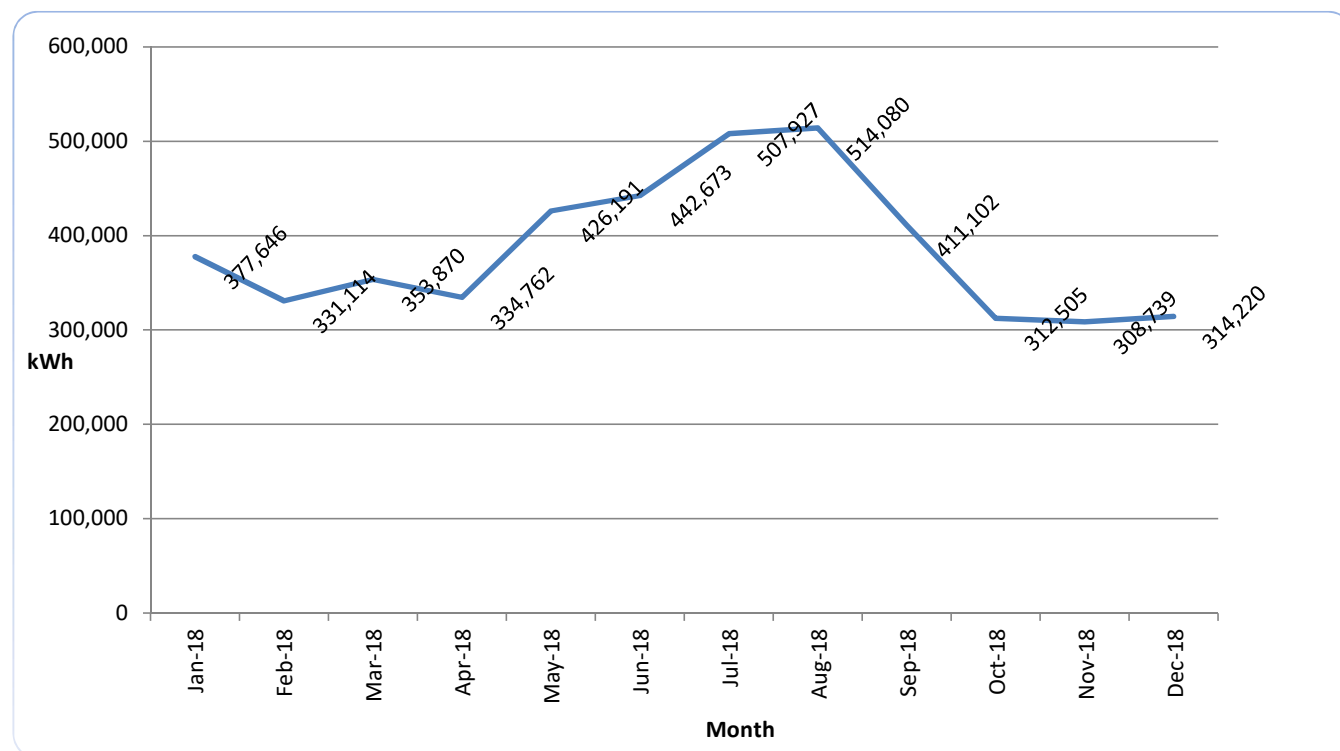
- Fuel switch: \$83,015
- Efficiency improvement: \$22,216

Appendix A - Utility Bill Summary

Facility: Ulster County Law Enforcement Center
Address: 380 Boulevard
City: Kingston, NY
ZIP: 12401

Utility Provider: Central Hudson Gas & Electric

From	To	Total Use kWh	Utility kW Demand	Utility Energy \$	Utility Demand \$	Utility \$/kWh	Utility \$/kW	Total Electricity \$
1/1/2018	1/31/2018	377,646	671.5	\$37,019	\$6,084	\$0.098	\$9.060	\$43,103
2/1/2018	2/28/2018	331,114	648.0	\$33,456	\$5,871	\$0.101	\$9.060	\$39,327
3/1/2018	3/31/2018	353,870	625.9	\$35,827	\$5,671	\$0.101	\$9.060	\$41,497
4/1/2018	4/30/2018	334,762	755.5	\$36,006	\$6,845	\$0.108	\$9.060	\$42,851
5/1/2018	5/31/2018	426,191	816.9	\$43,583	\$7,401	\$0.102	\$9.060	\$50,984
6/1/2018	6/30/2018	442,673	873.8	\$44,240	\$7,917	\$0.100	\$9.060	\$52,156
7/1/2018	7/31/2018	507,927	894.4	\$52,562	\$9,194	\$0.103	\$10.280	\$61,756
8/1/2018	8/31/2018	514,080	1,005.1	\$53,367	\$10,332	\$0.104	\$10.280	\$63,699
9/1/2018	9/30/2018	411,102	886.5	\$42,494	\$9,113	\$0.103	\$10.280	\$51,607
10/1/2018	10/31/2018	312,505	720.2	\$33,556	\$7,404	\$0.107	\$10.280	\$40,960
11/1/2018	11/30/2018	308,739	569.7	\$31,172	\$5,857	\$0.101	\$10.280	\$37,029
12/1/2018	12/31/2018	314,220	570.0	\$28,748	\$5,860	\$0.091	\$10.280	\$34,607
		4,634,829	753.1	\$472,029	\$87,548	\$0.102	\$9.670	\$559,577



Notes:

Facility: Ulster County Law Enforcement Center
Address: 380 Boulevard
City: Kingston, NY
ZIP: 12401

Utility Provider: Paraco and Bottini
 KoscoHeritage

BTU Content (Btu/Gallon):

139,600

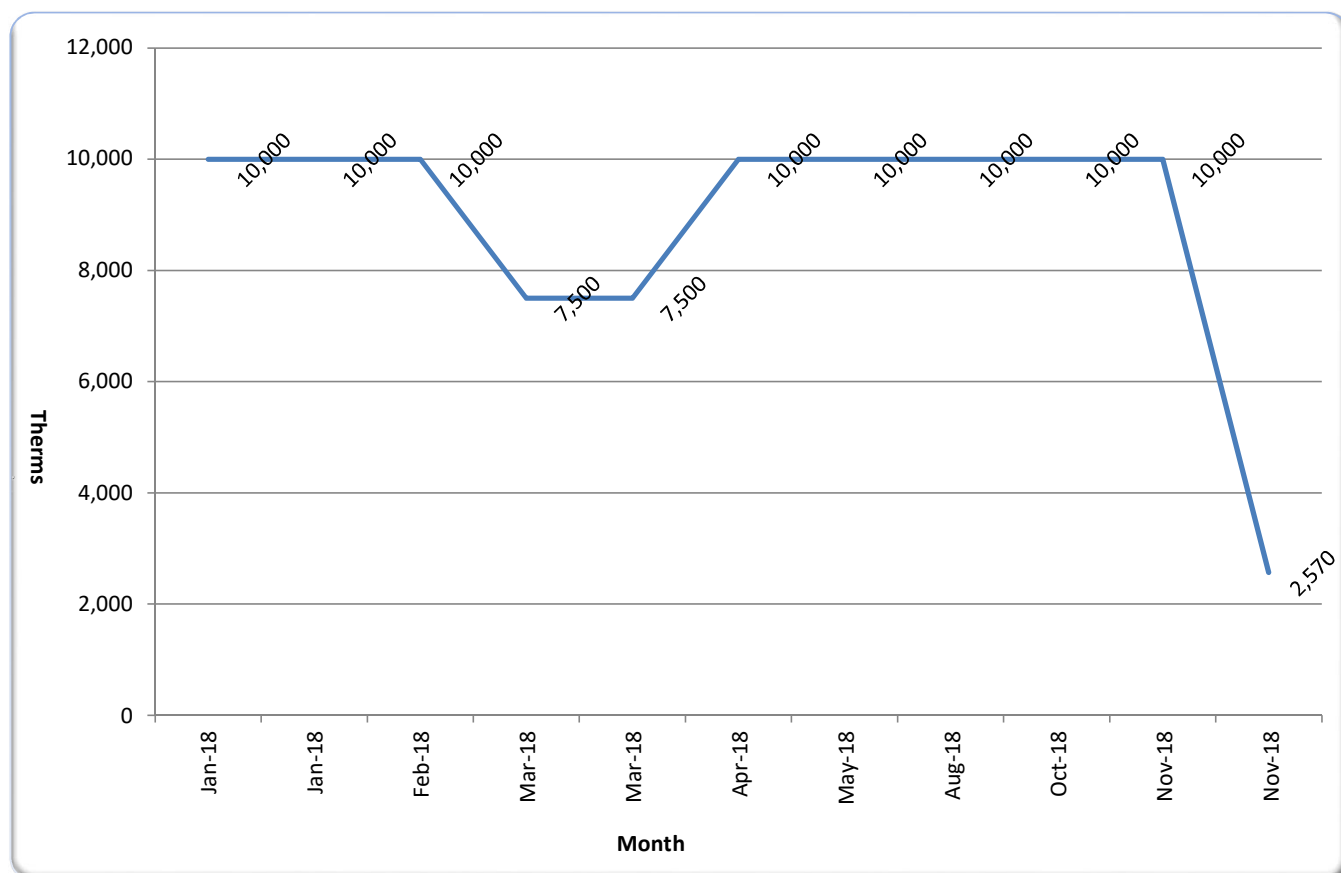
Deliveries only

From	To	Delivered Gallons	Fuel Oil \$	Total \$/gallon	Equivalent MMBtu's
1/9/2018	1/19/2018	10,000	\$22,517	\$2.252	1,396
1/19/2018	2/8/2018	10,000	\$22,256	\$2.226	1,396
2/8/2018	3/6/2018	10,000	\$20,290	\$2.029	1,396
3/6/2018	3/27/2018	7,500	\$16,135	\$2.151	1,047
3/27/2018	4/9/2018	7,500	\$16,087	\$2.145	1,047
4/9/2018	5/3/2018	10,000	\$23,059	\$2.306	1,396
5/3/2018	8/16/2018	10,000	\$21,730	\$2.173	1,396
8/16/2018	10/5/2018	10,000	\$21,730	\$2.173	1,396
10/5/2018	11/1/2018	10,000	\$23,841	\$2.384	1,396
11/1/2018	11/27/2018	10,000	\$21,087	\$2.109	1,396
11/27/2018	12/14/2018	2,570	\$3,284	\$1.278	359
		97,570	\$212,015	\$2.173	13,621

\$/MMBtu:

\$15.57

NOTE: Gallons delivered in italics not provided - amount shown is estimated





ENERGY STAR® Data Verification Checklist

N/A

ENERGY STAR®
Score¹

Ulster County Law Enforcement Center

Registry Name: Ulster County Law Enforcement Center
Property Type: Prison/Incarceration
Gross Floor Area (ft²): 277,000
Built: 2007

For Year Ending: Dec 31, 2018
Date Generated: Apr 2, 2019

1. The ENERGY STAR score is a 1-to-100 assessment of a building's energy efficiency as compared with similar building nationwide, adjusting for climate and business activity.

Property & Contact Information

Property Address
Ulster County Law Enforcement Center
380 Boulevard
Kingston, New York 12401

Property Owner

,
() -

Primary Contact

,
() -

Property ID: 2363735
Ulster County ID: B215

1. Review of Whole Property Characteristics

Basic Property Information

- 1) **Property Name:** Ulster County Law Enforcement Center

Is this the official name of the property?

If "No", please specify: _____

☐ Yes ☐ No
- 2) **Property Type:** Prison/Incarceration

Is this an accurate description of the primary use of this property?

☐ Yes ☐ No
- 3) **Location:**

380 Boulevard
Kingston, New York 12401

Is this correct and complete?

☐ Yes ☐ No
- 4) **Gross Floor Area:** 277,000 ft²

☐ Yes ☐ No

Is value an accurate account of the gross floor area for the property?

5) Average Occupancy (%): 100

☐ Yes ☐ No

Is this occupancy percentage accurate for the entire 12 month period being assessed?

6) Number of Buildings: 1

☐ Yes ☐ No

Does this number accurately represent all structures?

7) Whole Property Verification:

☐ Yes ☐ No

Does this application represent the entire property? If any space or energy use has been excluded from this property, please describe it in the notes section below.

Notes:

Indoor Environmental Quality

1) Outdoor Air Ventilation

☐ Yes ☐ No

Does this property meet the minimum ventilation rates according to ANSI/ASHRAE Standard 62.1, Ventilation for Acceptable Indoor Air Quality?

2) Thermal Environmental Conditions

☐ Yes ☐ No

Does this property meet the acceptable thermal environmental conditions according ANSI/ASHRAE Standard 55, Thermal Environmental Conditions for Human Occupancy?

3) Illumination

☐ Yes ☐ No

Does this property meet the minimum illumination levels as recommended by the Illuminating Engineering Society of North America (IESNA) Lighting Handbook?

Notes:

2. Review of Property Use Details

Office: Office Use

★ This Use Detail is used to calculate the 1-100 ENERGY STAR Score.

★ 1) **Gross Floor Area:** 28,307 ft²

☐ Yes ☐ No

Is this the total size, as measured between the outside surface of the exterior walls of the building(s)? This includes all areas inside the building(s) such as: occupied tenant areas, common areas, meeting areas, break rooms, restrooms, elevator shafts, mechanical equipment areas, and storage rooms. Gross Floor Area should not include interstitial plenum space between floors, which may house pipes and ventilation. Gross Floor Area is not the same as rentable, but rather includes all area inside the building(s). Leasable space would be a sub-set of Gross Floor Area. In the case where there is an atrium, you should count the Gross Floor Area at the base level only. Do not increase the size to accommodate open atrium space at higher levels. The Gross Floor Area should not include any exterior spaces such as balconies or exterior loading docks and driveways.

★ 2) **Weekly Operating Hours:** 65 ← default

☐ Yes ☐ No

Is this the total number of hours per week that the property is occupied by the majority of the employees? It does not include hours when the HVAC system is starting up or shutting down, or when property is occupied only by maintenance, security, cleaning staff, or other support personnel. For properties with a schedule that varies during the year, use the schedule most often followed.

★ 3) **Number of Workers on Main Shift:** 65.11 ← default

☐ Yes ☐ No

Is this the total number of workers present during the primary shift? This is not a total count of workers, but rather a count of workers who are present at the same time. For example, if there are two daily eight hour shifts of 100 workers each, the Number of Workers on Main Shift value is 100. Number of Workers on Main Shift may include employees of the property, sub-contractors who are onsite regularly, and volunteers who perform regular onsite tasks. Number of Workers should not include visitors to the buildings such as clients, customers, or patients.

★ 4) **Number of Computers:** 56.61 ← default

☐ Yes ☐ No

Is this the total number of computers, laptops, and data servers at the property? This number should not include tablet computers, such as iPads, or any other types of office equipment.

5) **Percent That Can Be Heated:** 100

☐ Yes ☐ No

Is this the total percentage of the property that can be heated by mechanical equipment?

★ 6) **Percent That Can Be Cooled:** 100

☐ Yes ☐ No

Is this the total percentage of the property that can be cooled by mechanical equipment? This includes all types of cooling from central air to individual window units.

Notes:

★ 1) **Gross Floor Area:** 248,693 ft²

☐ Yes ☐ No

Is this the total size, as measured between the outside surface of the exterior walls of the building(s)? This includes all areas inside the building(s) such as: occupied tenant areas, common areas, meeting areas, break rooms, restrooms, elevator shafts, mechanical equipment areas, and storage rooms. Gross Floor Area should not include interstitial plenum space between floors, which may house pipes and ventilation. Gross Floor Area is not the same as rentable, but rather includes all area inside the building(s). Leasable space would be a sub-set of Gross Floor Area. In the case where there is an atrium, you should count the Gross Floor Area at the base level only. Do not increase the size to accommodate open atrium space at higher levels. The Gross Floor Area should not include any exterior spaces such as balconies or exterior loading docks and driveways.

2) **Weekly Operating Hours:** 168

☐ Yes ☐ No

Is this the total number of hours per week that the property is occupied by the majority of the employees? It does not include hours when the HVAC system is starting up or shutting down, or when property is occupied only by maintenance, security, cleaning staff, or other support personnel. For properties with a schedule that varies during the year, use the schedule most often followed.

3) **Number of Workers on Main Shift:** 153

☐ Yes ☐ No

Is this the total number of workers present during the primary shift? This is not a total count of workers, but rather a count of workers who are present at the same time. For example, if there are two daily eight hour shifts of 100 workers each, the Number of Workers on Main Shift value is 100. Number of Workers on Main Shift may include employees of the property, sub-contractors who are onsite regularly, and volunteers who perform regular onsite tasks. Number of Workers should not include visitors to the buildings such as clients, customers, or patients.

4) **Number of Computers:** Not entered

☐ Yes ☐ No

Is this the total number of computers, laptops, and data servers at the property? This number should not include tablet computers, such as iPads, or any other types of office equipment.

Notes:

3. Review of Energy Consumption

Data Overview

Site Energy Use Summary

Propane (kBtu)	1,180,130 (4%)
Electric - Grid (kBtu)	15,814,036.9 (51%)
Fuel Oil (No. 2) (kBtu)	14,214,000.4 (46%)
Total Energy (kBtu)	31,208,167.3

National Median Comparison

National Median Site EUI (kBtu/ft²)	81.6
National Median Source EUI (kBtu/ft²)	156.4
% Diff from National Median Source EUI	38.1%

Energy Intensity

Site (kBtu/ft²) 112.7
 Source (kBtu/ft²) 216

Emissions (based on site energy use)

Greenhouse Gas Emissions (Metric Tons CO₂e) 1,752.8

Power Generation Plant or Distribution Utility:

Central Hudson Gas & Elec Corp

Note: All values are annualized to a 12-month period. Source Energy includes energy used in generation and transmission to enable an equitable assessment.

Summary of All Associated Energy Meters

The following meters are associated with the property, meaning that they are added together to get the total energy use for the property. Please see additional tables in this checklist for the exact meter consumption values. **Note: please review all meter entries, making note of any unusual entries, and, if they are correct, provide a manual note to explain.**

Meter Name	Fuel Type	Start Date	End Date	Associated With:
3121237500_Elec_Sup	Electric - Grid	09/16/2009	In Use	Ulster County Law Enforcement Center
334821C-2_Propane_f	Propane	01/01/2018	12/31/2018	Ulster County Law Enforcement Center
344008B-1_Propane_f	Propane	01/01/2018	In Use	Ulster County Law Enforcement Center
704321-1_Fuel Oil_Bottini_CLOSED	Fuel Oil (No. 2)	01/01/2012	12/31/2018	Ulster County Law Enforcement Center
3121237500_Elec_Del	Electric - Grid	09/15/2009	In Use	Ulster County Law Enforcement Center
334821C-1_Fuel Oil_Paraco	Fuel Oil (No. 2)	01/01/2018	In Use	Ulster County Law Enforcement Center

Total Energy Use

☐ Yes ☐ No

Do the meters shown above account for the total energy use of this property during the reporting period of this application?

Additional Fuels

☐ Yes ☐ No

Do the meters above include all fuel types at the property? That is, no additional fuels such as district steam, generator fuel oil have been excluded.

On-Site Solar and Wind Energy

☐ Yes ☐ No

Are all on-site solar and wind installations reported in this list (if present)? All on-site systems must be reported.

Notes:

Summary of Additional Meters

None of the following meters are associated with the property meaning that they are not added together to account for the total energy use of the property.

Meter Name	Fuel Type	Start Date	End Date	Associated With:
EVSE_02	Electric - Grid	09/01/2015	In Use	None

Sub (or Ancillary) Meter Energy Use

☐ Yes ☐ No

Are the meters in this list all sub-meters or other ancillary meters that do not need to be added to the total energy for the reporting period of this application?

Notes:

Electric - Grid Meter: 3121237500_Elec_Supply (kWh (thousand Watt-hours))

Associated With: Ulster County Law Enforcement Center

Start Date	End Date	Usage	Green Power?
01/01/2018	01/31/2018	0	No
02/01/2018	02/28/2018	0	No
03/01/2018	03/31/2018	0	No
04/01/2018	04/30/2018	0	No
05/01/2018	05/31/2018	0	No
06/01/2018	06/30/2018	0	No
07/01/2018	07/31/2018	0	No
08/01/2018	08/31/2018	0	No
09/01/2018	09/30/2018	0	No
10/01/2018	10/31/2018	0	No

Start Date	End Date	Usage	Green Power?
11/01/2018	11/30/2018	0	No
12/01/2018	12/31/2018	0	No
Total Consumption (kWh (thousand Watt-hours)):			0
Total Consumption (kBtu (thousand Btu)):			0

Total Energy Consumption for this Meter ☐ Yes ☐ No

Do the fuel consumption totals shown above include consumption of all energy tracked through this meter that affect energy calculations for the reporting period of this application (i.e., do the entries match the utility bills received by the property)?

Notes:

Propane Meter: 334821C-2_Propane_Paraco_CLOSED (Gallons)

Associated With: Ulster County Law Enforcement Center

Delivery Date	Quantity
01/17/2018	2,773
10/01/2018	0 ← estimate
11/01/2018	0 ← estimate
Total Consumption (Gallons):	
2,773	
Total Consumption (kBtu (thousand Btu)):	
255,116	

Total Energy Consumption for this Meter ☐ Yes ☐ No

Do the fuel consumption totals shown above include consumption of all energy tracked through this meter that affect energy calculations for the reporting period of this application (i.e., do the entries match the utility bills received by the property)?

Notes:

Propane Meter: 344008B-1_Propane_Paraco (Gallons)

Associated With: Ulster County Law Enforcement Center

Delivery Date	Quantity
05/02/2018	2,885
05/05/2018	2,600
05/10/2018	2,000
12/11/2018	2,569.5
Total Consumption (Gallons):	10,054.5
Total Consumption (kBtu (thousand Btu)):	925,014

Total Energy Consumption for this Meter ☐ Yes ☐ No

Do the fuel consumption totals shown above include consumption of all energy tracked through this meter that affect energy calculations for the reporting period of this application (i.e., do the entries match the utility bills received by the property)?

Notes:

Fuel Oil (No. 2) Meter: 704321-1_Fuel Oil_Bottini_CLOSED (Gallons)

Associated With: Ulster County Law Enforcement Center

Delivery Date	Quantity
10/31/2018	10,000
11/26/2018	10,000
Total Consumption (Gallons):	20,000
Total Consumption (kBtu (thousand Btu)):	2,760,000

Total Energy Consumption for this Meter ☐ Yes ☐ No

Do the fuel consumption totals shown above include consumption of all energy tracked through this meter that affect energy calculations for the reporting period of this application (i.e., do the entries match the utility bills received by the property)?

Notes:

Electric - Grid Meter: 3121237500_Elec_Delivery (kWh (thousand Watt-hours))

Associated With: Ulster County Law Enforcement Center

Start Date	End Date	Usage	Green Power?
01/01/2018	01/31/2018	377,646	No
02/01/2018	02/28/2018	331,114	No
03/01/2018	03/31/2018	353,870	No
04/01/2018	04/30/2018	334,762	No
05/01/2018	05/31/2018	426,191	No
06/01/2018	06/30/2018	442,673	No
07/01/2018	07/31/2018	507,927	No
08/01/2018	08/31/2018	514,080	No
09/01/2018	09/30/2018	411,102	No
10/01/2018	10/31/2018	312,505	No
11/01/2018	11/30/2018	308,739	No
12/01/2018	12/31/2018	314,220	No
		Total Consumption (kWh (thousand Watt-hours)):	4,634,829
		Total Consumption (kBtu (thousand Btu)):	15,814,036.5

Total Energy Consumption for this Meter

☐ **Yes** ☐ **No**

Do the fuel consumption totals shown above include consumption of all energy tracked through this meter that affect energy calculations for the reporting period of this application (i.e., do the entries match the utility bills received by the property)?

Notes:

Fuel Oil (No. 2) Meter: 334821C-1_Fuel Oil_Paraco (Gallons)

Associated With: Ulster County Law Enforcement Center

Delivery Date	Quantity
01/08/2018	10,000
01/18/2018	10,000
02/08/2018	10,000
03/05/2018	10,000
03/23/2018	7,500
04/06/2018	7,500
05/02/2018	10,000
12/13/2018	9,000
12/31/2018	9,000
Total Consumption (Gallons):	83,000
Total Consumption (kBtu (thousand Btu)):	11,454,000

Total Energy Consumption for this Meter

☐ Yes ☐ No

Do the fuel consumption totals shown above include consumption of all energy tracked through this meter that affect energy calculations for the reporting period of this application (i.e., do the entries match the utility bills received by the property)?

Notes:

4. Signature & Stamp of Verifying Licensed Professional

_____ (Name) visited this site on _____ (Date). Based on the conditions observed at the time of the visit to this property, I verify that the information contained within this application is accurate and in accordance with the Licensed Professional Guide.

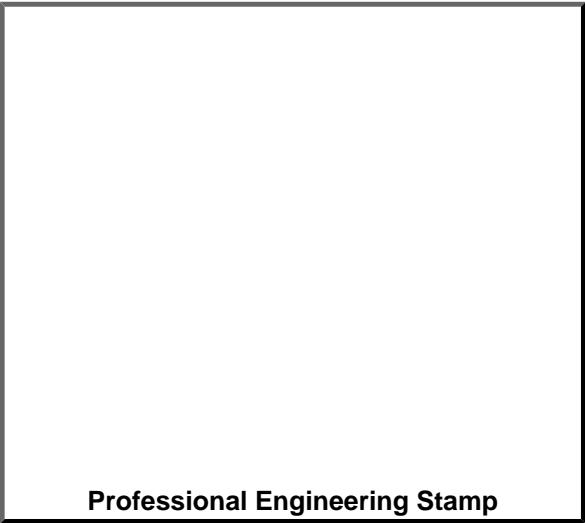
Signature _____

Date _____

Licensed Professional

,
(____)____-_____

NOTE: When applying for the ENERGY STAR, the signature of the Verifying Professional must match the stamp.



(if applicable)

Appendix B – ECM Calculation Data

UCLEC PFS 1: SOLAR DHW SCREEN

Background Info

F:\Mike Stiles\Ulster Co Law Enforcement Center (UCLEC)\UCLEC

UCLEC Summary

System includes (14) electric water heaters
PVI Industries QuickDraw® Water
(4) Model 4800 P A-IW in mechanical room (2,321,000 Btu/hr input)
(10) Model 1000 P A-IW distributed throughout building (358,000 Btu/hr input)

Note: The Calculator returns savings in kWh, adaptation to UCLEC fuels follows

Third-Party Screening Tool

https://apps1.eere.energy.gov/femp/solar_hotwater_system/

ENERGY.GOV

Office of
ENERGY EFFICIENCY &
RENEWABLE ENERGY

Federal Energy Management Program

EERE » Federal Energy Management Program

Solar Hot Water System Calculator

Use the FEMP solar hot water calculator to estimate what size of solar system will work best for your Federal facility and how much it will cost.

The Energy Independence and Security Act (EISA) of 2007 Section 523 requires new Federal buildings and major renovations to meet 30% of hot water demand using solar hot water equipment if it is life-cycle cost effective. This tool can help meet that goal.

Follow the steps below to calculate approximate solar hot water system size and cost needed to meet the Energy Independence and Security Act (EISA) of 2007 Section 523 solar hot water requirement for new Federal construction and major renovations.

Step 1. Enter project and location information.

Project Name

UCLEC

Select the nearest city/state

NY, ALBANY

ZIP Code

12401

Continue

Step 2. Calculate Hot Water Load and System Size

Select the appropriate building type from the drop-down menu. Tips on average Federal facility hot water load will be displayed to help complete the remaining fields. Then, enter the desired cold and hot water temperatures. Common temperatures are pre-entered for convenience, but can be changed to match your conditions.

Building Type

Barracks

Amount of Water Usage (M) - gallons / person / day / person

10

Number of person(s)

500

Cold Water Temperature (°F)(T_{cold})

50

Hot Water Temperature (°F)(T_{hot})

130

Calculate Load

Water Usage Estimates

Office: 1 gal/day/person
School: 2 gal/day/person
Barracks: 10 gal/day/person
Dormitory: 13 gal/day/person
Residence: 30 gal/day/person
Food Service: 2 gal/meal
Motel: 15 gal/day/room
Hospital: 18 gal/day/bed

Total Calculated Load:

981.58 kWh/day for 500 persons using 10 gallons/day/person

Estimated System Size: 419.93 m²

UCLEC PFS 1: SOLAR DHW SCREEN

Background Info

F:\Mike Stiles\Ulster Co Law Enforcement Center (UCLEC)\UCLEC

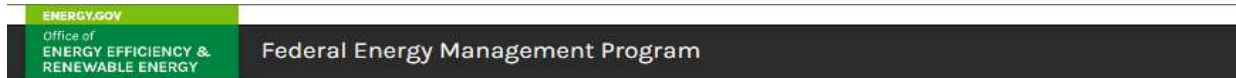
UCLEC Summary

System includes (14) electric water heaters
 PVI Industries QuickDraw® Water
 (4) Model 4800 P A-IW in mechanical room (2,321,000 Btu/hr input)
 (10) Model 1000 P A-IW distributed throughout building (358,000 Btu/hr input)

Note: The Calculator returns savings in kWh, adaptation to UCLEC fuels follows

Third-Party Screening Tool

https://apps1.eere.energy.gov/femp/solar_hotwater_system/



EERE » Federal Energy Management Program

Solar Hot Water System Calculator

Use the FEMP solar hot water calculator to estimate what size of solar system will work best for your Federal facility and how much it will cost.

The Energy Independence and Security Act (EISA) of 2007 Section 523 requires new Federal buildings and major renovations to meet 30% of hot water demand using solar hot water equipment if it is life-cycle cost effective. This tool can help meet that goal.

Follow the steps below to calculate approximate solar hot water system size and cost needed to meet the Energy Independence and Security Act (EISA) of 2007 Section 523 solar hot water requirement for new Federal construction and major renovations.

Step 1. Enter project and location information.

Project Name

Select the nearest city/state

ZIP Code

Step 2. Calculate Hot Water Load and System Size

Select the appropriate building type from the drop-down menu. Tips on average Federal facility hot water load will be displayed to help complete the remaining fields. Then, enter the desired cold and hot water temperatures. Common temperatures are pre-entered for convenience, but can be changed to match your conditions.

<p>Building Type <input type="text" value="Barracks"/></p> <p>Amount of Water Usage (M) - gallons / person / day / person <input type="text" value="10"/></p> <p>Number of person(s) <input type="text" value="500"/></p> <p>Cold Water Temperature (°F)(T_{cold}) <input type="text" value="50"/></p> <p>Hot Water Temperature (°F)(T_{hot}) <input type="text" value="130"/></p> <p><input type="button" value="Calculate Load"/></p>	<p>Water Usage Estimates Office: 1 gal/day/person School: 2 gal/day/person Barracks: 10 gal/day/person Dormitory: 13 gal/day/person Residence: 30 gal/day/person Food Service: 2 gal/meal Motel: 15 gal/day/room Hospital: 18 gal/day/bed</p> <p>Total Calculated Load: 981.58 kWh/day for 500 persons using 10 gallons/day/person</p> <p>Estimated System Size: 419.93 m²</p>
---	---

UCLEC PFS 1: SOLAR DHW SCREEN

Step 3. Estimate System Cost and Annual Savings

Annual energy and cost savings are calculated based on the current hot water heater fuel type, fuel price, and water heater efficiency level. Select the appropriate fuel type from the drop-down menu. The average efficiency level and fuel cost is provided, but can be changed to match your conditions.

Water Heater Type

ELECTRIC: 0.77 - 0.97, assume 0.88

Efficiency

0.88

Energy Cost / kWh

0.121

Calculate Energy Savings

Final Report

Based on the data provided, the results for your facility includes the following. Note that these outputs do not include available incentives or rebates.

SITE INFORMATION

Project Name	UCLEC
Nearest City	NY, ALBANY
ZIP Code	12401

INPUT VALUES

Building Type	
Amount of Water Usage	5,000 gal/day
Number of person(s)	500
Cold Water Temperature	50 (°F)(T_{cold})
Hot Water Temperature	130 (°F)(T_{hot})
Water Heater Fuel Type	electric
Water Heater Efficiency	0.88
Average Fuel Price	\$0.121/kWh

CALCULATIONS

System Size	419.93 m ²
System Cost	\$406,817.29
Annual Energy Savings	318,302.60 kWh/year
Annual Cost Savings	\$38,514.61 based on \$0.121/\$kWh
SIR	2.27
Simple Payback	10.56 years
Solar Fraction	78.00%
Annual Greenhouse Gas Reduction	720.798 lbs. of CO ₂

UCLEC PFS 1: SOLAR DHW SCREEN

Savings Summary

Calculator savings: 318,303 kWh
Conversion factor: 3,413 Btu/kWh
0.003413 mmBtu/kWh

Solar mmBtu savings = 1,086

Existing # 2 fuel oil savings:

\$15.566 \$/mmBtu #2 fuel oil
Cost savings = \$16,910 #2 oil

0.1396 mmBtu/gal #2 fuel oil
7,782 gallons #2 fuel oil saved

Natural gas (fuel switch) savings:

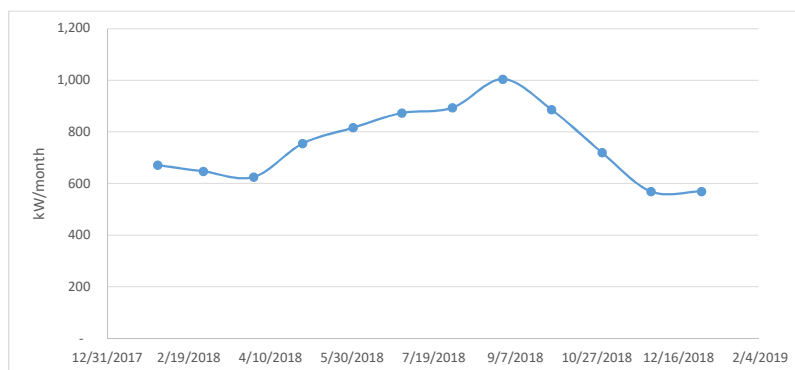
\$8.612 \$/mmBtu natural gas (proposed)
Cost savings = \$9,356 nat gas

UCLEC PFS 2: THERMAL STORAGE SCREENING ANALYSIS

Cooling Demand Estimated from Utility Data

Starting Data (from utility data summary):

End Date	kW	kW \$	\$/kW	
1/31/2018	672	\$6,084	\$9.06	
2/28/2018	648	\$5,871	\$9.06	
3/31/2018	626	\$5,671	\$9.06	
4/30/2018	756	\$6,845	\$9.06	
5/31/2018	817	\$7,401	\$9.06	apparent
6/30/2018	874	\$7,917	\$9.06	cooling
7/31/2018	894	\$9,194	\$10.28	season
8/31/2018	1,005	\$10,332	\$10.28	billing
9/30/2018	887	\$9,113	\$10.28	period
10/31/2018	720	\$7,404	\$10.28	
11/30/2018	570	\$5,857	\$10.28	
12/31/2018	570	\$5,860	\$10.28	



Avg kW for non-cooling season billing period = 617

End Date	kW	kW - avg kW for non clg season	
4/30/2018	756	138	
5/31/2018	817	200	
6/30/2018	874	257	
7/31/2018	894	277	
8/31/2018	1,005	388	
9/30/2018	887	269	
10/31/2018	720	103	

...do not take avg, use monthly profiles

Assumptions and Savings Estimates

Define the cooling kW as (monthly cooling season kW - avg kW for non clg season) per above

Estimated % reduction of chiller operation at peak due to thermal storage = 50%

http://illinoisashrae.org/images/meeting/032514/YEA_Conf_Presentations_2014/energy_storage.pdf

Savings calculations:

End Date	Cooling kW	50% cooling kW savings	50% cooling kW savings x \$/kW
4/30/2018	138	69.24	\$627
5/31/2018	200	99.94	\$905
6/30/2018	257	128.39	\$1,163
7/31/2018	277	138.69	\$1,426
8/31/2018	388	194.04	\$1,995
9/30/2018	269	134.74	\$1,385
10/31/2018	103	51.59	\$530
Totals:		816.63	\$8,032

Estimated annual cost savings
due to thermal storage

Estimated minimum cost of ice storage (300 ton chiller) = \$300,000

http://illinoisashrae.org/images/meeting/032514/YEA_Conf_Presentations_2014/energy_storage.pdf

+ cursory Google search

Simple payback = 37.4 years

UCLEC Boiler Replacement	
Ulster County Law Enforcement Center	380 Boulevard Kingston, NY 12402
ECM 1 - Install Condensing HHW Natural Gas Boiler	
Existing Boiler Input Capacity (MBH ea.):	
	12,263
Proposed Condensing Boiler Input Capacity (MBH ea.):	
	12,263
Bin Temp at Which 100% Load Occurs (deg F)	
	2.5
Bin Temp for Balance Point	
	57.5
Boiler Availability:	
	Heating season
Btus per Therm Conversion Factor, Natural Gas:	
	100,000
Therms per Gallon #2 Fuel Oil	
	1.396
Existing Boiler Efficiency (assumed system)	
	78%
Proposed Condensing Boiler Efficiency (condensing above 20°F OSA)	
	94%
Proposed Condensing Boiler Efficiency (non-condensing below 20°F OSA)	
	85%
\$/therm #2 fuel oil	
	\$ 1.56
\$/therm natural gas (proposed) - assumed 30% interrupted	
	\$ 0.57
#2 Fuel Oil Savings (mmBtu)	
	6,791
Natural Gas Savings (proposed usage, mmBtu)	
	(6,047)
Net mmBtu Savings	
	743
#2 Fuel Oil Cost Savings	
	\$ 105,700
Natural Gas Cost (proposed)	
	\$ (34,443)
Net Total Cost Savings (\$)	
	\$ 71,256

Notes: For this example, DHW load is removed, condensing boiler assumed 100% of existing boiler capacity; 30% interrupted and switch to existing oil boiler. Actual capacities to be determined at design.

Determine Existing Boiler Heating Usage:

Usage was analyzed using utility billing data from 1/9/2018 to 12/14/2018

Assumptions and Approach:

1. The model of heating energy usage is based on fuel oil delivery records and boiler room logs.
2. Usage is modeled by a regression analysis; its parameters are functions of heating degree days (HDD).
3. TMY3 data is from Poughkeepsie Dutchess Co AP; date, time, and outdoor air dry bulb temperature

See: Building Load Determination section of report for more details on regression analysis

4. Excerpts below are from 8760 model

TMY3 Data Excerpt:

Date	Time	Dry-bulb (F)	HDhr @57°F base
1/1/2005	1:00	35.6	21.4
1/1/2005	2:00	33.8	23.2
1/1/2005	3:00	37.4	19.6
1/1/2005	4:00	39.2	17.8
1/1/2005	5:00	33.8	23.2
1/1/2005	6:00	46.4	10.6
1/1/2005	7:00	35.6	21.4
1/1/2005	8:00	44.6	12.4
1/1/2005	9:00	44.6	12.4
1/1/2005	10:00	51.8	5.2
1/1/2005	11:00	53.6	3.4
1/1/2005	12:00	55.4	1.6
1/1/2005	13:00	53.6	3.4
1/1/2005	14:00	51.8	5.2
1/1/2005	15:00	50	7.0
...

ECM 1 - Install Condensing HHW Natural Gas Boiler

Regression analysis results:

therms/day = 23.4488 therms/HDD57 + 152.2483 therms/day

*Note: Only the slope is used for the HHW boiler analysis; the intercept is for ECM 2 DHW***Determine Existing Building Load:**

Billing date range and Assumptions and Approach following approach above.

Load Therms = Regression therms * Existing efficiency

Regression analysis results:

therms/day = 18.2900 therms/HDD57

Therms Usage by Regression -- Building Load Excerpt:

Date	Time	Therms
1/1/2005	1:00	16.3
1/1/2005	2:00	17.7
1/1/2005	3:00	14.9
1/1/2005	4:00	13.6
1/1/2005	5:00	17.7
1/1/2005	6:00	8.1
1/1/2005	7:00	16.3
1/1/2005	8:00	9.4
1/1/2005	9:00	9.4
1/1/2005	10:00	4.0
1/1/2005	11:00	2.6
1/1/2005	12:00	1.2
1/1/2005	13:00	2.6
1/1/2005	14:00	4.0
...

Building Load

Total Sum - Therms Monthly:	
Jan	18,505
Feb	14,535
Mar	8,717
Apr	4,582
May	1,608
Jun	338
Jul	41
Aug	252
Sep	796
Oct	5,370
Nov	6,688
Dec	14,234
Total	75,667

In a year of typical weather, existing system building load was estimated to be
75,667 therms

Apply 8760 hour model to existing system usage in a year of typical weather:

Hourly usage = hourly load / existing efficiency (78%)

Therms Usage by Regression -- Existing Excerpt:

Date	Time	Therms
1/1/2005	1:00	20.9
1/1/2005	2:00	22.7
1/1/2005	3:00	19.1
1/1/2005	4:00	17.4
1/1/2005	5:00	22.7
1/1/2005	6:00	10.4
1/1/2005	7:00	20.9
1/1/2005	8:00	12.1
1/1/2005	9:00	12.1
1/1/2005	10:00	5.1
1/1/2005	11:00	3.3
1/1/2005	12:00	1.6
1/1/2005	13:00	3.3
1/1/2005	14:00	5.1
1/1/2005	15:00	6.8
...

Existing NG Usage

Total Sum - Therms Monthly:	
Jan	23,724
Feb	18,635
Mar	11,175
Apr	5,874
May	2,062
Jun	434
Jul	52
Aug	323
Sep	1,021
Oct	6,884
Nov	8,575
Dec	18,249
Total	97,008

In a year of typical weather, existing system usage was estimated to be
97,008 therms

ECM 1 - Install Condensing HHW Natural Gas Boiler**Calculate Condensing Natural Gas Boiler Usage:**

Hourly usage = hourly load / condensing boiler efficiency where:

Condensing Boiler Efficiency Parameters

Outdoor air temperature (OAT, deg F) selections:

OAT for maximum condensing efficiency =

57 F

OAT below which condensing stops =

20 F

Gas is assumed to be interrupted 30% of the time (switch to 78% eff oil boiler).

OAT	effic		
20	85%	m=	0.00243
58	94%	b=	0.80135

Therms Usage -- Proposed Excerpt:

Date	Time	Condensing Boiler:		Oil Fired Boiler:	
		Efficiency	Total Therms	Efficiency	Total Therms
1/1/2005	1:00				
1/1/2005	2:00	89%	12.9	78%	6.3
1/1/2005	3:00	88%	14.0	78%	6.8
1/1/2005	4:00	89%	11.7	78%	5.7
1/1/2005	5:00	90%	10.6	78%	5.2
1/1/2005	6:00	88%	14.0	78%	6.8
1/1/2005	7:00	91%	6.2	78%	3.1
1/1/2005	8:00	89%	12.9	78%	6.3
1/1/2005	9:00	91%	7.3	78%	3.6
1/1/2005	10:00	91%	7.3	78%	3.6
1/1/2005	11:00	93%	3.0	78%	1.5
1/1/2005	12:00	93%	1.9	78%	1.0
1/1/2005	13:00	94%	0.9	78%	0.5
1/1/2005	14:00	93%	1.9	78%	1.0
1/1/2005	15:00	93%	3.0	78%	1.5
...

Proposed Boiler Usage

Total Sum - Therms Monthly:		
	NG Condensing	Oil Fired
Jan	15,032	7,117
Feb	11,777	5,590
Mar	6,884	3,353
Apr	3,568	1,762
May	1,231	619
Jun	256	130
Jul	31	16
Aug	191	97
Sep	607	306
Oct	4,190	2,065
Nov	5,264	2,572
Dec	11,443	5,475
Totals	60,471	29,103

Savings Summary

System	Usage	Costs	Fuel Switch:
	(Therms)		
Existing	97,008	\$ 151,000	#2 fuel oil
Proposed:	60,471	\$ 34,443	natural gas
	29,103	\$ 45,300	#2 fuel oil
Savings	7,435	\$ 71,256	

NIST BLCC 5.3-18: Comparative Analysis

Consistent with Federal Life Cycle Cost Methodology and Procedures, 10 CFR, Part 436, Subpart A FlexTech Study

Base Case: Existing Fuel Oil Boiler

Alternative: ECM 1 - Install Condensing HHW Natural Gas Boiler

General Information

File Name:	C:\Users\Bkelly\Documents\Projectfiles\Projects\FlexTech\L&SReports\Ulster County\UCLEC\Utility Bills\BLCC5\BLCC5 - UCLEC v.2.xml
Date of Study:	Tue Sep 17 08:54:24 EDT 2019
Project Name:	Ulster County Law Enforcement Center
Project Location:	New York
Analysis Type:	FEMP Analysis, Energy Project
Analyst:	Brendan Kelly
Base Date:	April 1, 2019
Service Date:	April 1, 2020
Study Period:	30 years 0 months (April 1, 2019 through March 31, 2049)
Discount Rate:	3%
Discounting Convention:	End-of-Year

Comparison of Present-Value Costs

PV Life-Cycle Cost

	Base Case	Alternative	Savings from Alternative
Initial Investment Costs:			
Capital Requirements as of Base Date	\$0	\$439,100	-\$439,100
Future Costs:			
Energy Consumption Costs	\$3,989,428	\$1,956,559	\$2,032,869
Energy Demand Charges	\$0	\$0	\$0
Energy Utility Rebates	\$0	\$0	\$0
Water Costs	\$0	\$0	\$0
Recurring and Non-Recurring OM&R Costs	\$0	\$0	\$0
Capital Replacements	\$0	\$0	\$0
Residual Value at End of Study Period	\$0	\$0	\$0
Subtotal (for Future Cost Items)	\$3,989,428	\$1,956,559	\$2,032,869
Total PV Life-Cycle Cost	\$3,989,428	\$2,395,659	\$1,593,769

Net Savings from Alternative Compared with Base Case

PV of Non-Investment Savings	\$2,032,869	Page 50	L&S Energy Services Inc.
- Increased Total Investment	\$439,100		

Savings-to-Investment Ratio (SIR)

SIR = 4.63

Adjusted Internal Rate of Return

AIRR = 8.40%

Payback Period

Estimated Years to Payback (from beginning of Service Period)

Simple Payback occurs in year 5

Discounted Payback occurs in year 6

Energy Savings Summary
Energy Savings Summary (in stated units)

Energy	-----Average	Annual	Consumption-----	Life-Cycle
Type	Base Case	Alternative	Savings	Savings
Distillate Fuel Oil (#1, #2)	9,701.0 MBtu	2,910.0 MBtu	6,791.0 MBtu	196,915.8 MBtu
Natural Gas	0.0 MBtu	6,047.0 MBtu	-6,047.0 MBtu	-175,342.3 MBtu

Energy Savings Summary (in MBtu)

Energy	-----Average	Annual	Consumption-----	Life-Cycle
Type	Base Case	Alternative	Savings	Savings
Distillate Fuel Oil (#1, #2)	9,701.0 MBtu	2,910.0 MBtu	6,791.0 MBtu	196,915.8 MBtu
Natural Gas	0.0 MBtu	6,047.0 MBtu	-6,047.0 MBtu	-175,342.3 MBtu

Emissions Reduction Summary

Energy	-----Average	Annual	Emissions-----	Life-Cycle
Type	Base Case	Alternative	Reduction	Reduction
Distillate Fuel Oil (#1, #2)				
CO2	704,053.21 kg	211,194.19 kg	492,859.02 kg	14,291,224.83 kg
SO2	5,036.26 kg	1,510.72 kg	3,525.54 kg	102,228.59 kg
NOx	634.65 kg	190.38 kg	444.28 kg	12,882.46 kg
Natural Gas				
CO2	0.00 kg	319,416.70 kg	-319,416.70 kg	-9,261,991.19 kg
SO2	0.00 kg	2,577.79 kg	-2,577.79 kg	-74,747.19 kg
NOx	0.00 kg	267.99 kg	-267.99 kg	-7,770.75 kg

Total:

CO2	704,053.21 kg	530,610.89 kg	173,442.32 kg	5,029,233.64 kg
SO2	5,036.26 kg	4,088.52 kg	947.75 kg	27,481.40 kg
NOx	634.65 kg	458.36 kg	176.29 kg	5,111.72 kg

UCLEC Boiler Replacement			
Ulster County Law Enforcement Center 380 Boulevard Kingston, NY 12402			
ECM 2 - Install Natural Gas DHW Boilers			
Existing DHW Heaters (Qty):			7
DHW fuel oil use (Intercept from the regression analysis)		therms/day	152.25
% Time Gas Interrupted			30%
Existing Boiler Efficiency (assumed system)			78%
Proposed Boiler Efficiency (assumed system)			94%
Annual Existing DHW Fuel Oil Use:			
152.25 therms/day * 365 days/yr =		5,557 mmBtu	
DHW load = existing consumption * existing efficiency =		4,335 mmBtu	
Proposed DHW energy consumption:			
DHW load / proposed efficiency =		4,895 mmBtu	
Energy Savings:			
existing mmBtu			5,557
proposed mmBtu			4,895
annual mmBtu savings			662
Rates:			
\$15.566 \$/mmBtu #2 fuel oil		existing	
\$5.696 \$/mmBtu nat gas		interruptible gas rate	
Cost Savings:			
Existing annual cost =	5,557 mmBtu *	\$15.566 \$/mmBtu =	\$86,499
Proposed annual cost =	4,895 mmBtu *	\$5.696 \$/mmBtu =	\$27,881
Annual cost savings =			\$58,618

Implementation Cost Notes:

Assumptions

Heat exchangers are redundant, so only one is operating at a time.

Redundant heat exchanger remains on hot water loop for periods when gas is interrupted (customer assumed 30% of time)

Material and labor installation costs:	Qty	\$ Each Instal	Total \$	Reference
Install natural gas high efficiency DHW boilers, 319 MBH each	7	\$34,800	\$243,600	Vendor

Simple payback = 4.2 years

NIST BLCC 5.3-18: Comparative Analysis

Consistent with Federal Life Cycle Cost Methodology and Procedures, 10 CFR, Part 436, Subpart A FlexTech Study

Base Case: Existing Fuel Oil Boiler - DHW Load

Alternative: ECM 2 - Install Natural Gas DHW Boilers

General Information

File Name:	C:\Users\Bkelly\Documents\Projectfiles\Projects\FlexTech\L&SReports\Ulster County\UCLEC\Utility Bills\BLCC5\BLCC5 - UCLEC - ECM-2 v.2.xml
Date of Study:	Tue Sep 17 09:05:55 EDT 2019
Project Name:	Ulster County Law Enforcement Center
Project Location:	New York
Analysis Type:	FEMP Analysis, Energy Project
Analyst:	Brendan Kelly
Base Date:	April 1, 2019
Service Date:	April 1, 2020
Study Period:	30 years 0 months (April 1, 2019 through March 31, 2049)
Discount Rate:	3%
Discounting Convention:	End-of-Year

Comparison of Present-Value Costs

PV Life-Cycle Cost

	Base Case	Alternative	Savings from Alternative
Initial Investment Costs:			
Capital Requirements as of Base Date	\$0	\$243,600	-\$243,600
Future Costs:			
Energy Consumption Costs	\$2,285,295	\$928,040	\$1,357,256
Energy Demand Charges	\$0	\$0	\$0
Energy Utility Rebates	\$0	\$0	\$0
Water Costs	\$0	\$0	\$0
Recurring and Non-Recurring OM&R Costs	\$0	\$0	\$0
Capital Replacements	\$0	\$0	\$0
Residual Value at End of Study Period	\$0	\$0	\$0
Subtotal (for Future Cost Items)	\$2,285,295	\$928,040	\$1,357,256
Total PV Life-Cycle Cost	\$2,285,295	\$1,171,640	\$1,113,656

Net Savings from Alternative Compared with Base Case

PV of Non-Investment Savings	\$1,357,256	Page 53	L&S Energy Services Inc.
- Increased Total Investment	\$243,600		

Savings-to-Investment Ratio (SIR)

SIR = 5.57

Adjusted Internal Rate of Return

AIRR = 9.07%

Payback Period

Estimated Years to Payback (from beginning of Service Period)

Simple Payback occurs in year 4

Discounted Payback occurs in year 5

Energy Savings Summary
Energy Savings Summary (in stated units)

Energy	-----Average	Annual	Consumption-----	Life-Cycle
Type	Base Case	Alternative	Savings	Savings
Distillate Fuel Oil (#1, #2)	5,557.1 MBtu	0.0 MBtu	5,557.1 MBtu	161,136.9 MBtu
Natural Gas	0.0 MBtu	4,895.0 MBtu	-4,895.0 MBtu	-141,938.2 MBtu

Energy Savings Summary (in MBtu)

Energy	-----Average	Annual	Consumption-----	Life-Cycle
Type	Base Case	Alternative	Savings	Savings
Distillate Fuel Oil (#1, #2)	5,557.1 MBtu	0.0 MBtu	5,557.1 MBtu	161,136.9 MBtu
Natural Gas	0.0 MBtu	4,895.0 MBtu	-4,895.0 MBtu	-141,938.2 MBtu

Emissions Reduction Summary

Energy	-----Average	Annual	Emissions-----	Life-Cycle
Type	Base Case	Alternative	Reduction	Reduction
Distillate Fuel Oil (#1, #2)				
CO2	403,308.33 kg	0.00 kg	403,308.33 kg	11,694,561.26 kg
SO2	2,884.96 kg	0.00 kg	2,884.96 kg	83,654.03 kg
NOx	363.55 kg	0.00 kg	363.55 kg	10,541.77 kg
Natural Gas				
CO2	0.00 kg	258,565.36 kg	-258,565.36 kg	-7,497,510.65 kg
SO2	0.00 kg	2,086.70 kg	-2,086.70 kg	-60,507.28 kg
NOx	0.00 kg	216.93 kg	-216.93 kg	-6,290.36 kg

Total:

CO2	403,308.33 kg	258,565.36 kg	144,742.96 kg	4,197,050.61 kg
SO2	2,884.96 kg	2,086.70 kg	798.26 kg	23,146.73 kg
NOx	363.55 kg	216.93 kg	146.62 kg	4,251.41 kg

UCLEC Boiler Replacement	
Ulster County Law Enforcement Center	380 Boulevard Kingston, NY 12402
ECM 3 - Install Biomass Boiler with Condensing HHW Natural Gas Boiler	
Existing Boiler Input Capacity (MBH ea.):	12,263
Proposed Boiler Plant Input Capacity (MBH ea.):	12,263
Bin Temp at Which 100% Load Occurs (deg F)	2.5
Bin Temp for Balance Point	57.5
Boiler Availability:	Heating season
Btus per Therm Conversion Factor, Natural Gas:	100,000
Btus per Ton Pellets Conversion Factor:	16,000,000
Therms per Gallon #2 Fuel Oil	1.396
Existing Boiler Efficiency (assumed system)	78%
Proposed Biomass Boiler Efficiency (product literature)	86%
Proposed Condensing Boiler Efficiency (condensing above 20°F OSA)	94%
Proposed Condensing Boiler Efficiency (non-condensing below 20°F OSA)	85%
\$/therm #2 fuel oil	\$ 1.56
\$/therm biomass (pellets)	\$ 1.88
\$/ton biomass (pellets)	\$ 300
\$/therm natural gas (proposed)	\$ 0.86
#2 Fuel Oil Savings (mmBtu)	9,701
Natural Gas Savings (proposed usage, mmBtu)	(3,456)
Biomass Savings (proposed usage, mmBtu)	(5,279)
Net mmBtu Savings	966
#2 Fuel Oil Cost Savings	\$151,000
Natural Gas Cost	-\$29,759
Biomass Cost	-\$98,982
Net Total Cost Savings (\$)	\$22,258

Notes:

For this example, the proposed boiler plant is assumed 100% of existing boiler capacity. Actual capacities to be determined at design.

Is also assumed that an interruptible natural gas service could not be used with this system.

Determine Existing Boiler Heating Usage:

Usage was analyzed using utility billing data from 1/9/2018 to 12/14/2018

Assumptions and Approach:

1. The model of heating energy usage is based on fuel oil delivery records and boiler room logs.
2. Usage is modeled by a regression analysis; its parameters are functions of heating degree days (HDD).
3. TMY3 data is from Poughkeepsie Dutchess Co AP; date, time, and outdoor air dry bulb temperature

See: Building Load Determination section of report for more details on regression analysis

4. Excerpts below are from 8760 model

TMY3 Data Excerpt:

Date	Time	Dry-bulb (F)	HDhr @57°F base
1/1/2005	1:00	35.6	21.4
1/1/2005	2:00	33.8	23.2
1/1/2005	3:00	37.4	19.6
1/1/2005	4:00	39.2	17.8
1/1/2005	5:00	33.8	23.2
1/1/2005	6:00	46.4	10.6
1/1/2005	7:00	35.6	21.4
1/1/2005	8:00	44.6	12.4
1/1/2005	9:00	44.6	12.4
1/1/2005	10:00	51.8	5.2
1/1/2005	11:00	53.6	3.4
1/1/2005	12:00	55.4	1.6
1/1/2005	13:00	53.6	3.4
1/1/2005	14:00	51.8	5.2
1/1/2005	15:00	50	7.0
...

Regression analysis results:

therms/day = 23.4488 therms/HDD57 + 152.2483 therms/day

Note: Only the slope is used for the HHW boiler analysis; the intercept is for ECM 2 DHW

Determine Existing Building Load:

Billing date range and Assumptions and Approach following approach above.

Load Therms = Existing usage therms * Existing efficiency

Regression analysis results:

therms/day = 18.2900 therms/HDD57

Therms Usage by Regression -- Building Load Excerpt:

Date	Time	Therms
1/1/2005	1:00	16.3
1/1/2005	2:00	17.7
1/1/2005	3:00	14.9
1/1/2005	4:00	13.6
1/1/2005	5:00	17.7
1/1/2005	6:00	8.1
1/1/2005	7:00	16.3
1/1/2005	8:00	9.4
1/1/2005	9:00	9.4
1/1/2005	10:00	4.0
1/1/2005	11:00	2.6
1/1/2005	12:00	1.2
1/1/2005	13:00	2.6
1/1/2005	14:00	4.0
...

Building Load

Total Sum - Therms Monthly:	
Jan	18,505
Feb	14,535
Mar	8,717
Apr	4,582
May	1,608
Jun	338
Jul	41
Aug	252
Sep	796
Oct	5,370
Nov	6,688
Dec	14,234
Total	75,667

In a year of typical weather, existing system building load was estimated to be
75,667 therms

Apply 8760 hour model to existing system usage in a year of typical weather:

Hourly usage = hourly load / existing efficiency (78%)

Therms Usage by Regression -- Existing Excerpt:

Date	Time	Therms
1/1/2005	1:00	20.9
1/1/2005	2:00	22.7
1/1/2005	3:00	19.1
1/1/2005	4:00	17.4
1/1/2005	5:00	22.7
1/1/2005	6:00	10.4
1/1/2005	7:00	20.9
1/1/2005	8:00	12.1
1/1/2005	9:00	12.1
1/1/2005	10:00	5.1
1/1/2005	11:00	3.3
1/1/2005	12:00	1.6
1/1/2005	13:00	3.3
1/1/2005	14:00	5.1
1/1/2005	15:00	6.8
...

Existing NG Usage

Total Sum - Therms Monthly:	
Jan	23,724
Feb	18,635
Mar	11,175
Apr	5,874
May	2,062
Jun	434
Jul	52
Aug	323
Sep	1,021
Oct	6,884
Nov	8,575
Dec	18,249
Total	97,008

In a year of typical weather, existing system usage was estimated to be
97,008 therms

Calculate Biomass Boiler and Condensing Natural Gas Boiler Usage:

Hourly usage = hourly load / proposed equipment efficiency

% Load Sharing:

Biomass	60%
Boiler	40%

Condensing Boiler Efficiency Parameters

Outdoor air temperature (OAT, deg F) selections:

OAT for maximum condensing efficiency =

57

F

OAT below which condensing stops =

20

F

OAT	effic		
20	85%	m=	0.00243
58	94%	b=	0.80135

Therms Usage -- Proposed Excerpt:

Date	Time	Biomass Boiler:		Condensing Boiler:		Total
		Efficiency	Therms	Efficiency	Therms	Therms
1/1/2005	1:00	86%	11.4	89%	7.3	18.7
1/1/2005	2:00	86%	12.3	88%	8.0	20.3
1/1/2005	3:00	86%	10.4	89%	6.7	17.1
1/1/2005	4:00	86%	9.5	90%	6.1	15.5
1/1/2005	5:00	86%	12.3	88%	8.0	20.3
1/1/2005	6:00	86%	5.6	91%	3.5	9.2
1/1/2005	7:00	86%	11.4	89%	7.3	18.7
1/1/2005	8:00	86%	6.6	91%	4.2	10.7
1/1/2005	9:00	86%	6.6	91%	4.2	10.7
1/1/2005	10:00	86%	2.8	93%	1.7	4.5
1/1/2005	11:00	86%	1.8	93%	1.1	2.9
1/1/2005	12:00	86%	0.9	94%	0.5	1.4
1/1/2005	13:00	86%	1.8	93%	1.1	2.9
1/1/2005	14:00	86%	2.8	93%	1.7	4.5
...

Proposed Usage

Total Sum - Therms Monthly:		
	Biomass	Boiler
Jan	12,910	8,590
Feb	10,141	6,730
Mar	6,081	3,933
Apr	3,197	2,039
May	1,122	703
Jun	236	146
Jul	28	17
Aug	176	109
Sep	556	347
Oct	3,746	2,394
Nov	4,666	3,008
Dec	9,931	6,539
Totals	52,791	34,555

Savings Summary

System	Usage		Costs
	Therms	Pellets (Tons)	
Existing:	97,008		\$151,000
Proposed:			
Biomass	52,791	329.94	\$98,982
Cond boiler	34,555		\$29,759
Savings	9,663	(329.94)	\$22,258

Fuel Switches:

#2 fuel oil

pellets

natural gas

NIST BLCC 5.3-18: Comparative Analysis

Consistent with Federal Life Cycle Cost Methodology and Procedures, 10 CFR, Part 436, Subpart A FlexTech Study

Base Case: Existing Fuel Oil Boiler

Alternative: ECM 3 - Install Biomass Boiler with Condensing HHW Natural Gas Boiler

General Information

File Name:	C:\Users\Bkelly\Documents\Projectfiles\Projects\FlexTech\L&SReports\Ulster County\UCLEC\Utility Bills\BLCC5\BLCC5 - UCLEC v.2.xml
Date of Study:	Tue Sep 17 11:23:40 EDT 2019
Project Name:	Ulster County Law Enforcement Center
Project Location:	New York
Analysis Type:	FEMP Analysis, Energy Project
Analyst:	Brendan Kelly
Base Date:	April 1, 2019
Service Date:	April 1, 2020
Study Period:	30 years 0 months (April 1, 2019 through March 31, 2049)
Discount Rate:	3%
Discounting Convention:	End-of-Year

Comparison of Present-Value Costs

PV Life-Cycle Cost

	Base Case	Alternative	Savings from Alternative
Initial Investment Costs:			
Capital Requirements as of Base Date	\$0	\$440,200	-\$440,200
Future Costs:			
Energy Consumption Costs	\$3,989,428	\$2,532,174	\$1,457,254
Energy Demand Charges	\$0	\$0	\$0
Energy Utility Rebates	\$0	\$0	\$0
Water Costs	\$0	\$0	\$0
Recurring and Non-Recurring OM&R Costs	\$0	\$0	\$0
Capital Replacements	\$0	\$0	\$0
Residual Value at End of Study Period	\$0	\$0	\$0
Subtotal (for Future Cost Items)	\$3,989,428	\$2,532,174	\$1,457,254
Total PV Life-Cycle Cost	\$3,989,428	\$2,972,374	\$1,017,054

Net Savings from Alternative Compared with Base Case

PV of Non-Investment Savings	\$1,457,254	Page 58	L&S Energy Services Inc.
- Increased Total Investment	\$440,200		

Savings-to-Investment Ratio (SIR)

SIR = 3.31

Adjusted Internal Rate of Return

AIRR = 7.19%

Payback Period

Estimated Years to Payback (from beginning of Service Period)

Simple Payback occurs in year 8

Discounted Payback occurs in year 9

Energy Savings Summary

Energy Savings Summary (in stated units)

Energy	-----Average	Annual	Consumption-----	Life-Cycle
Type	Base Case	Alternative	Savings	Savings
Distillate Fuel Oil (#1, #2)	9,701.0 MBtu	0.0 MBtu	9,701.0 MBtu	281,295.8 MBtu
Natural Gas	0.0 MBtu	3,456.0 MBtu	-3,456.0 MBtu	-100,212.2 MBtu
Coal	0.0 MBtu	5,279.0 MBtu	-5,279.0 MBtu	-153,072.9 MBtu

Energy Savings Summary (in MBtu)

Energy	-----Average	Annual	Consumption-----	Life-Cycle
Type	Base Case	Alternative	Savings	Savings
Distillate Fuel Oil (#1, #2)	9,701.0 MBtu	0.0 MBtu	9,701.0 MBtu	281,295.8 MBtu
Natural Gas	0.0 MBtu	3,456.0 MBtu	-3,456.0 MBtu	-100,212.2 MBtu
Coal	0.0 MBtu	5,279.0 MBtu	-5,279.0 MBtu	-153,072.9 MBtu

Emissions Reduction Summary

Energy	-----Average	Annual	Emissions-----	Life-Cycle
Type	Base Case	Alternative	Reduction	Reduction
Distillate Fuel Oil (#1, #2)				
CO2	704,053.21 kg	0.00 kg	704,053.21 kg	20,415,133.58 kg
SO2	5,036.26 kg	0.00 kg	5,036.26 kg	146,034.40 kg
NOx	634.65 kg	0.00 kg	634.65 kg	18,402.71 kg
Natural Gas				
CO2	0.00 kg	182,554.01 kg	-182,554.01 kg	-5,293,441.63 kg
SO2	0.00 kg	1,473.27 kg	-1,473.27 kg	-42,719.74 kg
NOx	0.00 kg	153.16 kg	-153.16 kg	-4,441.16 kg
Coal				
GPI				
CO2	0.00 kg	500,394.02 kg	-500,394.02 kg	-14,509,713.94 kg

SO2	0.00 kg	4,289.89 kg	-4,289.89 kg	-124,392.19 kg
Ulster County Law Enforcement Center				
NOx	0.00 kg	1,186.41 kg	-1,186.41 kg	-34,401.77 kg
NYSERDA FlexTech Study				

Total:

CO2	704,053.21 kg	682,948.03 kg	21,105.18 kg	611,978.00 kg
SO2	5,036.26 kg	5,763.16 kg	-726.90 kg	-21,077.54 kg
NOx	634.65 kg	1,339.57 kg	-704.92 kg	-20,440.23 kg

FA-PFS 1 - UCLEC SOLAR DHW SCREEN: REDUCED SOLAR LOAD

Goal: Re-run the analysis assuming the equivalent of only 4 of the 14 water heaters

% of usage = $4/14 = 14\%$

The on-line calculator estimates load based on gallons used/person/day

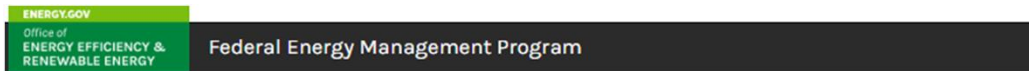
Original usage was 10 gallons/person/day

At 14% usage is equivalently reduced to 1.4 gallons/person/day

...rounded to 3 gallons/day (the calculator only inputs integers) -- 3 gallons crashes the calculator

...apply the reduction to the # of persons: $500 \text{ people} * 14\% = 71.4$

or 71 people



EERE » Federal Energy Management Program

Solar Hot Water System Calculator

Use the FEMP solar hot water calculator to estimate what size of solar system will work best for your Federal facility and how much it will cost.

The Energy Independence and Security Act (EISA) of 2007 Section 523 requires new Federal buildings and major renovations to meet 30% of hot water demand using solar hot water equipment if it is life-cycle cost effective. This tool can help meet that goal.

Follow the steps below to calculate approximate solar hot water system size and cost needed to meet the Energy Independence and Security Act (EISA) of 2007 Section 523 solar hot water requirement for new Federal construction and major renovations.

Step 1. Enter project and location information.

Step 2. Calculate Hot Water Load and System Size

Select the appropriate building type from the drop-down menu. Tips on average Federal facility hot water load will be displayed to help complete the remaining fields. Then, enter the desired cold and hot water temperatures. Common temperatures are pre-entered for convenience, but can be changed to match your conditions.

<p>Building Type</p> <p>Barracks</p> <p>Amount of Water Usage (M) - gallons / person / day / person</p> <p>10</p> <p>Number of person(s)</p> <p>71</p> <p>Cold Water Temperature (°F)(T_{cold})</p> <p>50</p> <p>Hot Water Temperature (°F)(T_{hot})</p> <p>130</p> <p>Calculate Load</p>	<p>Water Usage Estimates</p> <p>Office: 1 gal/day/person</p> <p>School: 2 gal/day/person</p> <p>Barracks: 10 gal/day/person</p> <p>Dormitory: 13 gal/day/person</p> <p>Residence: 30 gal/day/person</p> <p>Food Service: 2 gal/meal</p> <p>Motel: 15 gal/day/room</p> <p>Hospital: 18 gal/day/bed</p> <p>Total Calculated Load:</p> <p>139.38 kWh/day for 71 persons using 10 gallons/day/person</p> <p>Estimated System Size: 59.63 m²</p>
---	---

Step 3. Estimate System Cost and Annual Savings

Annual energy and cost savings are calculated based on the current hot water heater fuel type, fuel price, and water heater efficiency level. Select the appropriate fuel type from the drop-down menu. The average efficiency level and fuel cost is provided, but can be changed to match your conditions.

Water Heater Type

ELECTRIC: 0.77 - 0.97, assume 0.88

Efficiency

1

Energy Cost / kWh

0

Calculate Energy Savings

Final Report

Based on the data provided, the results for your facility includes the following. Note that these outputs do not include available incentives or rebates.

SITE INFORMATION

Project Name UCLEC (2/14 solar DHW load)

Nearest City NY, ALBANY

ZIP Code 12401

INPUT VALUES

Building Type

Amount of Water Usage 710 gal/day

Number of person(s) 71

Cold Water Temperature 50 (°F)(T_{cold})Hot Water Temperature 130 (°F)(T_{hot})

Water Heater Fuel Type electric

Water Heater Efficiency 1

Average Fuel Price \$0/kWh

CALCULATIONS

System Size 59.63 m²

System Cost \$57,768.06

Annual Energy Savings 39,775.09 kWh/year

Savings Summary

Calculator savings: 39,775 kWh

Conversion factor: 3,413 Btu/kWh

0.003413 mmBtu/kWh

Solar mmBtu savings = 136

Gas interrupted 30% of time

2 fuel oil boiler savings:

Efficiency 85.15%

48 mmBtu's

\$15.566 \$/mmBtu #2 fuel oil

Cost savings = \$744 #2 oil

Natural gas (fuel switch) savings:

Efficiency 85.15%

95 mmBtu's

\$5.700 \$/mmBtu natural gas nat gas

Cost savings = \$542

UCLEC Boiler Replacement	
Ulster County Law Enforcement Center	380 Boulevard Kingston, NY 12402
FA ECM 1 - Install Condensing HHW Natural Gas Boiler	
Existing Boiler System Capacity (Plant):	36,789
Proposed Condensing Boiler Input Capacity (MBH ea.):	10,000
Proposed Non-Condensing Boiler Input Capacity (Remaining Plant):	26,789
Bin Temp at Which 100% Load Occurs (deg F)	2.5
Bin Temp for Balance Point	57.5
Boiler Availability:	Year Round
Btus per Therm Conversion Factor, Natural Gas:	100,000
Therms per Gallon #2 Fuel Oil	1.396
Existing Boiler Efficiency (assumed system)	78%
Proposed Condensing Boiler Efficiency (condensing above 50°F OSA)	94%
Proposed Boiler Efficiency (non-condensing below 50°F OSA)	85%
\$/therm #2 fuel oil	\$ 1.56
\$/therm natural gas (proposed) - assumed 30% interrupted	\$ 0.57
#2 Fuel Oil Savings (mmBtu)	9,838
Natural Gas Savings (proposed usage, mmBtu)	(8,411)
Net mmBtu Savings	1,427
#2 Fuel Oil Cost Savings	\$ 153,138
Natural Gas Cost (proposed)	\$ (47,907)
Net Total Cost Savings (\$)	\$ 105,230

Notes: For this example, heating and DHW loads are included and gas is interrupted 30% of the time, as per customer. Actual capacities to be determined at design.

Determine Existing Boiler Heating Usage:

Usage was analyzed using utility billing data from 1/9/2018 to 12/14/2018

Assumptions and Approach:

1. The model of heating energy usage is based on fuel oil delivery records and boiler room logs.
2. Usage is modeled by a regression analysis; its parameters are functions of heating degree days (HDD).
3. TMY3 data is from Poughkeepsie Dutchess Co AP; date, time, and outdoor air dry bulb temperature

See: Building Load Determination section of report for more details on regression analysis

4. Excerpts below are from 8760 model

TMY3 Data Excerpt:

Date	Time	Dry-bulb (F)	HDhr @57°F base
1/1/2005	1:00	35.6	21.4
1/1/2005	2:00	33.8	23.2
1/1/2005	3:00	37.4	19.6
1/1/2005	4:00	39.2	17.8
1/1/2005	5:00	33.8	23.2
1/1/2005	6:00	46.4	10.6
1/1/2005	7:00	35.6	21.4
1/1/2005	8:00	44.6	12.4
1/1/2005	9:00	44.6	12.4
1/1/2005	10:00	51.8	5.2
1/1/2005	11:00	53.6	3.4
1/1/2005	12:00	55.4	1.6
1/1/2005	13:00	53.6	3.4
1/1/2005	14:00	51.8	5.2
1/1/2005	15:00	50	7.0
...

FA ECM 1 - Install Condensing HHW Natural Gas Boiler

Regression analysis results:

therms/day = 23.4488 therms/HDD57 + 152.2483 therms/day

Note: Only the slope is used for the HHW boiler analysis; the intercept is for ECM 2 DHW

Determine Existing Building Load:

Billing date range and Assumptions and Approach following approach above.

Load Therms = Regression therms * Existing efficiency

Regression analysis results:

therms/day = 18.2900 therms/HDD57

Therms Usage by Regression -- Building Load Excerpt:

Date	Time	Therms
1/1/2005	1:00	21.3
1/1/2005	2:00	22.6
1/1/2005	3:00	19.9
1/1/2005	4:00	18.5
1/1/2005	5:00	22.6
1/1/2005	6:00	13.0
1/1/2005	7:00	21.3
1/1/2005	8:00	14.4
1/1/2005	9:00	14.4
1/1/2005	10:00	8.9
1/1/2005	11:00	7.5
1/1/2005	12:00	6.2
1/1/2005	13:00	7.5
1/1/2005	14:00	8.9
...

Building Load

Total Sum - Therms Monthly:	
Jan	22,186
Feb	17,860
Mar	12,398
Apr	8,149
May	5,285
Jun	3,901
Jul	3,722
Aug	3,934
Sep	4,359
Oct	9,051
Nov	10,251
Dec	17,916
Total	119,012

In a year of typical weather, existing system building load was estimated to be
119,012 therms

Apply 8760 hour model to existing system usage in a year of typical weather:

Hourly usage = hourly load / existing efficiency (78%)

Therms Usage by Regression -- Existing Excerpt:

Date	Time	Therms
1/1/2005	1:00	27.3
1/1/2005	2:00	29.0
1/1/2005	3:00	25.5
1/1/2005	4:00	23.7
1/1/2005	5:00	29.0
1/1/2005	6:00	16.7
1/1/2005	7:00	27.3
1/1/2005	8:00	18.5
1/1/2005	9:00	18.5
1/1/2005	10:00	11.4
1/1/2005	11:00	9.7
1/1/2005	12:00	7.9
1/1/2005	13:00	9.7
1/1/2005	14:00	11.4
1/1/2005	15:00	13.2
...

Existing NG Usage

Total Sum - Therms Monthly:	
Jan	28,444
Feb	22,898
Mar	15,895
Apr	10,448
May	6,775
Jun	5,001
Jul	4,772
Aug	5,043
Sep	5,588
Oct	11,604
Nov	13,142
Dec	22,969
Total	152,579

In a year of typical weather, existing system usage was estimated to be
152,579 therms

FA ECM 1 - Install Condensing HHW Natural Gas Boiler**Calculate Condensing Natural Gas Boiler Usage:**

Hourly usage = hourly load / condensing boiler efficiency where:

Condensing Boiler Efficiency Parameters

Outdoor air temperature (OAT, deg F) selections:

OAT for maximum condensing efficiency =

57

F

OAT below which condensing stops =

50

F

Gas is assumed to be interrupted 30% of the time (switch to 85% of oil boiler).

OAT	effic		
50	85%	m=	0.01286
58	94%	b=	0.20714

Therms Usage -- Proposed Excerpt:

Date	Time	NG Condensing Boiler:		Oil Fired Boiler:	
		Efficiency	Total Therms	Efficiency	Total Therms
1/1/2005	1:00				
1/1/2005	2:00	85%	8.2	85%	16.8
1/1/2005	3:00	85%	8.2	85%	18.4
1/1/2005	4:00	85%	8.2	85%	15.2
1/1/2005	5:00	85%	8.2	85%	13.5
1/1/2005	6:00	85%	8.2	85%	18.4
1/1/2005	7:00	85%	8.2	85%	7.1
1/1/2005	8:00	85%	8.2	85%	16.8
1/1/2005	9:00	85%	8.2	85%	8.7
1/1/2005	10:00	85%	8.2	85%	8.7
1/1/2005	11:00	87%	7.1	85%	3.1
1/1/2005	12:00	90%	5.9	85%	2.7
1/1/2005	13:00	92%	4.7	85%	2.2
1/1/2005	14:00	90%	5.9	85%	2.7
1/1/2005	15:00	87%	7.1	85%	3.1
...

Proposed Boiler Usage**Total Sum - Therms Monthly:**

	NG Condensing	Oil Fired
Jan	6,072	20,023
Feb	14,700	6,304
Mar	10,157	4,376
Apr	6,589	2,876
May	4,130	1,865
Jun	2,944	1,377
Jul	2,776	1,314
Aug	2,961	1,388
Sep	3,344	1,538
Oct	7,334	3,194
Nov	8,358	3,618
Dec	14,745	6,323
Totals	84,110	54,197

Savings Summary

System	Usage (Therms)	Costs	Fuel Switch:
Existing	152,579	\$ 237,499	
Proposed:	84,110	\$ 47,907	natural gas
	54,197	\$ 84,361	#2 fuel oil
Savings	14,272	\$ 105,230	

NIST BLCC 5.3-18: Comparative Analysis

Consistent with Federal Life Cycle Cost Methodology and Procedures, 10 CFR, Part 436, Subpart A FlexTech Study

Base Case: FA (3) Existing Fuel Oil Boilers

Alternative: FA ECM 1 - Install Condensing HHW Natural Gas Boiler

General Information

File Name:	C:\Users\Bkelly\Documents\Projectfiles\Projects\FlexTech\L&SReports\Ulster County\UCLEC\Utility Bills\BLCC5\BLCC5 - UCLEC v.2.xml
Date of Study:	Tue Sep 17 11:09:53 EDT 2019
Project Name:	Ulster County Law Enforcement Center
Project Location:	New York
Analysis Type:	FEMP Analysis, Energy Project
Analyst:	Brendan Kelly
Base Date:	April 1, 2019
Service Date:	April 1, 2020
Study Period:	30 years 0 months (April 1, 2019 through March 31, 2049)
Discount Rate:	3%
Discounting Convention:	End-of-Year

Comparison of Present-Value Costs

PV Life-Cycle Cost

	Base Case	Alternative	Savings from Alternative
Initial Investment Costs:			
Capital Requirements as of Base Date	\$0	\$1,010,200	-\$1,010,200
Future Costs:			
Energy Consumption Costs	\$6,274,641	\$3,285,701	\$2,988,940
Energy Demand Charges	\$0	\$0	\$0
Energy Utility Rebates	\$0	\$0	\$0
Water Costs	\$0	\$0	\$0
Recurring and Non-Recurring OM&R Costs	\$0	\$0	\$0
Capital Replacements	\$0	\$0	\$0
Residual Value at End of Study Period	\$0	\$0	\$0
Subtotal (for Future Cost Items)	\$6,274,641	\$3,285,701	\$2,988,940
Total PV Life-Cycle Cost	\$6,274,641	\$4,295,901	\$1,978,740

Net Savings from Alternative Compared with Base Case

PV of Non-Investment Savings	\$2,988,940	Page 66	L&S Energy Services Inc.
- Increased Total Investment	\$1,010,200		

Savings-to-Investment Ratio (SIR)

SIR = 2.96

Adjusted Internal Rate of Return

AIRR = 6.79%

Payback Period

Estimated Years to Payback (from beginning of Service Period)

Simple Payback occurs in year 7

Discounted Payback occurs in year 9

Energy Savings Summary
Energy Savings Summary (in stated units)

Energy	-----Average	Annual	Consumption-----	Life-Cycle
Type	Base Case	Alternative	Savings	Savings
Distillate Fuel Oil (#1, #2)	15,257.9 MBtu	5,419.7 MBtu	9,838.2 MBtu	285,274.1 MBtu
Natural Gas	0.0 MBtu	8,411.0 MBtu	-8,411.0 MBtu	-243,890.2 MBtu

Energy Savings Summary (in MBtu)

Energy	-----Average	Annual	Consumption-----	Life-Cycle
Type	Base Case	Alternative	Savings	Savings
Distillate Fuel Oil (#1, #2)	15,257.9 MBtu	5,419.7 MBtu	9,838.2 MBtu	285,274.1 MBtu
Natural Gas	0.0 MBtu	8,411.0 MBtu	-8,411.0 MBtu	-243,890.2 MBtu

Emissions Reduction Summary

Energy	-----Average	Annual	Emissions-----	Life-Cycle
Type	Base Case	Alternative	Reduction	Reduction
Distillate Fuel Oil (#1, #2)				
CO2	1,107,347.02 kg	393,336.48 kg	714,010.54 kg	20,703,862.20 kg
SO2	7,921.12 kg	2,813.63 kg	5,107.49 kg	148,099.74 kg
NOx	998.19 kg	354.56 kg	643.63 kg	18,662.98 kg
Natural Gas				
CO2	0.00 kg	444,288.72 kg	-444,288.72 kg	-12,882,852.31 kg
SO2	0.00 kg	3,585.55 kg	-3,585.55 kg	-103,968.68 kg
NOx	0.00 kg	372.76 kg	-372.76 kg	-10,808.63 kg
Total:				
CO2	1,107,347.02 kg	837,625.20 kg	269,721.83 kg	7,821,009.88 kg
SO2	7,921.12 kg	6,399.18 kg	1,521.94 kg	44,131.06 kg
NOx	998.19 kg	727.32 kg	270.87 kg	7,854.35 kg

Appendix C – ECM Cost Estimates



Project Name: **Ulster County Law Enforcement Center**

Project No.: _____

Calculated by:	MS
----------------	----

Checked by: _____

Sheet No: 1 of 1

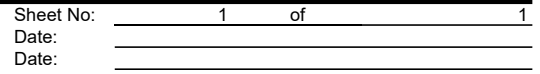
Date: _____

Date: _____

Measure: PFS 1 - Install Solar Thermal DHW

[illegible]

The costs noted above are estimates only and may be modified by changing conditions or the passage of time.



The costs noted above are estimates only and may be modified by changing conditions or the passage of time.



Project Name: **Ulster County Law Enforcement Center**

Project No.: _____

Calculated by:	MS
----------------	----

Checked by: _____

Sheet No: 1 of 1

Date: _____

Date: _____

Measure: ECM 1 - Install a HHW Condensing Boiler

[illegible]

The costs noted above are estimates only and may be modified by changing conditions or the passage of time.



Project Name: **Ulster County Law Enforcement Center**

Project No.: _____

Calculated by:	MS
----------------	----

Checked by: _____

Sheet No: 1 of 1

Date: _____

Date: _____

Measure: ECM 2 - Install Natural Gas DHW Boilers

[illegible]

The costs noted above are estimates only and may be modified by changing conditions or the passage of time.



Project Name: **Ulster County Law Enforcement Center**

Project No.: _____

Calculated by:	MS
----------------	----

Checked by: _____

Sheet No: 1 of 1

Date: _____

Date: _____

Measure: FA PFS 1 - Install Solar Thermal DHW

[illegible]

The costs noted above are estimates only and may be modified by changing conditions or the passage of time.

Project Name: **Ulster County Law Enforcement Center**

Project No.: _____

Sheet No: 1 of 1Calculated by: MS

Date: _____

Checked by: _____

Date: _____

Measure: FA ECM 1 - Install a HHW Condensing Boiler

Div.	Description	Qty.	Unit	Unit Labor	Cost Material	Total Labor	Total Material	Total	Ref.
	Demo of Existing boilers	3	ea	\$6,000		\$18,000		\$18,000	GPI
	Install new 300 HP nat gas condensing boiler	1	ea					\$211,200	GPI
	Install new 300 HP dual fuel non-condensing boilers	2	ea					\$558,000	GPI
	Venting	3	ea		\$1,000		\$3,000	\$3,000	GPI
	including an allowance for demo and new venting.								
	Central Hudson Gas Service	1	ea					\$220,000	Customer
	Total							\$1,010,200	

The costs noted above are estimates only and may be modified by changing conditions or the passage of time.

Appendix D – CHP pre-feasibility Model and NYSERDA/NYPA Geothermal Clean Energy Challenge Results

CHP Pre-Feasibility Model Results

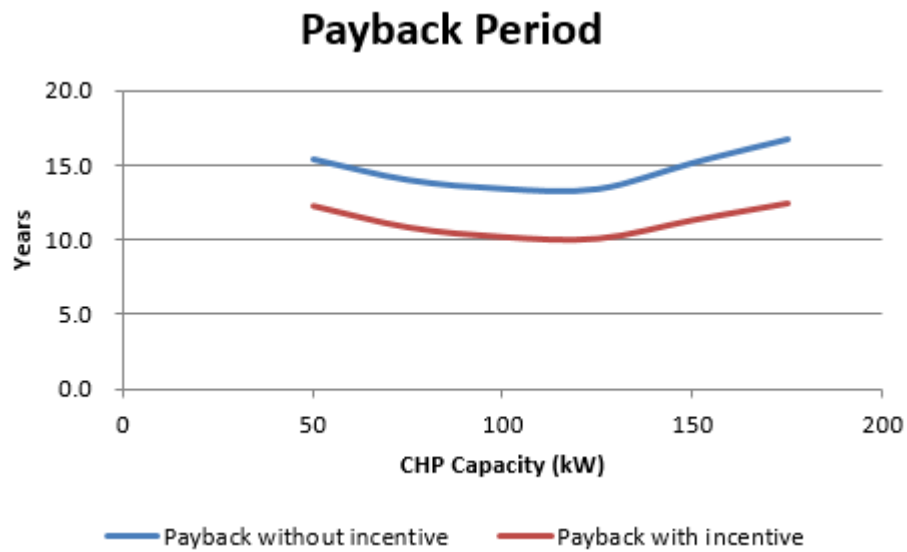
Summary of Savings

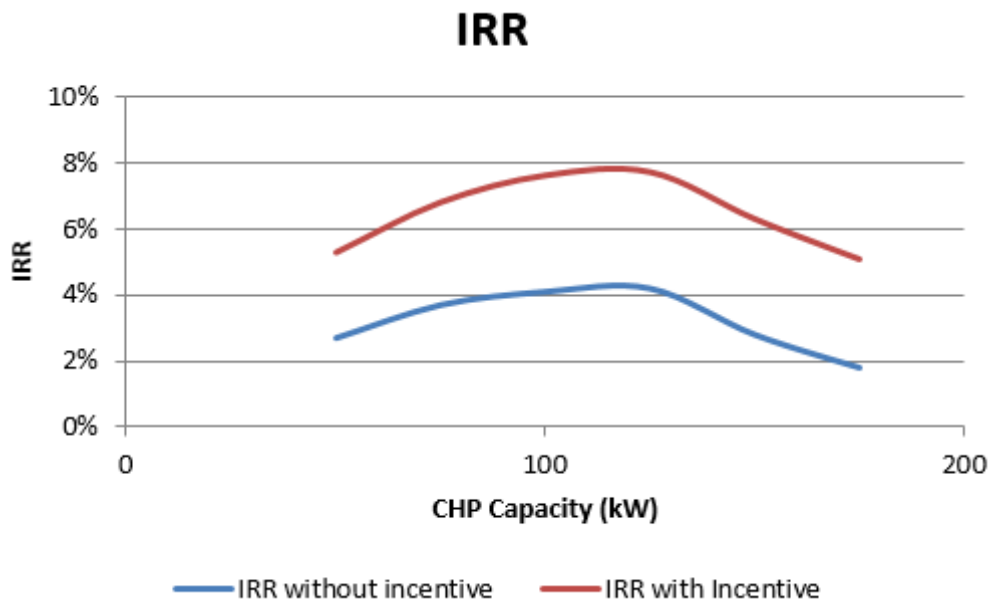
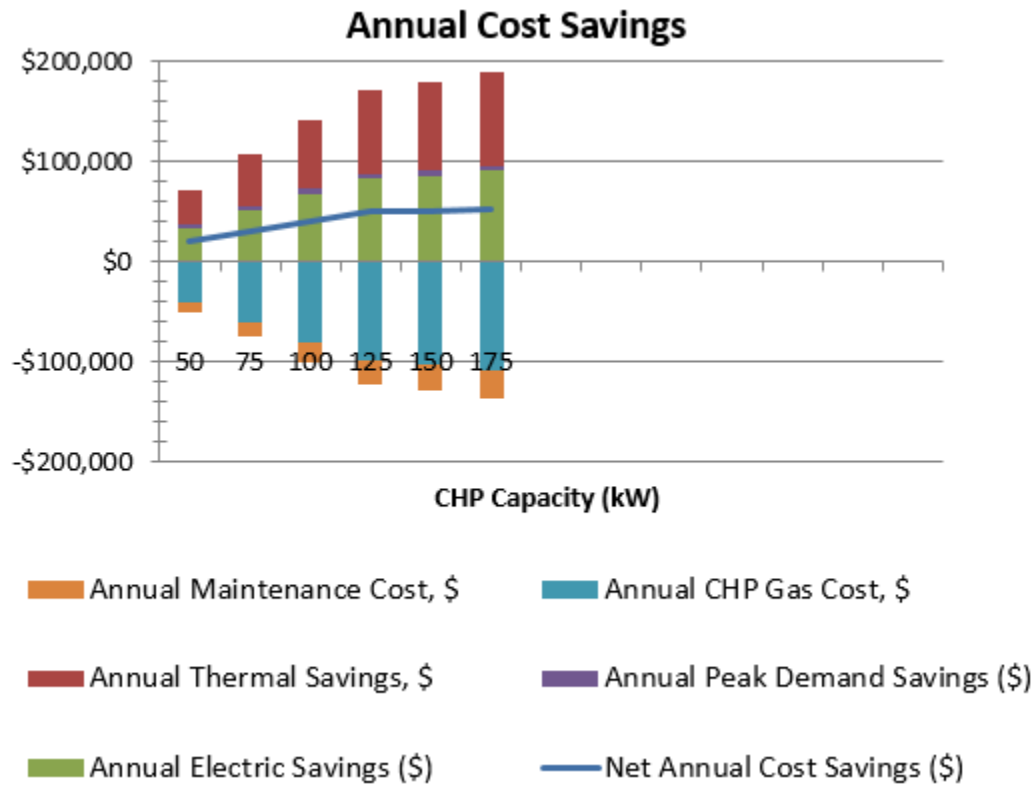
Facility	Variable Cost	Fixed Cost	Total Cost	kWh Rate	Summer kW Rate	Winter kW Rate	Gas Rate	CHP Gas Rate	Annual kWh	Peak Demand	Annual MMBtu	Optimal Size	Payback	Net annual cost savings	kWh savings	offset gas (MMBtu)	CO2 Savings
Ulster County Law Enforcement Center	\$4,500	\$100,000	\$550,000	\$0.083	\$8.68	\$8.49	\$11.84	\$7.50	4,929,057	948	16,311	100-125	13.5	\$40,820	809,048	5,805	164,646
	\$4,000	\$75,000	\$475,000										11.6	\$40,820	809,048	5,805	164,646
Ulster County Law Enforcement Center	\$4,500	\$100,000	\$550,000	\$0.083	\$9.16	\$9.16	\$9.77	\$7.00	4,929,057	948	16,311	100-125	16.0	\$34,474	809,048	5,805	164,646
	\$4,000	\$75,000	\$475,000										13.9	\$34,256	809,048	5,805	164,646
Ulster County Law Enforcement Center	\$4,500	\$100,000	\$550,000	\$0.090	\$9.50	\$9.50	\$10.50	\$7.00	4,929,057	948	16,311	100-125	12.4	\$44,353	809,048	5,805	164,646
	\$4,000	\$75,000	\$475,000										10.7	\$44,353	809,048	5,805	164,646

Option 1 Tables

Memo Output		Summary Information of Selected System Size	
Size min (kW)	75	Estimated electric savings (kWh)	809,048
Size max (kW)	150	Estimated offset gas savings (MMBtu)	5.805
Sample system size (kW)	100	Estimated CHP gas consumption (MMBtu)	10.667
System cost estimate	\$550,000	Estimated maintenance cost	\$20,226
Cost savings	\$40,820	Annual hours of operation	8,516
Payback period w/out Incentives (years)	13.5	Average summertime non-holiday weekday reduction in peak demand (9pm)	94
NYSERDA incentive	\$135,000	Average monthly demand reduction, kW	48
Payback period w/ incentives (years)	10.2	Annual electric demand savings	\$4,941
		Annual overall system efficiency	77.6%
		Electrical efficiency	25.9%
		Annual dump hours	0

Note: Incentive no longer available as discussed in “Discussion of CHP pre-feasibility model results” section above.

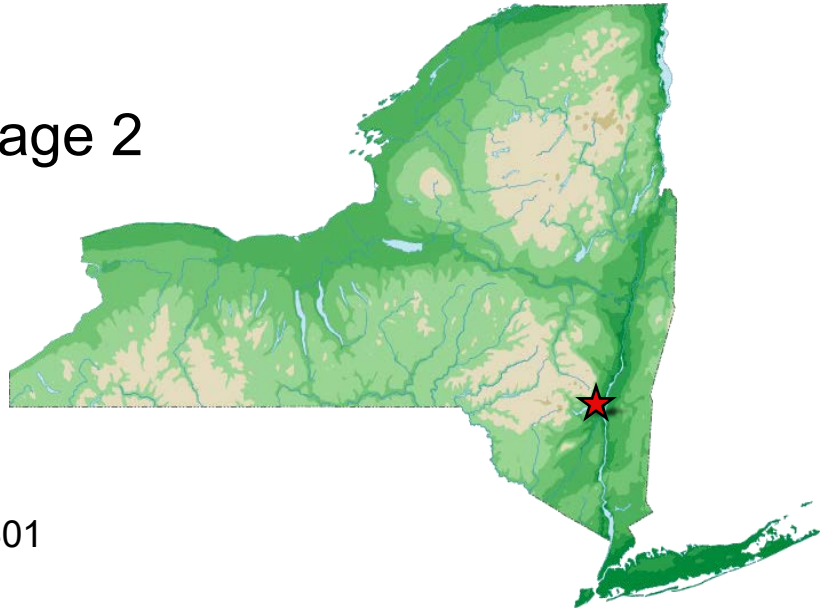






Geothermal Clean Energy Challenge

Advanced Report – Stage 2



Applicant: Ulster County
Address: 380 Boulevard
Kingston, NY 12401
Site Name: 380 Boulevard

Project Summary

This potential project was modeled as a single closed loop ground source heat pump (GSHP) system with 758 tons of cooling capacity that will serve the building listed on the next page with a total conditioned area of 277,000 square feet. The GSHP system is expected to serve an existing building that will require little to no significant interior modifications during installation to integrate with existing building HVAC systems, and this factor is reflected in the GSHP cost assumptions used in the model.

The analysis in this report is based on the results of a streamlined building energy model (BEM) using the supplemental data you provided for the building associated with your potential GSHP site. The BEM was used to fine-tune the energy load patterns and economic and technical results in this report. Compared to the Stage 1 report, this fine-tuning led to a larger GSHP system being required (758 tons in Stage 2 vs. 632 tons in Stage 1), slightly lower annual energy cost savings, and higher capital costs for traditional HVAC that would be avoided with a GSHP system. The net effect of these changes was an approximately three-year increase in the period needed to pay back the GSHP investment in the Stage 2 report compared to Stage 1, primarily due to the higher capital costs necessitated by the larger GSHP system in Stage 2.

As a reminder, the results presented in this report are preliminary, and a detailed feasibility assessment is a necessary next step in thoroughly exploring a GSHP project. Financial and technical support for conducting a detailed design study, including American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Level 2 targeted audits, site geotechnical testing and analyses, and schematic GSHP system design is available to eligible applicants in Stage 3 of the Geothermal Clean Energy Challenge.

Energy, Financial, and Environmental Savings Opportunities from GSHP Implementation

Buildings Included in the Site		
Building Name	Building Type	Building Conditioned Area (sqft)
Ulster County Law Enforcement Center (UCLEC)	Prison and Sheriff's Office	277,000

The tables below summarize the savings opportunities estimated for the site in terms of costs, energy and greenhouse gases when comparing the implementation of a ground source heat pump (GSHP) system to the existing (or planned) building HVAC systems.¹

Note: the value of the carbon emissions included in the table is not directly monetizable by the applicant, but rather reflects the overall value to society provided by the reduced carbon emissions. The value is not used as a factor in the economic analysis in this report. However, the benefits to society can be substantial, particularly when buildings consuming fuel oil switch to GSHP.

Volumetric Savings / Increases	
Annual Propane Savings	0 gallons
Annual Fuel Oil Savings	107,348 gallons
Annual Natural Gas Savings	0 [1000 ft ³]
Annual Electricity Increase	944,795 kWh
Annual GHG Emissions Reduction	877 metric tons (CO ₂ e)
Cost Savings (\$)	
Annual Energy Bill Savings	\$ 67,599
Annual O&M Savings ²	\$ 53,475
Investments & Incentives ³ (\$)	
Installed GSHP System Capital Costs (Est. Range)	\$ 4,963,384 - \$ 5,509,356
Avoided Capital Costs for Traditional HVAC System	\$ 937,486
NYSERDA Incentive Payment for GSHP System	\$ 500,000
Societal Value of Reduced Carbon Emissions ⁴	\$ 1,638,469

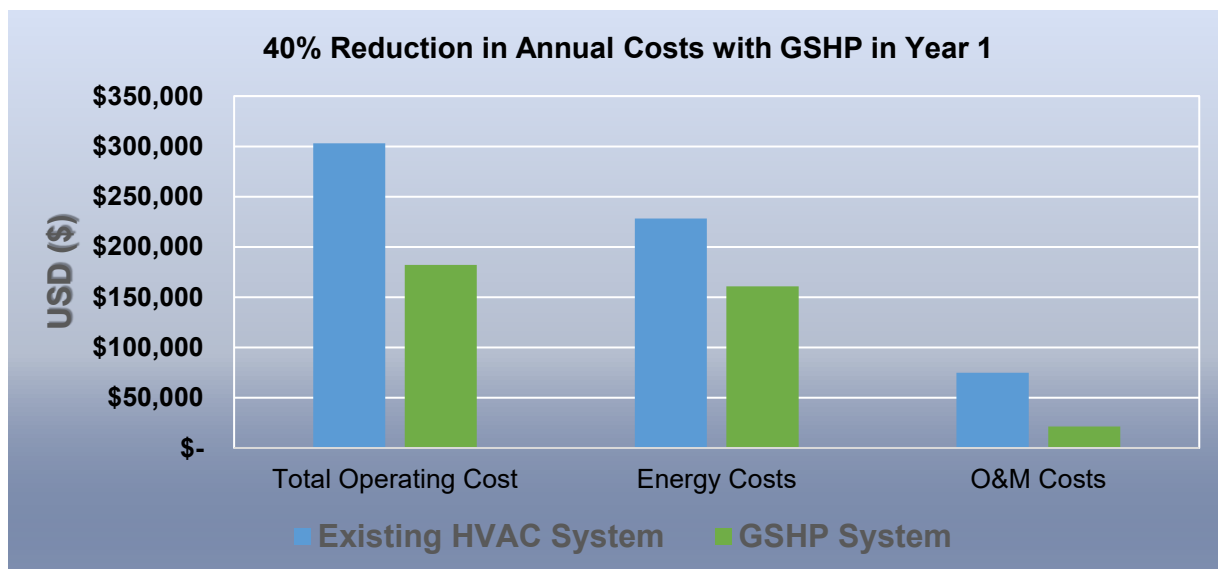
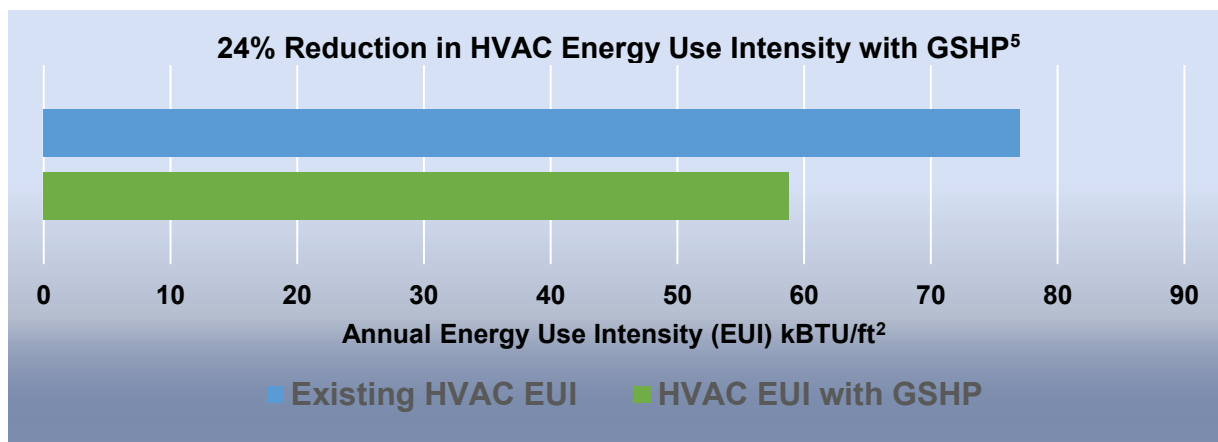
¹ The findings presented in this report are preliminary and should not be used as the sole basis for investment decisions.

² O&M savings include the savings associated with the avoided use of a cooling tower at the site.

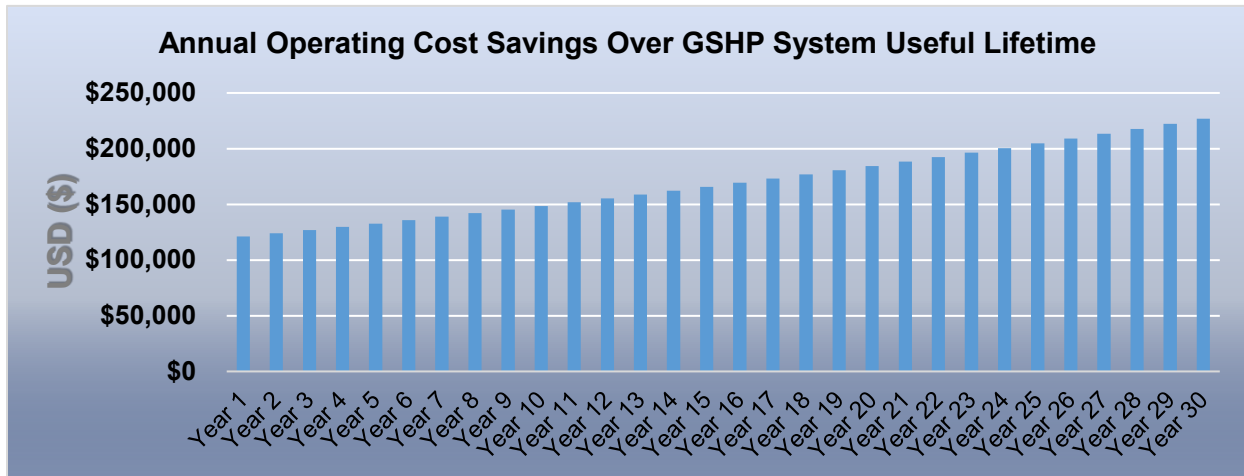
³ Estimated capital costs in this report reflect an expected range based on similar projects, but they may differ from the final minimum or maximum project costs that a GSHP site encounters in practice. Further incentives may also be available for GSHP systems through utility programs; contact your utility for more information. For-profit entities with sufficient tax liability may additionally be eligible for a 10% federal tax incentive on GSHP systems.

⁴ Societal cost of carbon (30 year net present value) calculated using EPA 3% average data in 2017 dollars (https://19january2017snapshot.epa.gov/climatechange/social-cost-carbon_.html)

Excluding NYSERDA Incentive	Including NYSERDA Incentive
GSHP Simple Investment Payback Period (Estimated Range)	
25 - 27 years	22 – 25 years
GSHP Net Present Value (Estimated Range over 30-year life)	
(-\$ 1,814,102) – (-\$ 1,268,130)	(-\$ 1,314,102) – (-\$ 768,130)
GSHP Savings to Investment Ratio (Estimated Range)	
0.67 - 0.74	0.74 - 0.83

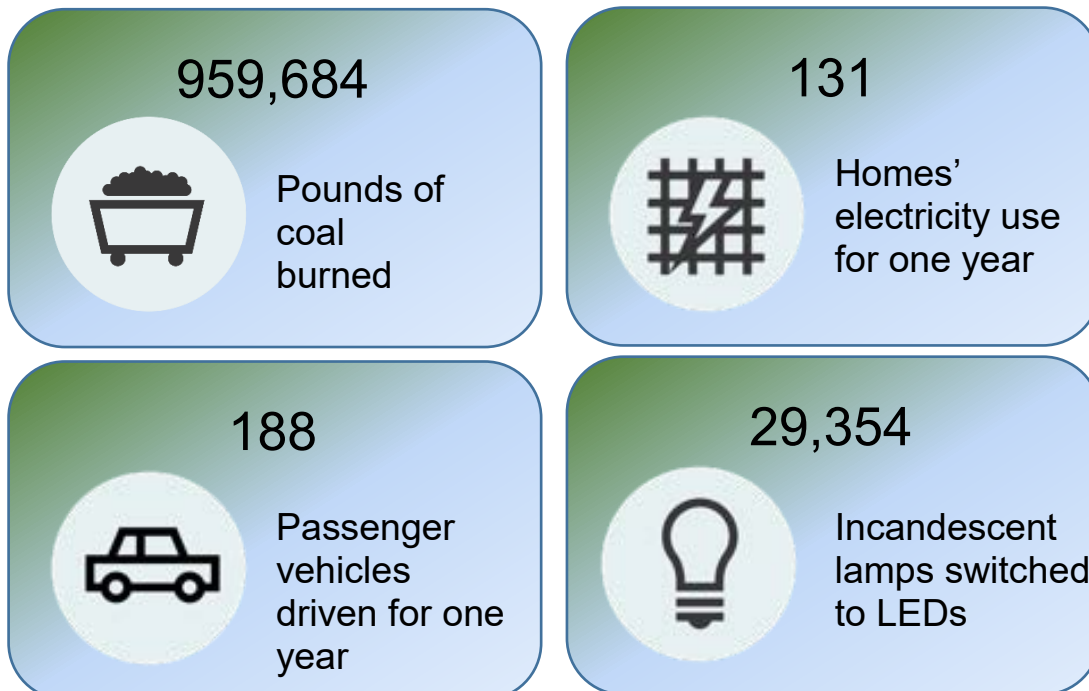


⁵ Energy Use Intensity is calculated based on source energy and encompassing all the energy used in delivering energy to a site, including power generation, transmission and distribution losses. (<https://www.governor.ny.gov/news/no-88-directing-state-agencies-and-authorities-improve-energy-efficiency-state-buildings>)



Greenhouse Gas Reduction Equivalencies

The annual carbon emissions reduction from the implementation of a GSHP system at your site can be translated to an equivalent reduction in any one of the following alternatives, including pounds of coal burned, electricity used by a home in one year, number of passenger vehicles driven in one year, and number of incandescent lightbulbs replaced with LED bulbs.⁶



⁶ EPA Greenhouse Gas Equivalencies Calculator (as of November 2018): <https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator>.

Environmental Permitting Considerations

Although GSHPs are clean energy technologies, some environmental factors should be considered to best manage the installation process. The following is an introductory, non-comprehensive list of considerations when GSHP boreholes are drilled:

- The drilling process can bring large amounts of ground water to the surface, and this water needs to be managed and disposed of in an appropriate manner. The volume, rate of flow, water quality, and local site conditions dictate the most appropriate approach. Most of the time, settling ponds with geotextile “silt fencing” and/or hay bales is sufficient, which allows an acceptable amount of slightly discolored water to run off via normal storm water drainage systems.
- GSHP projects in Western New York and the Southern Tier (counties west of the Catskill Mountains along the northern border of Pennsylvania) in particular may encounter pockets of natural gas, which must be handled with experience and caution.
- There are no state permits required for geothermal bore holes less than 500 feet deep. All bore holes deeper than 500 feet must apply for a permit from the Department of Environmental Conservation (DEC) for each hole. Local jurisdictions should also be contacted regarding specific requirements.
- Construction and grouting must be done in accordance with federal, state, and local regulations as well as current industry best practices to minimize contamination risk from either surface run-off or cross aquifer sources of contamination.

Additional considerations associated with each type of geothermal loop field can include:

Closed Loop	Open Loop	Standing Column
<p><i>Less than 500 feet:</i> No additional considerations</p> <p><i>Greater than 500 feet:</i> Must apply for DEC permit; permit may require drift monitoring and/or a bond to cover costs associated with abandonment.</p>	<p><i>Supply Well:</i> Must comply with water well permitting and construction requirements as regulated by the New York State Department of Health (DOH).</p> <p><i>Discharge Well:</i> Must be reviewed by DEC; if initial water quality meets discharge standards and nothing will be substantially added during use, the system is not required to obtain a discharge permit.</p>	<p>Must apply for DEC permit, which requires drift monitoring and a bond to cover abandonment costs.</p> <p>Due to the open nature of the borehole in which groundwater is recirculated, the water chemistry will change as geologic formations are dissolved. This can potentially increase the concentration of dissolved solids or salinity, which can impact the reliability of the heat exchange surfaces.</p>

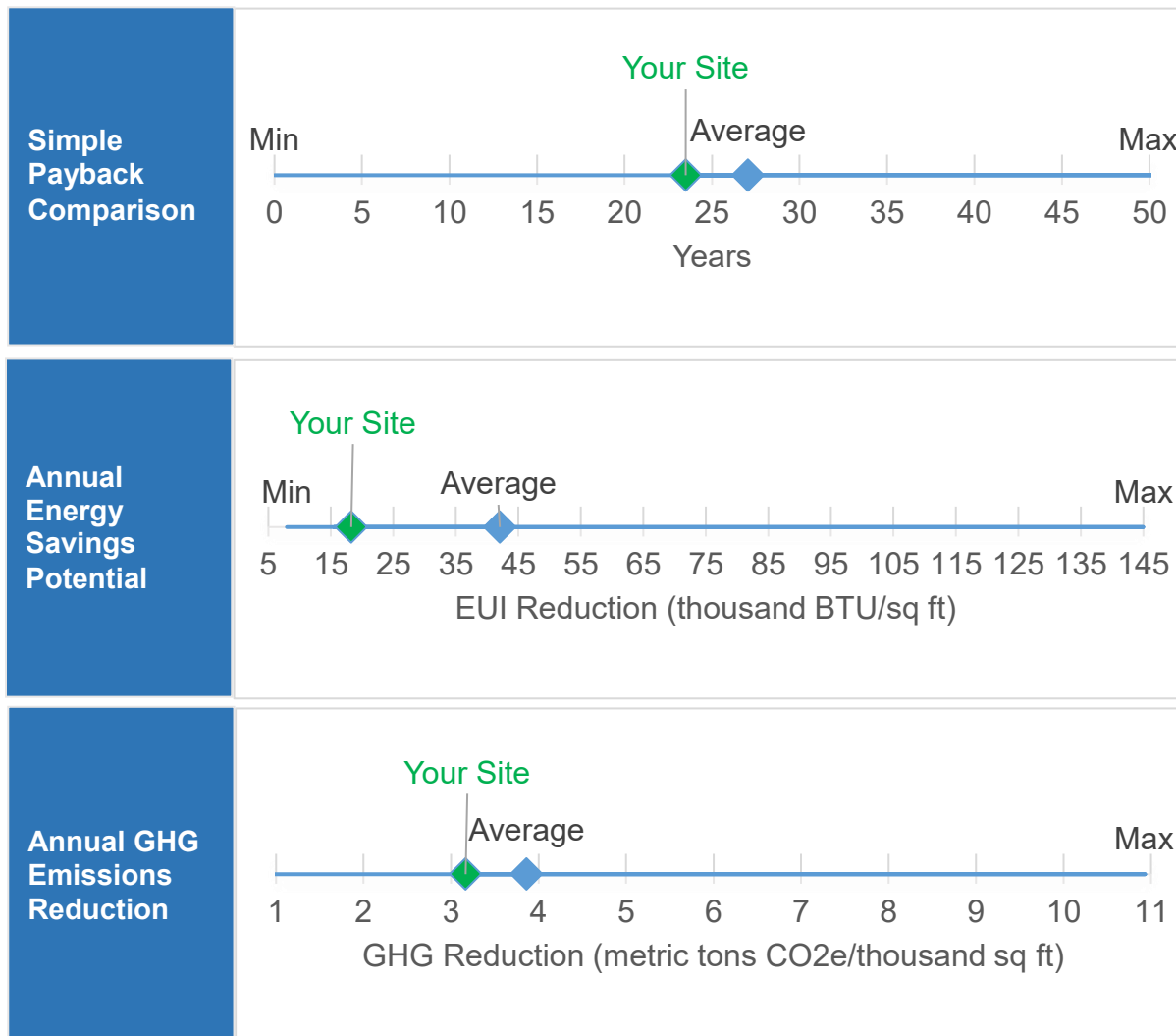
For more information on different types of GSHP loop fields and on environmental factors in GSHP system construction and operations, please see:

- NYPA’s *Geothermal Clean Energy Challenge* website: <https://www.nypa.gov/about/geothermalchallenge>.
- NYSERDA’s *Renewable Heating and Cooling Policy Framework*: <https://www.nyserdera.ny.gov/-/media/Files/Publications/PPSER/NYSERDA/RHC-Framework.pdf>.

- NY-GEO, a nonprofit trade association dedicated to geothermal heating and cooling: <https://ny-geo.org/pages/frontpage>.
- U.S. Environmental Protection Agency's *Renewable Heating and Cooling* website: <https://www.epa.gov/rhc/geothermal-heating-and-cooling-technologies>.

Site Specific Considerations and Selection Criteria

A set of screening criteria was used to determine the most viable sites for the implementation of a GSHP system from those applying to the Geothermal Clean Energy Challenge. The criteria include a quantitative analysis of the technical and economic viability of a potential system and a review of important qualitative implementation factors for potential sites. Your site was one of the top-ranked sites selected to advance to Stage 2 of this Challenge. A description of each criteria is provided on the next page. The graphs below demonstrate how the benefits of a GSHP installation at your site compare to the benefits at other sites that applied. Your site is shown in green, compared with the minimum, maximum, and average values from the pool of applicants.



Screening Criteria	Description
Presence of a GSHP Champion	Is there an individual, or group of individuals, within the applicant organization that is significantly invested in making sure a GSHP system is installed at the site? This person can be a facility manager, board member, or any other influential individual. Often the presence of a champion can make or break whether a GSHP system is ultimately implemented.
Accessibility of Data for Screening Analysis	How responsive and forthcoming was the applicant during the facility engagement process? Were they able to provide data at the individual building level, or only at the campus level? Detailed building level data significantly improves the accuracy of the inputs used for the screening analysis and provides a higher level of confidence that the results from this first round economic screening are reliable.
Organizational Readiness to Implement	Does the applicant appear able and willing to pursue implementation of a GSHP system soon? Are there examples of previous or ongoing efficiency and renewable work funded by the applicant? Given the capital-intensive nature of a GSHP project, existing financial commitments for energy savings can help illustrate a readiness to undertake the investment required.
Sustainable Program Commitment	Does a GSHP system integrate into an existing sustainability program that the applicant has created (or is participating in)? Will the GSHP system be able to be tied to educational or community engagement work? A key goal of the Geothermal Clean Energy Challenge is to promote public awareness and education of GSHP systems within the State of New York.
Technical Viability	Are there any significant technical hurdles for implementation of a GSHP system at the site? Is there green or brown field space available on location?
Economic Benefits	Does the preliminary screening indicate that the installation of a GSHP system is financially attractive? The financial merit of the project is evaluated across three different standard financial metrics: Net Present Value (NPV), Savings to Investment Ratio (SIR) and Simple Payback Period.
Greenhouse Gas (GHG) Reductions	How significant are the estimated GHG reduction benefits? Is fuel switching from GHG intensive fuels such as fuel oil planned? GHG benefits are estimated based on reduction in annual metric tons of CO2 emissions.
Site Adds to Program Sectoral Diversity	Is the site part of a sector that is under-represented in the general applicant pool? If so, then the site is helping to add valued diversity to the types of facilities included in the program.
Site Adds to Program Geographic Diversity	Is the site part of a geographic region that is under-represented in the general applicant pool? If so, then the site is helping to add valued diversity to the types of facilities included in the program.



FLEXTECH STUDY AND HEATING/COOLING MASTER PLAN

For

**Ulster County Office Building
244 Fair St.
Kingston, NY 12402**

**New York State Energy Research and
Development Authority
17 Columbia Circle
Albany, New York 12203-6399**



Final Report: 09-17-2019

For questions regarding this report, please contact FlexTech@nyserda.ny.gov.

We hope the findings of this report will assist you in making decisions about energy efficiency improvements in your facility. Thank you for your participation in this program.

NOTICE

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State of New York
Andrew Cuomo, Governor

New York State Energy Research and Development Authority

FLEXTech ENERGY STUDY

Ulster County Office Building

**244 Fair St.
Kingston, NY 12402**



Prepared for:

Ulster County

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ABSTRACT

Ulster County has a strong track record of being a leader in green power use and environmental sustainability. Ulster County has demonstrated its commitment to clean energy by participating in the New York State Energy Research and Development Authority (NYSERDA) Clean Energy Communities Program and was the first County in New York State to achieve the designation of a Clean Energy Community.

Pursuant to Executive Order Number 1-2016, Ulster County is required to decrease greenhouse gas emissions associated with its operations (through conservation, efficiency, and on-site renewable generation) by 25% by 2025 and 80% by 2050, using the County's 2012 greenhouse gas emission inventory as a baseline.

The purpose of this study was to investigate and report on near term heating needs, using energy efficient equipment, and clean alternatives to natural gas combustion equipment for long-term energy reduction plans at the Ulster County Office Building - Kingston, NY.

Data was gathered by an experienced team of HVAC and energy engineers during on-site surveys through the visual observation of the building and its energy consuming systems, interviews with operating personnel, and analysis of energy records pertaining to electricity and natural gas.



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PROJECT TEAM AND INFORMATION

The follow table presents the individual professionals that lead and participated in the energy study activities. The name, certifications, and qualifications of the Consultants' staff that performed and were involved with the energy study are:

Role and Name	Contact Information	Certifications & Experience	Applicable Experience
Lead Engineer Daniel Hampson GPI	DHampson@gpinet.com (518) 453-9431	PE	37 years
Project Manager Brendan Kelly L&S Energy Services	BKelly@LS-Energy.com (518) 383-9405 x 214	PE, CEM, LEED® AP, CGI	21 years
Project Manager Tom Lamb GPI	TLamb@gpinet.com (518) 453-9431		30 years
QA/QC Ron Slosberg L&S Energy Services	RSlosberg@LS-Energy.com (518) 383-9405 x 216	CEM, CMVP, LEED® AP, EBCP	30 years
HVAC Engineer Daniel Ryan GPI	DRyan@gpinet.com (518) 453-9431		22 years
Energy Engineer Mike Stiles L&S Energy Services	MStiles@LS-Energy.com (518) 383-9405 x219	CEM, PhD	30 years

We would like to thank the staff at Ulster County, especially Nick Hvozda and David Gruskiewicz, for their time and effort during our site visits and with subsequent information requests. Should you have any questions, please do not hesitate to contact Daniel Hampson (518) 453-9431 x 1519 or Brendan Kelly (518) 383-9405 x 214.

Sincerely,

GPI

Daniel Hampson, PE
Vice President and Director of MEP-FP

EXECUTIVE SUMMARY

DESCRIPTION OF STUDY

The focus of this Energy Study was to evaluate the replacement of boiler equipment, while simultaneously developing an implementable strategy for reducing energy use through the application of best-available clean heating and cooling technologies in both the near and long-term at the Ulster County Office Building - Kingston, NY.

Interviews with County personnel and equipment surveys of the Ulster County Office Building - Kingston, NY were conducted by GPI and L&S Energy Services on February 8th, 2019. The purpose of the interviews and equipment survey were to assess the existing heating and cooling systems, energy savings goals, and the operation of the existing Building Energy Management System (BMS). Historic design documents, energy bills, and BMS trend data were provided by the site contact and were reviewed.

Interviews and walk-through audits were performed to gather equipment nameplate data, review operational schedules, and procure annual electric and fossil fuel utility bills and consumption schedules. The layouts and general conditions of the existing HVAC heating and cooling systems were compared to the plans and documentation received. System operation schedules were obtained from the Direct Digital Control (DDC). The goal of these activities was to calculate the building load coefficient (BLC) and the balance point temperature for heating as the basis for recommending energy efficiency improvements.

For the one year period from November 2017 through November 2018, the Ulster County Office Building used a total of 938,560 kWh at a cost of \$122,873.

Over the same date period, 29,651 therms of natural gas were consumed at a cost of \$25,536 and used for heating and domestic hot water.

A utility bill summary is included in Appendix A. Energy use, costs and rates are based on values provided by the County through Energy Star Portfolio Manager.

The cost per million Btus (\$/MMBtu) was calculated for each fuel source below.

<u>Utility Type</u>	<u>Avg. Unit Cost</u>	<u>\$/MMBtu</u>
Electric Energy (Central Hudson)	\$0.109/kWh	\$32.05/MMbtu
Electric Demand (Central Hudson)	\$8.17 /kW	--
Natural Gas (Central Hudson)	\$0.861/therm	\$8.61/MMbtu

3,413 Btu = 1 kWh; 100,000 Btu = 1 therm

A pre-feasibility study (PFS) was conducted for the following clean heating & cooling technologies:

- Air source heat pumps (ASHP)
- Solar Thermal DHW
- Cooling Energy Thermal Storage

The following energy conservation measures (ECMs) were evaluated as feasible options:

- Condensing Natural Gas Boiler
- Biomass Boiler and a Condensing Natural Gas Boiler
- AC-4R VAV Conversion

For each qualified measure, energy use and projected cost savings were calculated using spreadsheet analysis. ECM analysis, life-cycle cost analysis and calculation data are included in Appendix B. The cost estimate for each ECM is included in Appendix C. The simple payback period for each measure was calculated. A description was prepared for each ECM which details baseline and proposed equipment.

Pre-feasibility measures were evaluated using screening level vendor tools or simple spreadsheet calculations. These preliminary studies were also detailed with savings, costs, and paybacks. Life-cycle cost analysis was not completed at the screen level.

The Technology Evaluation section of this study only takes into consideration energy cost savings. Incentives were not incorporated into the economic evaluation of technologies because they may change, or be eliminated by the time the final selected equipment is determined. Incentives should be re-evaluated when the final selected system/technology is selected.

The final section of this report details the selected course of action for the Heating/Cooling Master Plan, supported by detailed (specification-level) cost estimation and economic analysis.

Additionally, NYSERDA/NYPA Geothermal Clean Energy Challenge Stage 1 and 2 reports were provided by the County and summarized. Detailed results are included in Appendix D.

A summary of preliminary energy conservation measures evaluated and those selected for further analysis as part of the HVAC Master Plan are shown in Figure 1 below.

Figure 1

Ulster County Office Building

Energy Conservation Measure Energy Savings Summary - 244 Fair Street, Kingston NY 12402

	Measure Description	Measure Status (See Notes)	kWh Savings	kW Savings	Natural Gas mmBtu Savings	Total mmBtu Savings	Annual Cost Savings	Project Cost	Payback (Years)
PFS 1	Install Solar Thermal DHW	NR			51	51	\$439	\$16,946	38.6
PFS 2	Install Air Source Heat Pumps	NR	-114,275		2,965	2,575	\$10,575	\$525,187	49.7
PFS 3	Install Cooling Energy Storage	NR		266.4		0	\$2,194	\$300,000	136.8
ECM 1	Install a Condensing Natural Gas Boiler (existing conditions baseline)	ME			402	402	\$3,461	\$109,625	31.7
ECM 1a	Install a Condensing Natural Gas Boiler (code minimum baseline, FYI only)	N/A			232	232	\$1,996	\$94,625	47.4
ECM 2	Install a Biomass Boiler and a Condensing Natural Gas Boiler	NR			367	367	-\$12,740	\$310,250	-24.4
ECM 3	Convert AC-4R to VAV	ME	34,591		0	118	\$3,523	\$48,200	13.7
FA ECM 1	Install Two Condensing Natural Gas Boilers (existing conditions baseline)	RME			402	402	\$3,461	\$241,600	69.8
FA ECM 3	Convert AC-4R to VAV	RME	No change from ECM 3 above						
Totals (All Measures Excluding 1a)			-79,684	266.4	4,187	3,915	\$10,912	\$1,393,982	127.7
Totals R, I, and RNE Only			34,591	0	402	520	\$6,983	\$241,600	34.6

Measure Status: Recommended (R); Not Recommended (NR); Further Study Recommended (RS); Recommended for Non-Energy Benefits (RNE);

Implemented (I); Recommended Mutually Exclusive; Mutually Exclusive

FA measures were selected by the customer for further analysis by the customer as part of the Heating/Cooling Master Plan.

1 MMBtu = 1,000,000 Btu; 3,413 Btu/kWh

ECM 3: Demand kW and kW \$ savings are not included, VFD modulation not expected during utility peak times

ECM 5's kW savings is cumulative annual

Annual cost savings for R/I/RNE measures:

\$6,983

Base year costs - proposed annual cost savings

\$141,425

Base year energy costs

% savings

4.7%

Electric

\$122,873

Natural Gas

\$25,536

Total

\$148,408

GENERAL NOTES:

1. Savings round to nearest whole number.
2. A description of each measure and associated savings are included in the Energy Conservation Measures section.
3. ECM supporting calculations and cost estimates are included in Appendices B and C, respectively.
4. Savings are based upon 2017/2018 utility rates (Appendix A).
5. Interactivity among the individual ECMs was not considered (unless where noted), so the savings may change depending on the combination of improvements implemented.
6. Incentives and O&M costs are not considered.

Based upon full implementation of all ECMs selected by the County for further analysis in the HVAC Master Plan, the annual savings currently projected in this analysis are \$6,983 per year. This would reduce the annual energy costs by approximately 4.7% from the base amount of \$148,408 to a proposed amount of \$141,425. The estimated capital cost associated with implementing all recommended energy conservation measures is \$241,600 with a simple payback period of 34.6 years.

This report is the final deliverable under the project's statement of work. Savings assumptions are based on the conditions present at the site at the time of the initial audit.

ASSESSMENT OF SITE CONDITIONS

BUILDING OVERVIEW

The Ulster County Office Building is a 62,396 square foot office building located in Kingston, NY. The building is occupied by DMV, records storage, and other County departments on the following schedule: Monday through Friday, 9:00 AM – 5:00 PM. The six story building with basement was constructed in 1964 and contains offices, mechanical areas, corridors, file vault, and restrooms. The building has experienced multiple space layout reconfigurations over the years, including changes to mechanical and electrical systems.

Architectural Features

The Ulster County Office Building is a steel framed structure with a curtain wall system. Its flat black EPDM roof has been identified for replacement in the County's 2019 – 2024 Capital Improvement Program. Insulation values are assumed to match the performance defined in the construction design documents. A detailed study of the curtain wall systems was completed in 2016.

The windows are original to the building and have tinted insulated glazing, single glazing, and non-thermally broken aluminum frames. Operable windows are installed in all areas except record storage. During the interview, staff indicated that thermal discomfort due to both conductive heat loss and convective drafts were reported in spaces adjacent to the windows.

The main entrances are located on opposite sides of the building and include vestibules. The staff mentioned during the interview that the corridor running between the two doors experiences a wind tunnel effect. We suggested during the site visit that the County investigate adjusting the timing for opening the interior and exterior doors and installing air curtains over the doors to minimize infiltration.

Heating, Air Conditioning, and Controls

A summary of the building HVAC, DHW, and Building Control systems is included below. The boilers are the primary focus of the study, so their performance, existing conditions, and control parameters are discussed in greater detail.

Cooling is supplied to the air handlers in the building from a VSD water cooled centrifugal chiller, coupled with a cooling tower that is planned for replacement. Chilled water and condenser water pumps operated lead/lag with a spare pump and are constant speed. The chilled water system has a single loop, and the design drawings show three-way valves installed at the cooling coils.

Heating is provided by two natural gas fired hot water boilers. Both were installed in 1988 and are near or at the end of their useful lives. Only one boiler is typically needed to meet the peak building load. Staff noted during the interview that burners need frequent adjustments during operation and air slugs are common. A recent boiler efficiency test was not provided for this study, but the boilers are serviced annually. The boilers are enabled through the BMS when the outside air dry bulb temperature falls below 58°F and are



always available when outside air temperature falls below 40°F. The boilers are manually switched from lead to lag. The hot water supply set point for each boiler is linearly scaled as a function of outside air temperature (OAT) as follows: 180°F HWS @ 0°F OAT and 120°F HWS @ 60°F OAT.

Table 1

Boiler Schedule						
B-	Manufacturer	Model Number	Input MBH	Output MBH	Design Thermal Efficiency	Fuel
1	Weil McLain	1688	5124	4090	80.0%	NG
2	Weil McLain	1688	5124	4090	80.0%	NG

Three hot water pumps operate at constant speed, lead/lag, to supply hot water to separate systems in the building. The design drawings show three-way valves installed at the heating coils. Staff noted during the interview that water flow to the fifth and sixth floors is inadequate.

Note: If the implementation of variable speed drives is considered for either the chilled water or hot water pumps, then two way valves will need to be installed in place of three-way to achieve differential pressure in the loop.

The air handling systems in the building utilize chilled water (CHW) and hot water (HW) coils to supply conditioned air to the building. Four of five air handlers (AC-1-3 and 5) were installed in 1987. AC-1, 3, and 5 have economizers and reheat coils; they serve the basement, first through fifth floor offices, and the sixth floor.

AC-2 feeds a floor-discharge air curtain installed in front of an interior vestibule door. As previously indicated, an overhead air curtain should replace the floor outlet.

AC-4R is the only component of the distribution system analyzed as an ECM in this study. A VAV system will be evaluated as a replacement. This multi-zone unit was replaced in 1993 and includes a constant speed 7.5 HP fan motor, split DX cooling along with CHW and HW coils. The unit supplies conditioned air to the file vault that spans multiple floors. There is dedicated ductwork with reheat coils and zone dampers; electric reheat coils were recently replaced with hot water coils. An electric

humidifier installed in the main ductwork has been inoperable for close to 5 years and is planned for replacement.

HHW fin tube radiation is installed at various locations on all floors. Five exhaust fans operate on a BMS schedule with set-back schedules for weekends.

Domestic hot water is supplied by natural gas fired stand-alone hot water heaters with storage. There is an aquastat on the circulation loop pump.

Electrical Systems

Staff mentioned during the interview that there are no unused slots left in the electric panels. Interior and exterior lighting systems were recently upgraded with LED. Lighting sensor upgrades are planned.

Process and Plug Loads

Process and plug loads include equipment and systems typically found in office buildings and miscellaneous systems. An air compressor that's at the end of its useful life serves the pneumatic control system.

Building Control System

The building has a Johnson Controls Metasys Building Automation System interfaced with pneumatic controls on the majority of the HVAC and plant equipment. Perimeter fin tube heaters are on unitary thermostats. EmTech currently maintains the system. The control panel is a standalone workstation in the basement. The system has trending capabilities, which are not utilized to their fullest capabilities by the County.

Re-commissioning of the control system should be conducted periodically to ensure sensors are calibrated and trend results are reasonable. Staff noted during the survey that they are working through many alarms on the system. Demand control ventilation is planned for some time in the future.

BUILDING BALANCE POINT TEMPERATURE AND LOAD COEFFICIENT

The balance point temperature and load coefficient are two metrics used to estimate the heating and cooling requirements of a building. Both were computed using historical utility data and weather (temperature) data. Because boiler replacement is the primary focus of this project, calculations were completed for the heating season only. The following high-level summary assumes that the reader is familiar with regression statistics as applied to building energy analysis.

The balance point temperature is the temperature below which a building requires active heating. It is a function not only of the size and composition of a building but also of internal, solar, and other gains. There are several ways to estimate it. For purposes of this report it was based on a heating degree day (HDD) analysis.

The number of heating degree days for a given day is (average daily temperature – degree day base temperature) when that number is greater than zero. A regression analysis is performed on utility heating fuel data as a function of heating degree days for the billing periods¹.

The objective is to select the degree day base temperature that maximizes the correlation coefficient of the regression. By the definition of correlation coefficient, this minimizes the regression's ratio of unexplained variation to total variation with respect to degree day base temperature. The base temperature that maximizes the correlation coefficient is then taken as the balance point temperature of the building.

The results were as follows for the natural gas data:

- HDD base temperature = 58° F giving R^2 (squared correlation coefficient) of 0.988
- Slope = 6.15 therms/day / HDD58/day
- Intercept = 7.49 therms/day

The process is completed by multiplying the regression parameters (slope and intercept) by the estimated efficiency of the heating system – to get an estimate that is independent of the HVAC system. The seasonal efficiency of the heating system was estimated at 76%. Note that this procedure does not change the HDD base temperature or correlation coefficient of the data set.

The results that describe the heating load of the building independently of the heating system were found to be:

- Slope = 4.68 therms/day / HDD58/day
- Intercept = 5.70 therms/day

These results were used to model proposed boiler energy usage (ECMs 1 and 2) as detailed in Appendix B. The models were based on projected fuel use in a year of typical weather (using TMY3 data). The model calculations were cast in a form that does not require the use of the building load

¹ See ASHRAE Guideline 14-2002 pgs 139-140, which includes a description of eliminating *sample interval bias* from the data that was used in the present analysis.

coefficient. However for sake of completeness the load coefficient was calculated using the information outlined above.

Recall that the building load coefficient is defined as the quantity UA in the conductive heat transfer formula $\text{Btu/hour} = UA \Delta T$. The load coefficient may be derived from the utility data regression slope in the following way:

1. The physical units of the load coefficient are Btu/hour °F
2. The physical units of the regression slope are therms/HDD, that is, therms/day °F
3. The conversion of the utility data regression slope to load coefficient is:

Utility regression therms / day deg F * 10^5 Btu/therm * 1 day/24 hours * heating efficiency = Btu / hr deg F

The building load coefficient was thus found to be 19,491 Btu/hr °F.

PRELIMINARY ENERGY USE ANALYSIS (PEA)

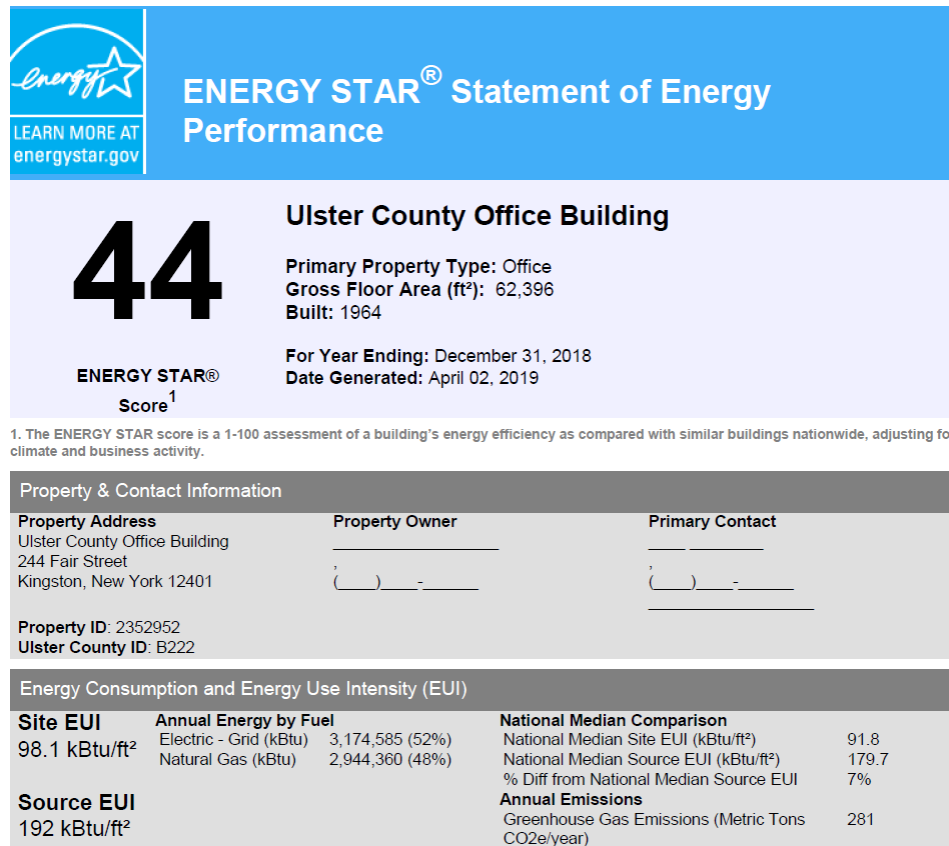
Data and Building Characteristics for EPA Portfolio Manager

The utility data used for energy and cost savings analysis for ECMs is listed in Appendix A. Also included in Appendix A is the Energy Star Data Verification Checklist (DVC). The DVC lists its version of the utility data as well as building age, gross floor area, and other relevant information.

EPA Portfolio Manager Results

Figure 2 shows the Energy Star score and the building's Energy Usage Intensity (EUI). A score of 50 is the median. The building's score is 44 which indicates it is performing slightly under the median for buildings in its class.

Figure 2



The EUI is a building's energy use normalized to floor area. Based on 12 months of energy consumption history the site EUI is 98.1 kBtu/ft². According to Energy Star's Portfolio Manager, the EUI of comparative sites (Office Buildings) is 91.8 kBtu/ft², or 7% more efficient than this site.

TECHNOLOGY EVALUATION

The supporting calculation data for the following Pre-Feasibility Studies (PFSs) and Energy Conservation Measures (ECMs) can be referenced in Appendix B.

ECM No.	Energy Conservation Measure Description
PFS-1	Install Solar Thermal DHW
PFS-2	Install Air Source Heat Pumps
PFS-3	Install Cooling Energy Thermal Storage
ECM-1	Install a Condensing Natural Gas Boiler
ECM-2	Install a Biomass Boiler and a Condensing Natural Gas Boiler
ECM-3	Convert AC-4R to VAV

Supporting Information

- ECM 1 (upgrade to condensing natural gas boiler): Savings calculations used a baseline derived from existing conditions. ECM 1a was created using a baseline assuming a code-minimum boiler. ECM 1a was the basis for determining the *incremental* savings (energy and cost) of the energy-efficient option of ECM 1 over a code-standard installation. The maximum efficiency of the code-minimum boiler was 82%². See the narrative for ECM 1a below for further details.
- ECM 2 (Install a Biomass Boiler and a Condensing Natural Gas Boiler): There is not sufficient supporting information in the industry to estimate CO₂ emissions reductions for biomass boilers. For example, Energy Star Portfolio Manager lists CO₂ emissions for #2 fuel oil as 74.21 kg/MBtu and wood is listed as 95.05 kg/MBtu, a 28% increase. High efficiency biomass boilers are advertised to reduce CO₂ emissions as compared to fuel oil by varying amounts (56% in one study, 1.5 tons of CO₂ per ton of pellets in another), however we had a low confidence in using these references for this study due to high variability. Ultimately, low emissions are achieved in high efficiency biomass boilers by installing controls and thermal storage that allow for long on-cycles followed by long off-cycles.

² IECC 2015, page C-47, Table C403.2.3(5)

PFS-1: Install Solar Thermal DHW

Project Cost:	\$16,946	
Simple Payback:	38.6	Years
Electricity Savings:	0	kWh /Year
Peak Demand Savings:	0	kW
Gas Heating Savings:	51	mmBtu/Year
Annual Energy Cost Savings:	\$439	

EXISTING CONDITIONS:

Domestic hot water is presently provided by two natural gas-fired hot water heaters.

ECM SPECIFICATIONS:

Install solar-assisted domestic hot water heating. A pre-feasibility study was applied to this measure. An on-line calculator maintained by energy.gov determined there to be minimal energy savings (51 mmBtu/year) with a simple payback of almost 40 years.

ACTION ITEMS:

Due to the modest energy savings and long payback, this measure is not recommended.

PFS-2: Install Air Source Heat Pumps

Project Cost:	\$525,187	
Simple Payback:	49.7	Years
Electricity Savings:	-114,275	kWh /Year
Peak Demand Savings:	0	kW
Gas Heating Savings:	2,965	mmBtu/Year
Annual Energy Cost Savings:	\$10,575	

EXISTING CONDITIONS:

Heating and cooling are presently provided by the systems described in the Assessment of Site Conditions section (boilers and chillers).

ECM SPECIFICATIONS:

Replace the existing HVAC infrastructure with variable refrigerant flow (VRF) air source heat pumps. A pre-feasibility study was applied to this measure. Energy savings were estimated using “one line” calculations based on heating and cooling usage derived from utility data and typical heat pump efficiencies (heating COP, cooling SEER). The measure would save on natural gas heating and some electrical energy for cooling at the expense of an increase in electrical energy to operate the heat pumps.

ACTION ITEMS:

This measure is not recommended due to its long payback. This condition is unlikely to change given the high initial cost of VRF systems relative to fuel prices.

PFS-3: Install Cooling Energy Thermal Storage

Project Cost:	\$300,000	
Simple Payback:	136.8	Years
Electricity Savings:	0	kWh /Year
Peak Demand Savings:	266.4	kW
Gas Heating Savings:	0	mmBtu/Year
Annual Electric Demand Cost Savings:	\$2,194	

EXISTING CONDITIONS:

The existing chillers cool the building with no thermal storage.

ECM SPECIFICATIONS:

Install ice-based storage for cooling. A pre-feasibility study was applied to this measure. The modest cooling requirements for this building were estimated from electric utility data. The savings calculations were based on the potential of this technology to shave peak electric demand. Using typical equipment and performance specs for this technology, it was determined that for six months of the year chiller electric demand could be shaved by 50% resulting in a total annual reduction of 266 kW.

ACTION ITEMS:

This measure is not recommended due to its very long payback.

ECM-1: Install a Condensing Natural Gas Boiler (existing conditions baseline)

Project Cost:	\$109,625	
Simple Payback:	31.7	Years
Electricity Savings:	0	kWh /Year
Peak Demand Savings:	0	kW
Gas Heating Savings:	402	mmBtu/Year
Annual Energy Cost Savings:	\$3,461	
% Reduction in CO2 Emissions:	14%	

EXISTING CONDITIONS:

The Ulster County Office Building receives its heating hot water from two failing standard efficiency natural gas boilers. The performance characteristics are included in Table 1 in the Assessment of Site Conditions section.

ECM SPECIFICATIONS:

Install a natural gas fired high efficiency condensing boiler. Retain one of the existing boilers as a backup.

One condensing boiler was modeled with a full load capacity of 5,124 MBH and an efficiency of 94%, based on manufacturer specifications. The boiler capacity was verified by GPI through a Trane Trace building load simulation. The existing boilers are modeled with a system efficiency of 76%; to account for losses associated with distribution and the age of the system. It is assumed that hot water is supplied from the boiler at the same temperatures as existing, where condensing occurs only during part load operation. As noted in the Assessment of Site Conditions, the second boiler rarely operates.

ACTION ITEMS:

The measure has a long energy savings-based payback. However this ECM is recommended based on the end-of-life conditions of the existing boilers.

ECM-1a: Install a Condensing Natural Gas Boiler (code minimum baseline)

Project Cost:	\$94,625	
Simple Payback:	47.4	Years
Electricity Savings:		kWh /Year
Peak Demand Savings:		kW
Gas Heating Savings:	232	mmBtu/Year
Annual Energy Cost Savings:	\$1,996	
% Reduction in CO2 Emissions:	8%	

EXISTING CONDITIONS:

The Ulster County Office Building receives its heating hot water from two failing standard efficiency natural gas boilers. The performance characteristics are included in Table 1 in the Assessment of Site Conditions section.

ECM SPECIFICATIONS:

Install a code-minimum efficiency natural gas fired boiler. A 5124 MBH code-standard boiler was modeled with an efficiency that varied linearly between 82% at outdoor temperature of 20° F and 78% at outdoor temperature of 58° F. The boiler capacity was verified by GPI through a Trane Trace building load simulation.

INCREMENTAL DIFFERENCES:

The incremental cost and savings differences between ECMs 1 and 1a are listed in Table 2 (for informational purposes only).

Table 2

	Implementation \$	Annual mmBtu Savings	Annual \$ Savings
ECM 1	\$109,625	402	\$3,461
ECM 1a	\$94,625	232	\$1,996
Incremental Difference	\$15,000	170	\$1,464

With a \$15K greater initial cost, ECM 1 saves more energy and annual cost than ECM 1a.

ECM-2: Install a Biomass Boiler and a Condensing Natural Gas Boiler

Project Cost:	\$310,250	
Simple Payback:	N/A	Years
Electricity Savings:	0	kWh /Year
Peak Demand Savings:	0	kW
Gas Heating Savings:	367	mmBtu/Year
Annual Energy Cost Savings:	-\$12,740	
% Reduction in CO2 Emissions:	See discussion in Supporting Information above	

EXISTING CONDITIONS:

The Ulster County Office Building receives its heating hot water from two failing standard efficiency natural gas boilers. The performance characteristics are included in Table 1 in the Assessment of Site Conditions section.

ECM SPECIFICATIONS:

Install a biomass hot water boiler system sized to handle about 60% of the peak heating load (3074 MBH) in the building and a condensing gas fired boiler for auxiliary heat (2050 MBH). These systems would replace the existing gas fired boilers, of which only one fires at a time (5124 MBH).

Biomass is any plant-derived organic matter available on a renewable basis, including dedicated energy crops and trees, agricultural food and feed crops, agricultural crop wastes and residues, wood wastes and residues, aquatic plants, animal wastes, municipal wastes, and other waste materials³.

The building heat load was calculated via the methods described above. The existing systems were modeled as meeting the load at an average seasonal efficiency of 76%. The fuel requirements for meeting the load with the proposed systems were then calculated. The proposed biomass boiler was modeled at a 100% firing rate with efficiency of 86% based on typical product literature. The proposed condensing boiler was modeled with an efficiency that varied linearly between 85% at outdoor temperature of 20° F and 94% at outdoor temperature of 58° F.

The model projected that in a year of typical weather, the biomass boiler would use 15,685 therms (98 tons pellets) annually and the condensing boiler would use 10,225 therms. The resulting 25,910 therms consumption represents a 12.4% savings over the existing system under the same conditions.

ACTION ITEMS:

As detailed in Appendix B, the energy savings would not be advantageous due to the present

³ <https://www.nyserdera.ny.gov/Researchers-and-Policymakers/Biomass>

disparities in fuel prices between biomass pellets and natural gas. L&S contacted several pellet suppliers in New York State and Pennsylvania; however none would have vacuum delivery services available for Ulster County. Further, L&S contacted NYSERDA's Renewable Heat New York program management, who also could not identify a supplier. Net cost savings would be on the order of -\$13K at present prices giving a negative payback. This measure is not recommended unless fuel prices change to favor the cost of biomass pellets over natural gas.

ECM-3: Convert AC-4R to VAV

Project Cost:	\$48,200	
Simple Payback:	13.7	Years
Electricity Savings:	34,591	kWh /Year
Peak Demand Savings:	0	kW
Gas Heating Savings:	0	mmBtu/Year
Annual Cost Savings:	\$3,523	
% Reduction in CO2 Emissions:	37%	

EXISTING CONDITIONS:

AC-4R is multi-zone constant air volume air handling unit with a 7.5 HP fan motor, assumed to have a standard efficiency of 89.5%. There are reheat coils and zone dampers for each thermal zone.

ECM SPECIFICATIONS:

Replace the air handling unit AC-4R with a VAV unit. The system will include a new 7.5 HP supply fan and NEMA premium efficiency motor, controlled by a 7.5 HP VFD. The VAV unit will also include the necessary controls, heating and cooling water coils and dX coil with spit condenser.

ACTION ITEMS:

This measure is recommended.

Discussion of NYSERDA/NYPA Geothermal Clean Energy Challenge Stage 2 Report

The County is participating in the NYSERDA/NYPA Geothermal Clean Energy Challenge. At the onset of this study, the County was in Stage 1 (Summary Report) of the Geothermal Clean Energy Challenge, and we were only tasked with providing insights associated with this stage. In the meantime, the County had a Stage 2 (Advanced Report) completed, so we expanded our efforts to include insights for Stage 2 below. The complete Advanced Report is included in Appendix D.

The Stage 2 building energy model (BEM) analysis of the Office Building was completed with the whole building energy simulation program Energy Plus, through Open Studio software. The estimated energy use was simulated for the single closed loop ground source heat pump (GSHP) system. Energy Plus includes a library of typical loads and system performance characteristics that were likely used to fine tune the energy load patterns, in addition to input parameters provided by the County. The study cautions that the results are still considered preliminary and a detailed feasibility assessment (Stage 3) should be pursued, if the County finds the results of the Stage 2 favorable.

In summary, the Stage 2 report does not specify how the GSHP would be integrated with the existing Office Building HVAC systems, or the type of GSHP system that should be considered, i.e. air to water or water to water. The payback with incentive is estimated to be 15-17 years, which is the median of the range from our experience. The County was approved for Stage 3, which may give an opportunity to flush out some more of the assumptions and look for opportunities to reduce the implementation costs. The assumptions and energy rates used in the GSHP study may be different from the parameters used in this FlexTech study and may be too extensive to list in detail here. The simple payback would be about the same if the rates in this report were used.

HEATING/COOLING MASTER - FURTHER ANALYSIS (FA)

GPI/L&S meet with the County on May 16, 2019 to review the draft Flex Tech Study and technologies evaluated. On July 10, 2019, the County provided guidance to L&S/GPI on a selected course of action to integrate into the final Flex Tech Study and Heating/Cooling Master Plan.

The County selected the following measures for detailed (specification-level) cost estimation and economic analysis for the Ulster County Office Building. Adjustments to energy analysis may also be completed when deemed appropriate and within the project scope of work.

- ECM-1: Install Two Condensing Natural Gas Boilers
- ECM-3: Convert AC-4R to VAV

FA ECM-1: Install Two Condensing Natural Gas Boilers

Project Cost:	\$241,600	
Simple Payback:	69.8	Years
Electricity Savings:	0	kWh /Year
Peak Demand Savings:	0	kW
Gas Heating Savings:	402	mmBtu/Year
Annual Energy Cost Savings:	\$3,461	
% Reduction in CO2 Emissions:	14%	

COUNTY SELECTED COURSE OF ACTION:

Replace the two existing sectional, gas-fired boilers with two new condensing boilers.

EXISTING CONDITIONS:

The Ulster County Office Building receives its heating hot water from two failing standard efficiency natural gas boilers. The performance characteristics are included in Table 1 in the Assessment of Site Conditions section.

COUNTY SOW SPECIFICATIONS:

Work to include replacement of the two original 120 HP gas-fired cast iron sectional boilers with two 120 HP gas-fired condensing boilers. Gas-fired burners shall be modulating. The design basis for these will be Cleaver Brooks. Replace existing heating system service valves in Mechanical Room. Modify or replace existing systems as needed. Modify the existing Building Management System control sequences to operate the heating system to take advantage of condensing mode as frequently as possible and schedule operation of boilers in lead-lag arrangement. Automatically reset the supply water temperature in accordance with the New York State Energy Code.

As per the scope of work for this project, the assumption that only one boiler runs at a time has not changed from the preliminary analysis for ECM-1; one condensing boiler was modeled with a full load capacity of 5,124 MBH and an efficiency of 94%, based on manufacturer specifications. The customer noted that both boilers occasionally run at the same time (during peak heating), however, the loads in the analysis are based on historical energy use, so this should not have a significant impact on the energy savings estimate.

Considering two boilers are being replaced, rather than just one, the energy savings-based payback essentially doubled.

FA ECM-3: Convert AC-4R to VAV

Project Cost:	\$48,200	
Simple Payback:	13.7	Years
Electricity Savings:	34,591	kWh /Year
Peak Demand Savings:	0	kW
Gas Heating Savings:	0	mmBtu/Year
Annual Cost Savings:	\$3,523	
% Reduction in CO2 Emissions:	37%	

COUNTY SELECTED COURSE OF ACTION:

Convert AC-4R to VAV.

EXISTING CONDITIONS:

AC-4R is multi-zone constant air volume air handling unit with a 7.5 HP fan motor, assumed to have a standard efficiency of 89.5%. There are reheat coils and zone dampers for each thermal zone.

COUNTY SOW SPECIFICATIONS:

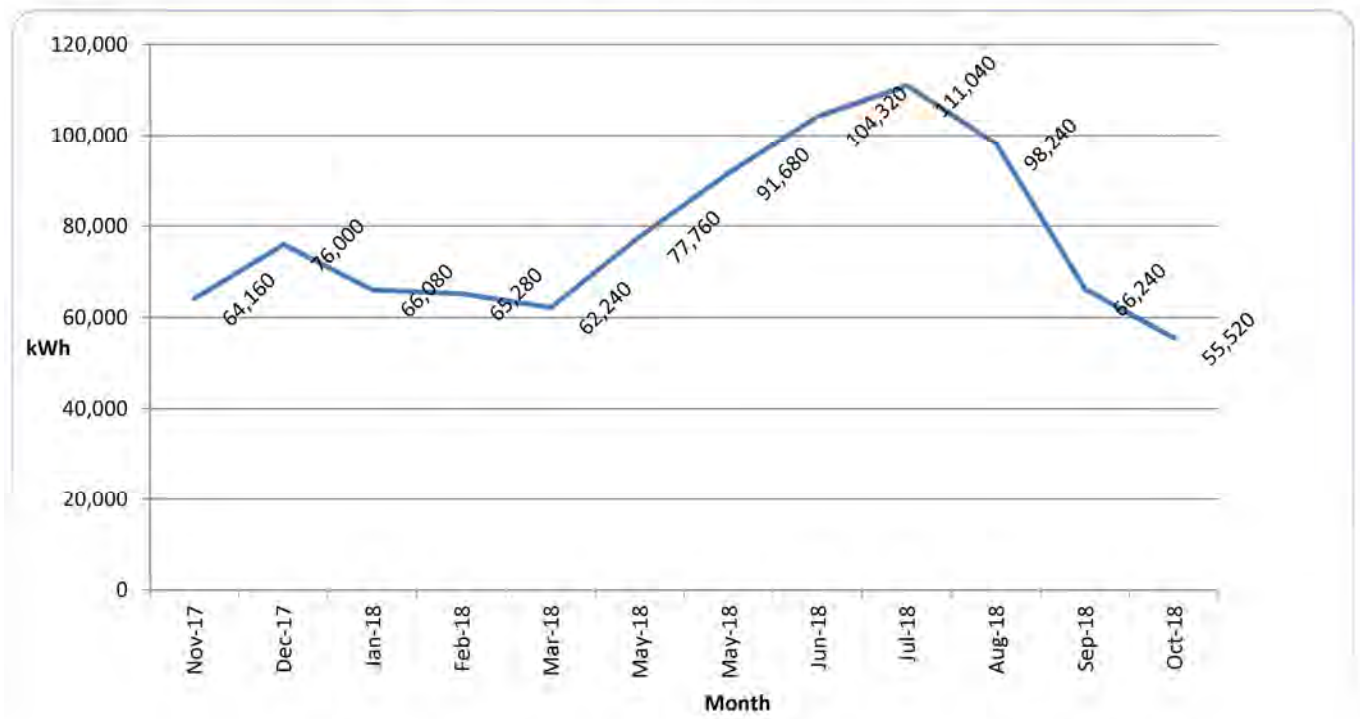
Work to include replacement of existing AC-4R with a VAV unit/system. This unit currently is a two-deck multizone unit with DX, chilled water and hot water coils. Reconfigure each existing zone as a VAV zone. DX and chilled water are there for redundancy. Maintain DX, chilled water and hot water functionality.

Appendix A – Utility Bill Summary

Facility: Ulster County Office Building
Address: 244 Fair St.
City: Kingston, NY
ZIP: 12402

Utility Provider: Central Hudson Gas & Electric

From	To	Total Use kWh	Utility kW Demand	Utility Energy \$	Utility Demand \$	Utility \$/kWh	Utility \$/kW	Total Electricity \$
11/13/2017	12/14/2017	64,160	152.0	\$6,924	\$1,161	\$0.108	\$7.640	\$8,086
12/14/2017	1/17/2018	76,000	171.2	\$7,777	\$1,308	\$0.102	\$7.640	\$9,085
1/17/2018	2/15/2018	66,080	155.2	\$6,968	\$1,186	\$0.105	\$7.642	\$8,154
2/16/2018	3/20/2018	65,280	147.2	\$7,095	\$1,350	\$0.109	\$9.171	\$8,445
3/21/2018	5/1/2018	62,240	150.4	\$6,789	\$1,149	\$0.109	\$7.640	\$7,938
5/2/2018	5/22/2018	77,760	238.4	\$8,715	\$1,821	\$0.112	\$7.638	\$10,536
5/23/2018	6/21/2018	91,680	252.8	\$9,833	\$1,931	\$0.107	\$7.638	\$11,764
6/22/2018	7/19/2018	104,320	257.6	\$11,054	\$2,121	\$0.106	\$8.234	\$13,175
7/20/2018	8/21/2018	111,040	249.6	\$12,100	\$2,154	\$0.109	\$8.630	\$14,254
8/22/2018	9/20/2018	98,240	270.4	\$10,826	\$2,334	\$0.110	\$8.632	\$13,160
9/21/2018	10/17/2018	66,240	233.6	\$7,860	\$2,016	\$0.119	\$8.630	\$9,876
10/18/2018	11/15/2018	55,520	193.6	\$6,730	\$1,671	\$0.121	\$8.631	\$8,401
		938,560	206.0	\$102,671	\$20,202	\$0.110	\$8.147	\$122,873



Facility: Ulster County Office Building
Address: 244 Fair St.
City: Kingston, NY
ZIP: 12402

Utility Provider: Central Hudson Gas and Electric

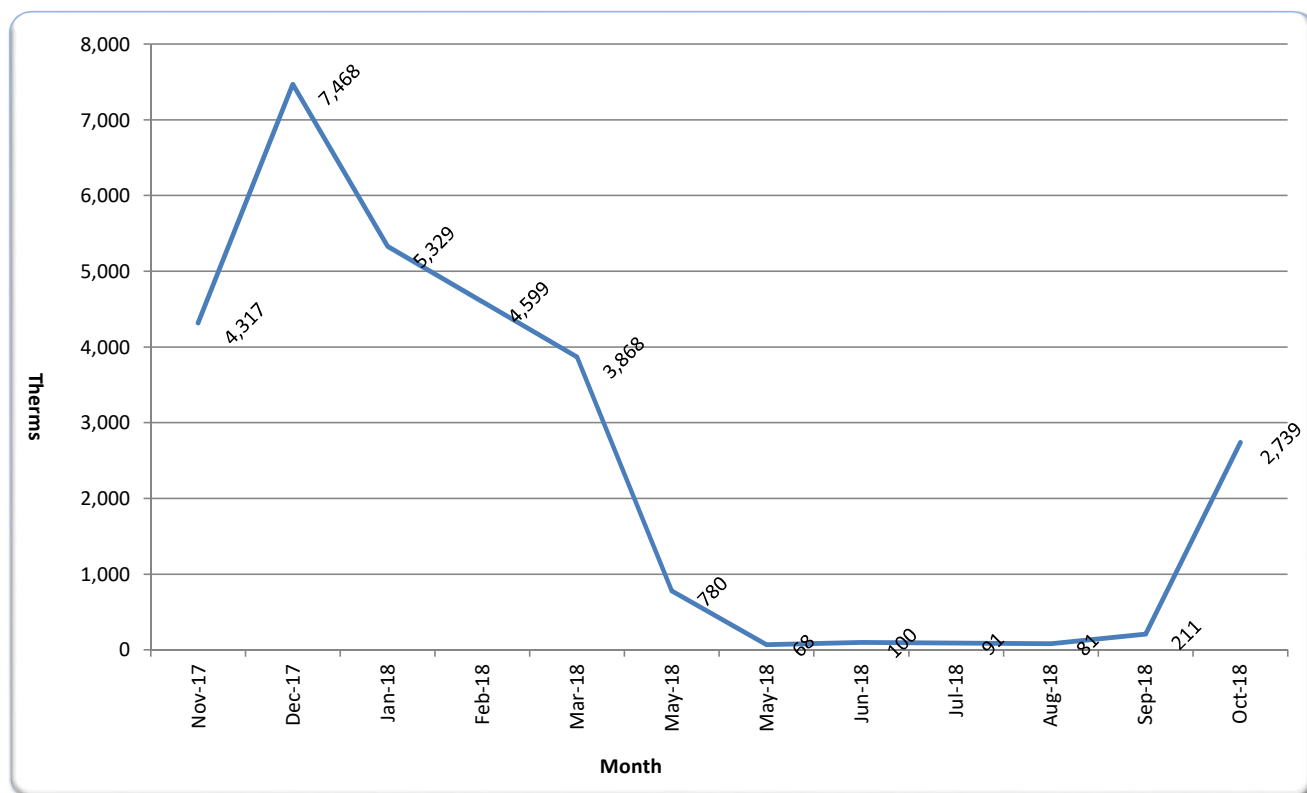
Natural Gas

BTU Content (Btu/therm):
 100,000

From	To	Natural Gas Therms	NG \$	Supply \$	Total Natural Gas \$	Total \$/therm
11/13/2017	12/14/2017	4,317	\$1,439	\$2,229	\$3,668	\$0.850
12/14/2017	1/17/2017	7,468	\$2,084	\$3,856	\$5,940	\$0.795
1/17/2018	2/15/2018	5,329	\$1,950	\$2,751	\$4,701	\$0.882
2/16/2018	3/20/2018	4,599	\$1,801	\$2,374	\$4,175	\$0.908
3/21/2018	5/1/2018	3,868	\$1,210	\$1,997	\$3,207	\$0.829
5/2/2018	5/22/2018	780	\$347	\$394	\$741	\$0.950
5/23/2018	6/21/2018	68	\$79	\$35	\$114	\$1.674
6/22/2018	7/19/2018	100	\$98	\$52	\$150	\$1.500
7/20/2018	8/21/2018	91	\$92	\$48	\$140	\$1.535
8/22/2018	9/20/2018	81	\$84	\$42	\$125	\$1.544
9/21/2018	10/17/2018	211	\$130	\$108	\$238	\$1.126
10/18/2018	11/15/2018	2,739	\$896	\$1,441	\$2,337	\$0.853
		29,651	\$4,736	\$6,491	\$25,535	\$0.861

NOTE: Supply costs in italics not provided - amount shown is estimated

\$/MMBtu: **\$8.61**





ENERGY STAR® Data Verification Checklist

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ENERGY STAR®
Score¹

Ulster County Office Building

Registry Name: Ulster County Office Building

Property Type: Office

Gross Floor Area (ft²): 62,396

Built: 1964

For Year Ending: Dec 31, 2018

Date Generated: Apr 2, 2019

1. The ENERGY STAR score is a 1-to-100 assessment of a building's energy efficiency as compared with similar building nationwide, adjusting for climate and business activity.

Property & Contact Information

Property Address

Ulster County Office Building
244 Fair Street
Kingston, New York 12401

Property Owner

,
(____)____-____

Primary Contact

,
(____)____-____

Property ID: 2352952

Ulster County ID: B222

1. Review of Whole Property Characteristics

Basic Property Information

1) Property Name: Ulster County Office Building

☐ Yes ☐ No

Is this the official name of the property?

If "No", please specify: _____

2) Property Type: Office

☐ Yes ☐ No

Is this an accurate description of the primary use of this property?

3) Location:

☐ Yes ☐ No

244 Fair Street
Kingston, New York 12401

Is this correct and complete?

4) Gross Floor Area: 62,396 ft²

☐ Yes ☐ No

Is value an accurate account of the gross floor area for the property?

5) Average Occupancy (%): 100

☐ Yes ☐ No

Is this occupancy percentage accurate for the entire 12 month period being assessed?

6) Number of Buildings: 1

☐ Yes ☐ No

Does this number accurately represent all structures?

7) Whole Property Verification:

☐ Yes ☐ No

Does this application represent the entire property? If any space or energy use has been excluded from this property, please describe it in the notes section below.

Notes:

Indoor Environmental Quality

1) Outdoor Air Ventilation

☐ Yes ☐ No

Does this property meet the minimum ventilation rates according to ANSI/ASHRAE Standard 62.1, Ventilation for Acceptable Indoor Air Quality?

2) Thermal Environmental Conditions

☐ Yes ☐ No

Does this property meet the acceptable thermal environmental conditions according ANSI/ASHRAE Standard 55, Thermal Environmental Conditions for Human Occupancy?

3) Illumination

☐ Yes ☐ No

Does this property meet the minimum illumination levels as recommended by the Illuminating Engineering Society of North America (IESNA) Lighting Handbook?

Notes:

2. Review of Property Use Details

Office: UCOB

★ This Use Detail is used to calculate the 1-100 ENERGY STAR Score.

★ 1) **Gross Floor Area:** 62,396 ft²

☐ Yes ☐ No

Is this the total size, as measured between the outside surface of the exterior walls of the building(s)? This includes all areas inside the building(s) such as: occupied tenant areas, common areas, meeting areas, break rooms, restrooms, elevator shafts, mechanical equipment areas, and storage rooms. Gross Floor Area should not include interstitial plenum space between floors, which may house pipes and ventilation. Gross Floor Area is not the same as rentable, but rather includes all area inside the building(s). Leasable space would be a sub-set of Gross Floor Area. In the case where there is an atrium, you should count the Gross Floor Area at the base level only. Do not increase the size to accommodate open atrium space at higher levels. The Gross Floor Area should not include any exterior spaces such as balconies or exterior loading docks and driveways.

★ 2) **Weekly Operating Hours:** 60

☐ Yes ☐ No

Is this the total number of hours per week that the property is occupied by the majority of the employees? It does not include hours when the HVAC system is starting up or shutting down, or when property is occupied only by maintenance, security, cleaning staff, or other support personnel. For properties with a schedule that varies during the year, use the schedule most often followed.

★ 3) **Number of Workers on Main Shift:** 204

☐ Yes ☐ No

Is this the total number of workers present during the primary shift? This is not a total count of workers, but rather a count of workers who are present at the same time. For example, if there are two daily eight hour shifts of 100 workers each, the Number of Workers on Main Shift value is 100. Number of Workers on Main Shift may include employees of the property, sub-contractors who are onsite regularly, and volunteers who perform regular onsite tasks. Number of Workers should not include visitors to the buildings such as clients, customers, or patients.

★ 4) **Number of Computers:** 173

☐ Yes ☐ No

Is this the total number of computers, laptops, and data servers at the property? This number should not include tablet computers, such as iPads, or any other types of office equipment.

5) **Percent That Can Be Heated:** 100

☐ Yes ☐ No

Is this the total percentage of the property that can be heated by mechanical equipment?

★ 6) **Percent That Can Be Cooled:** 100

☐ Yes ☐ No

Is this the total percentage of the property that can be cooled by mechanical equipment? This includes all types of cooling from central air to individual window units.

Notes:

Parking: Parking Use

★ This Use Detail is used to calculate the 1-100 ENERGY STAR Score.

★ 1) **Open Parking Lot Size:** 45,500 ft²

☐ Yes ☐ No

Is this the total area that is lit and used for parking vehicles? Open Parking Lot Size refers specifically to open area, which may include small shading covers but does not include any full structures with roofs. Parking lot size may include the area of parking spots, lanes, and driveways.

★ 2) **Partially Enclosed Parking Garage Size:** 0 ft²

☐ Yes ☐ No

Is this the total area of parking structures that are partially enclosed? This includes parking garages where each level is covered at the top, but the walls are partially or fully open.

★ 3) **Completely Enclosed Parking Garage:** 0 ft²

☐ Yes ☐ No

Is this the total area of parking structures that are completely enclosed on all four sides and have a roof? This includes underground parking or fully enclosed parking on the first few stories of a building.

★ 4) **Supplemental Heating:** No

☐ Yes ☐ No

Is this the correct answer to whether your parking garage has Supplemental Heating, which is a heating system to pre-heat ventilation air and/or maintain a minimum temperature during winter months?

Notes:

3. Review of Energy Consumption

Data Overview

Site Energy Use Summary

Natural Gas (kBtu)	2,944,360.2 (48%)
Electric - Grid (kBtu)	3,174,585.4 (52%)
Total Energy (kBtu)	6,118,945.6

Energy Intensity

Site (kBtu/ft ²)	98.1
Source (kBtu/ft ²)	192

National Median Comparison

National Median Site EUI (kBtu/ft ²)	91.8
National Median Source EUI (kBtu/ft ²)	179.7
% Diff from National Median Source EUI	6.9%

Emissions (based on site energy use)

Greenhouse Gas Emissions (Metric Tons CO ₂ e)	281.3
--	-------

Power Generation Plant or Distribution Utility:

Central Hudson Gas & Elec Corp

Note: All values are annualized to a 12-month period. Source Energy includes energy used in generation and transmission to enable an equitable assessment.

Summary of All Associated Energy Meters

The following meters are associated with the property, meaning that they are added together to get the total energy use for the property. Please see additional tables in this checklist for the exact meter consumption values. **Note: please review all meter entries, making note of any unusual entries, and, if they are correct, provide a manual note to explain.**

Meter Name	Fuel Type	Start Date	End Date	Associated With:
3620023000_Fixed Usage Lighting	Electric - Grid	01/01/2010	In Use	Ulster County Office Building
3620023000_NG_Supl	Natural Gas	05/01/2018	In Use	Ulster County Office Building
3620022000_Elec_Sup	Electric - Grid	03/20/2009	In Use	Ulster County Office Building
3620023000_NG_Supl Energy_CLOSED	Natural Gas	11/01/2014	05/01/2018	Ulster County Office Building
3620022000_Elec_Del	Electric - Grid	08/19/2009	In Use	Ulster County Office Building
3620023000_NG_Deli	Natural Gas	07/18/2009	In Use	Ulster County Office Building

Total Energy Use

☐ Yes ☐ No

Do the meters shown above account for the total energy use of this property during the reporting period of this application?

Additional Fuels

☐ Yes ☐ No

Do the meters above include all fuel types at the property? That is, no additional fuels such as district steam, generator fuel oil have been excluded.

On-Site Solar and Wind Energy

☐ Yes ☐ No

Are all on-site solar and wind installations reported in this list (if present)? All on-site systems must be reported.

Notes:

Summary of Additional Meters

None of the following meters are associated with the property meaning that they are not added together to account for the total energy use of the property.

Meter Name	Fuel Type	Start Date	End Date	Associated With:
EVSE_06	Electric - Grid	07/01/2015	In Use	None

Sub (or Ancillary) Meter Energy Use ☐ Yes ☐ No

Are the meters in this list all sub-meters or other ancillary meters that do not need to be added to the total energy for the reporting period of this application?

Notes:

Electric - Grid Meter: 3620023000_Fixed Usage Lighting (kWh (thousand Watt-hours))				
Associated With: Ulster County Office Building				
Start Date	End Date	Usage	Green Power?	
01/01/2018	01/31/2018	573	No	
02/01/2018	02/28/2018	477	No	
03/01/2018	03/31/2018	465	No	
04/01/2018	04/30/2018	411	No	
05/01/2018	05/31/2018	369	No	
06/01/2018	06/30/2018	327	No	
07/01/2018	07/31/2018	354	No	
08/01/2018	08/31/2018	396	No	
09/01/2018	09/30/2018	438	No	
10/01/2018	10/31/2018	504	No	
11/01/2018	11/30/2018	546	No	
12/01/2018	12/31/2018	600	No	
		Total Consumption (kWh (thousand Watt-hours)):	5,460	
		Total Consumption (kBtu (thousand Btu)):	18,629.5	

Total Energy Consumption for this Meter ☐ Yes ☐ No

Do the fuel consumption totals shown above include consumption of all energy tracked through this meter that affect energy calculations for the reporting period of this application (i.e., do the entries match the utility bills received by the property)?

Notes:

Natural Gas Meter: 3620023000_NG_Supply_Agera (ccf (hundred cubic feet))

Associated With: Ulster County Office Building

Start Date	End Date	Usage
05/01/2018	05/22/2018	0
05/22/2018	06/21/2018	0
06/21/2018	07/19/2018	0
07/19/2018	08/21/2018	0
08/21/2018	09/20/2018	0
09/20/2018	10/17/2018	0
10/17/2018	11/15/2018	0
11/15/2018	12/19/2018	0
12/19/2018	01/23/2019	0
Total Consumption (ccf (hundred cubic feet)):		0
Total Consumption (kBtu (thousand Btu)):		0

Total Energy Consumption for this Meter

☐ Yes ☐ No

Do the fuel consumption totals shown above include consumption of all energy tracked through this meter that affect energy calculations for the reporting period of this application (i.e., do the entries match the utility bills received by the property)?

Notes:

Electric - Grid Meter: 3620022000_Elec_Supply (kWh (thousand Watt-hours))

Associated With: Ulster County Office Building

Start Date	End Date	Usage	Green Power?
12/14/2017	01/17/2018	0	No
01/17/2018	02/15/2018	0	No
02/15/2018	03/20/2018	0	No
03/20/2018	04/19/2018	0	No
04/19/2018	05/22/2018	0	No
05/22/2018	06/19/2018	0	No
06/19/2018	07/19/2018	0	No
07/19/2018	08/21/2018	0	No
08/21/2018	09/20/2018	0	No
09/20/2018	10/17/2018	0	No
10/17/2018	11/15/2018	0	No
11/15/2018	12/19/2018	0	No
12/19/2018	01/23/2019	0	No
Total Consumption (kWh (thousand Watt-hours)):			0
Total Consumption (kBtu (thousand Btu)):			0

Total Energy Consumption for this Meter ☐ Yes ☐ No

Do the fuel consumption totals shown above include consumption of all energy tracked through this meter that affect energy calculations for the reporting period of this application (i.e., do the entries match the utility bills received by the property)?

Notes:

Natural Gas Meter: 3620023000_NG_Supply_Direct Energy_CLOSED (ccf (hundred cubic feet))

Associated With: Ulster County Office Building

Start Date	End Date	Usage
01/01/2018	01/17/2018	0
01/18/2018	01/31/2018	0
02/01/2018	02/15/2018	0
02/16/2018	02/28/2018	0
03/01/2018	03/20/2018	0
03/21/2018	03/31/2018	0

Start Date	End Date	Usage
04/01/2018	05/01/2018	0
Total Consumption (ccf (hundred cubic feet)):		0
Total Consumption (kBtu (thousand Btu)):		0

Total Energy Consumption for this Meter ☐ Yes ☐ No

Do the fuel consumption totals shown above include consumption of all energy tracked through this meter that affect energy calculations for the reporting period of this application (i.e., do the entries match the utility bills received by the property)?

Notes:

Electric - Grid Meter: 3620022000_Elec_Delivery (kWh (thousand Watt-hours))			
Associated With: Ulster County Office Building			
Start Date	End Date	Usage	Green Power?
12/14/2017	01/17/2018	76,000	No
01/17/2018	02/15/2018	66,080	No
02/16/2018	03/20/2018	65,280	No
03/21/2018	04/19/2018	62,240	No
04/20/2018	05/22/2018	77,760	No
05/23/2018	06/19/2018	91,680	No
06/20/2018	07/19/2018	104,320	No
07/20/2018	08/21/2018	111,040	No
08/22/2018	09/20/2018	98,240	No
09/21/2018	10/17/2018	66,240	No
10/18/2018	11/15/2018	55,520	No
11/16/2018	12/19/2018	67,040	No
12/20/2018	01/23/2019	69,280	No
Total Consumption (kWh (thousand Watt-hours)):		1,010,720	
Total Consumption (kBtu (thousand Btu)):		3,448,576.6	

Total Energy Consumption for this Meter ☐ Yes ☐ No

Do the fuel consumption totals shown above include consumption of all energy tracked through this meter that affect energy calculations for the reporting period of this application (i.e., do the entries match the utility bills received by the property)?

Notes:

Natural Gas Meter: 3620023000_NG_Delivery (ccf (hundred cubic feet))

Associated With: Ulster County Office Building

Start Date	End Date	Usage
12/14/2017	01/17/2018	7,468
01/17/2018	02/15/2018	5,329
02/16/2018	03/20/2018	4,599
03/21/2018	05/01/2018	3,868
05/02/2018	05/22/2018	780
05/23/2018	06/21/2018	68
06/22/2018	07/19/2018	100
07/20/2018	08/21/2018	91
08/22/2018	09/20/2018	81
09/21/2018	10/17/2018	211
10/18/2018	11/15/2018	2,739
11/16/2018	12/19/2018	5,177
12/20/2018	01/23/2019	6,242
Total Consumption (ccf (hundred cubic feet)):		36,753
Total Consumption (kBtu (thousand Btu)):		3,770,857.8

Total Energy Consumption for this Meter

☐ Yes ☐ No

Do the fuel consumption totals shown above include consumption of all energy tracked through this meter that affect energy calculations for the reporting period of this application (i.e., do the entries match the utility bills received by the property)?

Notes:

4. Signature & Stamp of Verifying Licensed Professional

_____ (Name) visited this site on _____ (Date). Based on the conditions observed at the time of the visit to this property, I verify that the information contained within this application is accurate and in accordance with the Licensed Professional Guide.

Signature _____

Date _____

Licensed Professional

,
(____)____-____

NOTE: When applying for the ENERGY STAR, the signature of the Verifying Professional must match the stamp.

Professional Engineering Stamp

(if applicable)

Appendix B – ECM Calculation Data

UCOB PFS 1: SOLAR DHW SCREEN

Background Info

2,735 therms/yr DHW UCOB balance temp & building load coefficient

F:\Mike Stiles\Ulster Co Law Enforcement Center (UCLEC)\UCOB

UCOB Summary

Domestic hot water is provided by two (2) natural gas-fired hot water heaters

Ulster County Office Building_mechanicals_from 2010 audit

21/36: Bradford White Magnum PHCC natural gas fired DHW
80 gal 250 MBH input

Third-Party Screening Tool

https://apps1.eere.energy.gov/femp/solar_hotwater_system/

ENERGY.GOV

Office of
ENERGY EFFICIENCY &
RENEWABLE ENERGY

Federal Energy Management Program

EERE » Federal Energy Management Program

Solar Hot Water System Calculator

Use the FEMP solar hot water calculator to estimate what size of solar system will work best for your Federal facility and how much it will cost.

The Energy Independence and Security Act (EISA) of 2007 Section 523 requires new Federal buildings and major renovations to meet 30% of hot water demand using solar hot water equipment if it is life-cycle cost effective. This tool can help meet that goal.

Follow the steps below to calculate approximate solar hot water system size and cost needed to meet the Energy Independence and Security Act (EISA) of 2007 Section 523 solar hot water requirement for new Federal construction and major renovations.

Step 1. Enter project and location information.

Project Name

UCOB

Select the nearest city/state

NY, ALBANY

ZIP Code

12402

Continue

Step 2. Calculate Hot Water Load and System Size

Select the appropriate building type from the drop-down menu. Tips on average Federal facility hot water load will be displayed to help complete the remaining fields. Then, enter the desired cold and hot water temperatures. Common temperatures are pre-entered for convenience, but can be changed to match your conditions.

Building Type

Office

Amount of Water Usage (M) - gallons / person / day / person

1

Number of person(s)

200

Cold Water Temperature (°F)(T_{cold})

50

Hot Water Temperature (°F)(T_{hot})

130

Calculate Load

Water Usage Estimates

Office: 1 gal/day/person
School: 2 gal/day/person
Barracks: 10 gal/day/person
Dormitory: 13 gal/day/person
Residence: 30 gal/day/person
Food Service: 2 gal/meal
Motel: 15 gal/day/room
Hospital: 18 gal/day/bed

Estimated System Size: 16.80 m²

Step 3. Estimate System Cost and Annual Savings

Annual energy and cost savings are calculated based on the current hot water heater fuel type, fuel price, and water heater efficiency level. Select the appropriate fuel type from the drop-down menu. The average efficiency level and fuel cost is provided, but can be changed to match your conditions.

Water Heater Type

GAS: 0.43 - 0.86, assume 0.57

Efficiency

0.75

Energy Cost / 1,000 cu. ft.

8.61

Calculate Energy Savings

UCOB PFS 1: SOLAR DHW SCREEN	
Final Report	
Based on the data provided, the results for your facility includes the following. Note that these outputs do not include available incentives or rebates.	
SITE INFORMATION	
Project Name	UCOB
Nearest City	NY, ALBANY
ZIP Code	12402
INPUT VALUES	
Building Type	Office
Amount of Water Usage	200 gal/day
Number of person(s)	200
Cold Water Temperature	50 (°F)(T _{cold})
Hot Water Temperature	120 (°F)(T _{hot})
Water Heater Fuel Type	gas
Water Heater Efficiency	0.75
Average Fuel Price	\$8.61/1,000 cu. ft.
CALCULATIONS	
System Size	16.80 m ²
System Cost	\$16,945.80
Annual Energy Savings	14,939.00 kWh/year
Annual Cost Savings	\$427.33 Based on \$8.61/\$1,000 cu. ft.
SIR	0.61
Simple Payback	29.66 years
Solar Fraction	79.00%
Annual Greenhouse Gas Reduction	5,961.26 lbs. of CO ₂

Savings Summary

Calculator savings:	14,939 kWh
Conversion factor:	3,413 Btu/kWh
	0.003413 mmBtu/kWh

Solar mmBtu savings = 51

Natural gas cost savings:

\$8.612 \$/mmBtu natural gas (proposed)
Cost savings = \$439

UCOB PFS 2: AIR SOURCE HEAT PUMP SCREENING CALCULATIONS

Existing Equipment

Heating

Boiler type	Natural gas fired hot water boiler
Make, model, age	Weil McClain Model 1688; 1988
MBH input	5124
# units	1 (there are two but one is used at a time)
Total MBH input	5,124
Efficiency	79.8% nameplate; boilers are well maintained
Assumed maximum efficiency	76.0%
Assumed avg seasonal efficiency	73.4%

Cooling

Equipment Year	Unit	Type	Comments
2003	VSD Chiller	York MaxE Centrifugal Chiller Model YTG1A1B2-CHJ	237.6 ton cooling coil capacity (from Trane-Trace analysis)

Strategy for Screening: Heating

Issues

The goal is to compare existing with proposed equipment performance, given that existing heating is from A natural gas-fired boiler, proposed is from air source heat pump(s)

Strategy

Convert existing building heating load, natural gas consumption to equivalent kWh

Building load	22,482 therms
See:	UCOB BIOMASS + CONDENSING BOILER MODEL
	3413 Btu/kWh
	658,707 kWh equivalent heating load (FYI)

Assumptions about proposed heat pumps

High-efficiency
In order to effectively operate all season, must have good COP to low outdoor air temperature
>>> This requires a variable refrigerant flow (VRF) system
Example heating COP is thus assumed = 3.3
(Example system: Mitsubishi PUMY or PURY -- *not a recommendation, for illustrative purposes only*)

Existing boiler usage base year (setup for savings calculation)

29,651 therms annual usage
3413 Btu/kWh
868,766 kWh equivalent heating usage (FYI)

Heat Pump Energy Usage Calculation: Heating

$$\text{Proposed kWh} = \# \text{ of Units} \times \left(\frac{\text{kBtu}_{\text{h out}}}{\text{Unit}} \right) \times \left(\frac{1}{\text{COP}_{\text{ee}}} \right) \times \frac{\text{EFLH}_{\text{heat}}}{3.413}$$

From above; use building load to get usage:

$$\# \text{ of Units} \times (\text{kBtu}_{\text{h out}}/\text{unit}) \times \text{EFLH}_{\text{heat}} = 22,482 \text{ therms} \times 100 \text{ kBtu/therm} = 2,248,167 \text{ kBtu}$$

$$\text{COP} = 3.3$$

$$\text{Proposed kWh} = 199,608 \text{ kWh}$$

Strategy for Screening: Cooling

Issues

Need to estimate existing cooling energy usage & system efficiency

Strategy

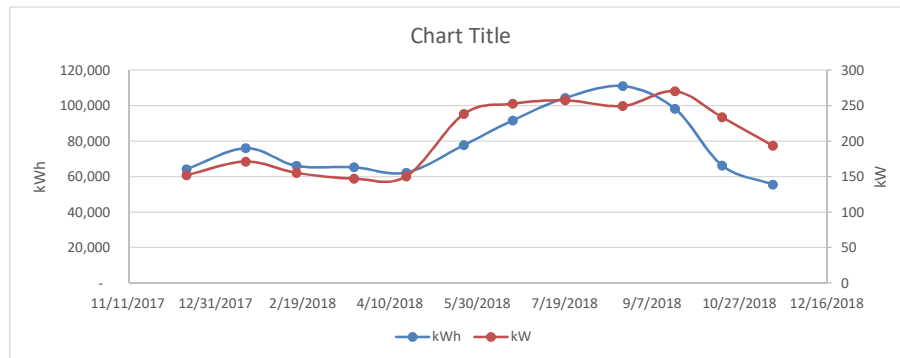
Rough estimates from base year utility data

UCOB PFS 2: AIR SOURCE HEAT PUMP SCREENING CALCULATIONS

Existing system analysis

Utility data for base year:

Read Date	kWh	kW
12/14/2017	64,160	152
1/17/2018	76,000	171.2
2/15/2018	66,080	155.2
3/20/2018	65,280	147.2
4/19/2018	62,240	150.4
5/22/2018	77,760	238.4
6/19/2018	91,680	252.8
7/19/2018	104,320	257.6
8/21/2018	111,040	249.6
9/20/2018	98,240	270.4
10/17/2018	66,240	233.6
11/15/2018	55,520	193.6



Re-order data for further analysis:

Read Date	kWh	Avg non-cooling kWh
11/15/2018	55,520	64,880
12/14/2017	64,160	
1/17/2018	76,000	
2/15/2018	66,080	
3/20/2018	65,280	
4/19/2018	62,240	
	kWh	kWh - Avg non clg kWh
5/22/2018	77,760	12,880
6/19/2018	91,680	26,800
7/19/2018	104,320	39,440
8/21/2018	111,040	46,160
9/20/2018	98,240	33,360
10/17/2018	66,240	1,360
		160,000 total base year cooling usage

Existing operational parameters

$$\text{Baseline kWh} = \# \text{ of Units} \times \text{Tons per Unit} \times \left(\frac{12}{\text{SEER}_{\text{base}}} \right) \times \text{EFLH}_{\text{cooling}}$$

baseline kWh =	160,000
# of units x tons/unit =	237.6 tons (See Existing Equipment, above)
SEERbase =	7 estimated based on engineering experience
EFLHcooling =	392.8 ...and assume this remains constant for proposed equipment

UCOB PFS 2: AIR SOURCE HEAT PUMP SCREENING CALCULATIONS

Heat Pump Energy Usage Calculation: Cooling

$$\text{Proposed kWh} = \# \text{ of Units} \times \text{Tons per Unit} \times \left(\frac{12}{\text{SEER}_{ee}} \right) \times \text{EFLH}_{cooling}$$

where SEER_{ee} is for the proposed energy-efficient equipment

For the Mitsubishi PUMY unit referenced above, SEER ~ 15

Proposed kWh = 74,667

Energy and Cost Savings Summary

	Heating		Cooling
	therms	kWh	kWh
Existing	29,651	0	160,000
Proposed	0	199,608	74,667
Savings	29,651	(199,608)	85,333

Net energy savings: 29,651 therms
(114,275) kWh

Utility Rates: \$0.131 \$/kWh blended
\$0.861 \$/therm natural gas

	Heating		Cooling
	therms	kWh	kWh
Existing	\$25,536	\$0	\$20,947
Proposed	\$0	\$26,132	\$9,775
Savings	\$25,536	-\$26,132	\$11,172

\$10,575 net cost savings

Estimated Implementation Cost and Simple Payback

RSMeans Mechanical 2018

23 81 29.10 1010 Multi-Zone Split

Assume labor includes demolition of existing equipment & prep for new

Material	Labor	Total
\$32,322	\$778	\$33,100

for 15 ton system

Assume cost scales proportionally according to 238 tons / 15 tons:

Material	Labor	Total
\$512,850	\$12,337	\$525,187

Simple Payback

Cost \$525,187
Annual Savings \$10,575
Payback 49.7 years

UCOB PFS 3: THERMAL STORAGE SCREENING ANALYSIS

Cooling Demand Estimated from Utility Data

Starting Data (from utility data summary):

End Date	kW	kW \$	\$/kW	
12/14/2017	152	\$1,161	\$7.64	
1/17/2018	171.2	\$1,308	\$7.64	
2/15/2018	155.2	\$1,186	\$7.64	
3/20/2018	147.2	\$1,350	\$9.17	
4/19/2018	150.4	\$1,149	\$7.64	
5/22/2018	238.4	\$1,821	\$7.64	apparent cooling season billing period
6/19/2018	252.8	\$1,931	\$7.64	
7/19/2018	257.6	\$2,121	\$8.23	
8/21/2018	249.6	\$2,154	\$8.63	
9/20/2018	270.4	\$2,334	\$8.63	
10/17/2018	233.6	\$2,016	\$8.63	
11/15/2018	193.6	\$1,671	\$8.63	

Avg kW for non-cooling season billing period = 161.6

Avg \$/kW during cooling season = \$8.23 \$/kW

End Date	kW	kW - avg kW for non clg season	
5/22/2018	238.4	76.8	
6/19/2018	252.8	91.2	These values do not show a marked peak, take the average for analysis
7/19/2018	257.6	96	
8/21/2018	249.6	88	
9/20/2018	270.4	108.8	
10/17/2018	233.6	72	
			88.8 kW avg monthly peak demand increase attributed to cooling

Assumptions and Savings Estimates

Estimated monthly demand charge due to centrifugal chiller =

88.8 kW/month * \$8.23 \$/kW = \$731 monthly existing cost

Estimated % reduction of chiller operation at peak due to thermal storage =

50%

http://illinoisashrae.org/images/meeting/032514/YEA_Conf_Presentations_2014/energy_storage.pdf

Estimated cost savings/month if thermal storage installed =

\$366

Months of cooling season demand charges (see above)

6

kW demand reduction @ 50% for # months indicated =

266.4

Estimated annual demand savings if thermal storage installed =

\$2,194

Estimated minimum cost of ice storage (238 ton chiller) =

\$300,000

http://illinoisashrae.org/images/meeting/032514/YEA_Conf_Presentations_2014/energy_storage.pdf

+ cursory Google search

Simple payback =

136.8 years

UCOB Boiler Replacement	
Ulster County Office Building	244 Fair Street
	Kingston, NY 12402
ECM 1 - Install Condensing Natural Gas Boiler	
Existing Boiler Input Capacity (MBH ea.):	5,124
Proposed Condensing Boiler Input Capacity (MBH ea.):	5,124
Bin Temp at Which 100% Load Occurs (deg F)	2.5
Bin Temp for Balance Point	57.5
Boiler Availability:	Heating season
Btus per Therm Conversion Factor:	100,000
Existing Boiler Efficiency (assumed system)	76%
Proposed Condensing Boiler Efficiency (condensing above 20°F OSA)	94%
Proposed Condensing Boiler Efficiency (non-condensing below 20°F OSA)	85%
\$/therm natural gas	\$ 0.86
Gas Savings (mmBtu)	402
Gas Savings Cost	\$3,461
Total Savings (\$)	\$3,461

Notes: For this example, condensing boiler assumed 100% of existing boiler capacity. Actual capacities to be determined at design.

Determine Existing Boiler Heating Usage:

Usage was analyzed using utility billing data from 2/17/17 to 11/15/18

Assumptions and Approach:

1. The model of heating energy usage is based on utility natural gas data that is billed monthly.
2. Usage is modeled by a regression analysis; its parameters are functions of heating degree days (HDD).
3. TMY3 data is from Poughkeepsie Dutchess Co AP; date, time, and outdoor air dry bulb temperature

See: Building Load Determination section of report for more details on regression analysis

4. Excerpts below are from 8760 model

TMY3 Data Excerpt:

Date	Time	Dry-bulb (F)	HDhr @58°F base
1/1/2005	1:00	35.6	22.4
1/1/2005	2:00	33.8	24.2
1/1/2005	3:00	37.4	20.6
1/1/2005	4:00	39.2	18.8
1/1/2005	5:00	33.8	24.2
1/1/2005	6:00	46.4	11.6
1/1/2005	7:00	35.6	22.4
1/1/2005	8:00	44.6	13.4
1/1/2005	9:00	44.6	13.4
1/1/2005	10:00	51.8	6.2
1/1/2005	11:00	53.6	4.4
1/1/2005	12:00	55.4	2.6
1/1/2005	13:00	53.6	4.4
1/1/2005	14:00	51.8	6.2
1/1/2005	15:00	50	8
...

Regression analysis results:

therms/day = 6.1549 therms/HDD58 + 7.4944 therms/day

ECM 1 - Install Condensing Natural Gas Boiler**Determine Existing Building Load:**

Billing date range and Assumptions and Approach following approach above.

Load Therms = Existing usage therms * Existing efficiency

Regression analysis results:

therms/day = 4.6777 therms/HDD58 + 5.6957 therms/day

Therms Usage by Regression -- Building Load Excerpt:

Date	Time	Therms
1/1/2005	1:00	4.6
1/1/2005	2:00	5.0
1/1/2005	3:00	4.3
1/1/2005	4:00	3.9
1/1/2005	5:00	5.0
1/1/2005	6:00	2.5
1/1/2005	7:00	4.6
1/1/2005	8:00	2.8
1/1/2005	9:00	2.8
1/1/2005	10:00	1.4
1/1/2005	11:00	1.1
1/1/2005	12:00	0.7
1/1/2005	13:00	1.1
1/1/2005	14:00	1.4
...

Building Load

Total Sum - Therms Monthly:	
Jan	5,054
Feb	4,008
Mar	2,537
Apr	1,442
May	658
Jun	286
Jul	193
Aug	258
Sep	418
Oct	1,668
Nov	2,000
Dec	3,962
Total	22,482

In a year of typical weather, existing system building load was estimated to be
22,482 therms

Apply 8760 hour model to existing system usage in a year of typical weather:

Hourly usage = hourly load / existing efficiency (76%)

Therms Usage by Regression -- Existing Excerpt:

Date	Time	Therms
1/1/2005	1:00	6.1
1/1/2005	2:00	6.5
1/1/2005	3:00	5.6
1/1/2005	4:00	5.1
1/1/2005	5:00	6.5
1/1/2005	6:00	3.3
1/1/2005	7:00	6.1
1/1/2005	8:00	3.7
1/1/2005	9:00	3.7
1/1/2005	10:00	1.9
1/1/2005	11:00	1.4
1/1/2005	12:00	1.0
1/1/2005	13:00	1.4
1/1/2005	14:00	1.9
1/1/2005	15:00	2.4
...

Existing NG Usage

Total Sum - Therms Monthly:	
Jan	6,649
Feb	5,273
Mar	3,338
Apr	1,897
May	866
Jun	376
Jul	253
Aug	339
Sep	550
Oct	2,195
Nov	2,631
Dec	5,213
Total	29,581

In a year of typical weather, existing system natural gas usage was estimated to be
29,581 therms

ECM 1 - Install Condensing Natural Gas Boiler**Calculate Condensing Natural Gas Boiler Usage:**

Hourly usage = hourly load / condensing boiler efficiency where:

Condensing Boiler Efficiency Parameters

Outdoor air temperature (OAT, deg F) selections:

OAT for maximum condensing efficiency =

58 F

OAT below which condensing stops =

20 F

OAT	effic		
20	85%	m=	0.00237
58	94%	b=	0.80263

Therms Usage -- Proposed Excerpt:

Date	Time	Condensing Boiler:	
		Efficiency	Total Therms
1/1/2005	1:00		
1/1/2005	2:00	89%	5.2
1/1/2005	3:00	88%	5.6
1/1/2005	4:00	89%	4.8
1/1/2005	5:00	90%	4.4
1/1/2005	6:00	88%	5.6
1/1/2005	7:00	91%	2.7
1/1/2005	8:00	89%	5.2
1/1/2005	9:00	91%	3.1
1/1/2005	10:00	91%	3.1
1/1/2005	11:00	93%	1.6
1/1/2005	12:00	93%	1.2
1/1/2005	13:00	93%	0.8
1/1/2005	14:00	93%	1.2
1/1/2005	15:00	93%	1.6
...

Proposed Usage

Total Sum - Therms Monthly:	
	Boiler
Jan	5,863
Feb	4,636
Mar	2,860
Apr	1,600
May	716
Jun	307
Jul	205
Aug	276
Sep	451
Oct	1,856
Nov	2,244
Dec	4,548
Totals	25,563

Savings Summary

System	Usage	Costs
	NG (Therms)	
Existing	29,581	\$ 25,476
Proposed:	25,563	\$ 22,015
Savings	4,018	\$ 3,461

NIST BLCC 5.3-18: Comparative Analysis

Consistent with Federal Life Cycle Costing Methodology and Procedures, 10 CFR, Part 436, Subpart A FlexTech Study

Base Case: Existing NG Boiler

Alternative: ECM 1 - Install Condensing Natural Gas Boiler

General Information

File Name:	C:\Users\Bkelly\Documents\Projectfiles\Projects\FlexTech\L&SReports\Ulster County\UCOB\Utility Bills\BLCC5\BLCC5 - UCOB - fuel v.2.xml
Date of Study:	Tue Sep 17 12:29:49 EDT 2019
Project Name:	Ulster County Office Building
Project Location:	New York
Analysis Type:	FEMP Analysis, Energy Project
Analyst:	Brendan Kelly
Base Date:	April 1, 2019
Service Date:	April 1, 2020
Study Period:	30 years 0 months (April 1, 2019 through March 31, 2049)
Discount Rate:	3%
Discounting Convention:	End-of-Year

Comparison of Present-Value Costs

PV Life-Cycle Cost

	Base Case	Alternative	Savings from Alternative
Initial Investment Costs:			
Capital Requirements as of Base Date	\$0	\$109,625	-\$109,625
Future Costs:			
Energy Consumption Costs	\$560,824	\$483,897	\$76,927
Energy Demand Charges	\$0	\$0	\$0
Energy Utility Rebates	\$0	\$0	\$0
Water Costs	\$0	\$0	\$0
Recurring and Non-Recurring OM&R Costs	\$0	\$0	\$0
Capital Replacements	\$0	\$0	\$0
Residual Value at End of Study Period	\$0	\$0	\$0
	-----	-----	-----
Subtotal (for Future Cost Items)	\$560,824	\$483,897	\$76,927
	-----	-----	-----
Total PV Life-Cycle Cost	\$560,824	\$593,522	-\$32,698

Net Savings from Alternative Compared with Base Case

PV of Non-Investment Savings	\$76,927	Page 49	L&S Energy Services Inc.
- Increased Total Investment	\$109,625		

Net Savings - \$32,698

Savings-to-Investment Ratio (SIR)

SIR = 0.70

SIR is lower than 1.0; project alternative is not cost effective.

Adjusted Internal Rate of Return

AIRR = 1.79%

AIRR is lower than your discount rate; project alternative is not cost effective.

Payback Period

Estimated Years to Payback (from beginning of Service Period)

Discounted Payback never reached during study period.

Simple Payback occurs in year 27

Energy Savings Summary

Energy Savings Summary (in stated units)

Energy	-----Average	Annual	Consumption-----	Life-Cycle
Type	Base Case	Alternative	Savings	Savings
Natural Gas	2,958.1 MBtu	2,556.3 MBtu	401.8 MBtu	11,650.8 MBtu

Energy Savings Summary (in MBtu)

Energy	-----Average	Annual	Consumption-----	Life-Cycle
Type	Base Case	Alternative	Savings	Savings
Natural Gas	2,958.1 MBtu	2,556.3 MBtu	401.8 MBtu	11,650.8 MBtu

Emissions Reduction Summary

Energy	-----Average	Annual	Emissions-----	Life-Cycle
Type	Base Case	Alternative	Reduction	Reduction
Natural Gas				
CO2	156,253.77 kg	135,029.75 kg	21,224.02 kg	615,423.86 kg
SO2	1,261.02 kg	1,089.73 kg	171.28 kg	4,966.66 kg
NOx	131.10 kg	113.29 kg	17.81 kg	516.34 kg

Total:

CO2	156,253.77 kg	135,029.75 kg	21,224.02 kg	615,423.86 kg
SO2	1,261.02 kg	1,089.73 kg	171.28 kg	4,966.66 kg
NOx	131.10 kg	113.29 kg	17.81 kg	516.34 kg

NIST BLCC 5.3-18: Comparative Analysis

Consistent with Federal Life Cycle Costing Methodology and Procedures, 10 CFR, Part 436, Subpart A FlexTech Study

Base Case: Existing NG Boiler

Alternative: FA ECM 1 - Install Condensing Natural Gas Boiler

General Information

File Name:	C:\Users\Bkelly\Documents\Projectfiles\Projects\FlexTech\L&SReports\Ulster County\UCOB\Utility Bills\BLCC5\BLCC5 - UCOB - fuel v.2.xml
Date of Study:	Tue Sep 17 12:31:09 EDT 2019
Project Name:	Ulster County Office Building
Project Location:	New York
Analysis Type:	FEMP Analysis, Energy Project
Analyst:	Brendan Kelly
Base Date:	April 1, 2019
Service Date:	April 1, 2020
Study Period:	30 years 0 months (April 1, 2019 through March 31, 2049)
Discount Rate:	3%
Discounting Convention:	End-of-Year

Comparison of Present-Value Costs

PV Life-Cycle Cost

	Base Case	Alternative	Savings from Alternative
Initial Investment Costs:			
Capital Requirements as of Base Date	\$0	\$241,600	-\$241,600
Future Costs:			
Energy Consumption Costs	\$560,824	\$483,897	\$76,927
Energy Demand Charges	\$0	\$0	\$0
Energy Utility Rebates	\$0	\$0	\$0
Water Costs	\$0	\$0	\$0
Recurring and Non-Recurring OM&R Costs	\$0	\$0	\$0
Capital Replacements	\$0	\$0	\$0
Residual Value at End of Study Period	\$0	\$0	\$0
	-----	-----	-----
Subtotal (for Future Cost Items)	\$560,824	\$483,897	\$76,927
	-----	-----	-----
Total PV Life-Cycle Cost	\$560,824	\$725,497	-\$164,673

Net Savings from Alternative Compared with Base Case

PV of Non-Investment Savings	\$76,927	Page 51	L&S Energy Services Inc.
- Increased Total Investment	\$241,600		

Net Savings - \$164,673

Savings-to-Investment Ratio (SIR)

SIR = 0.32

SIR is lower than 1.0; project alternative is not cost effective.

Adjusted Internal Rate of Return

AIRR = -0.86%

AIRR is lower than your discount rate; project alternative is not cost effective.

Payback Period

Estimated Years to Payback (from beginning of Service Period)

Simple Payback never reached during study period.

Discounted Payback never reached during study period.

Energy Savings Summary

Energy Savings Summary (in stated units)

Energy	-----Average	Annual	Consumption-----	Life-Cycle
Type	Base Case	Alternative	Savings	Savings
Natural Gas	2,958.1 MBtu	2,556.3 MBtu	401.8 MBtu	11,650.8 MBtu

Energy Savings Summary (in MBtu)

Energy	-----Average	Annual	Consumption-----	Life-Cycle
Type	Base Case	Alternative	Savings	Savings
Natural Gas	2,958.1 MBtu	2,556.3 MBtu	401.8 MBtu	11,650.8 MBtu

Emissions Reduction Summary

Energy	-----Average	Annual	Emissions-----	Life-Cycle
Type	Base Case	Alternative	Reduction	Reduction
Natural Gas				
CO2	156,253.77 kg	135,029.75 kg	21,224.02 kg	615,423.86 kg
SO2	1,261.02 kg	1,089.73 kg	171.28 kg	4,966.66 kg
NOx	131.10 kg	113.29 kg	17.81 kg	516.34 kg
Total:				
CO2	156,253.77 kg	135,029.75 kg	21,224.02 kg	615,423.86 kg
SO2	1,261.02 kg	1,089.73 kg	171.28 kg	4,966.66 kg
NOx	131.10 kg	113.29 kg	17.81 kg	516.34 kg

UCOB Boiler Replacement	
Ulster County Office Building	244 Fair Street
	Kingston, NY 12402
ECM 1a - Install Condensing Natural Gas Boiler	
Existing Boiler Input Capacity (MBH ea.):	
	5,124
Proposed Condensing Boiler Input Capacity (MBH ea.):	
	5,124
Bin Temp at Which 100% Load Occurs (deg F)	
	2.5
Bin Temp for Balance Point	
	57.5
Boiler Availability:	
	Heating season
Btus per Therm Conversion Factor:	
	100,000
Code Standard Min Boiler Efficiency (assumed)	
	78%
Code Standard Max Boiler Efficiency (below 20°F OSA)	
	82%
Proposed Max Condensing Boiler Efficiency (condensing above 20°F OSA)	
	94%
Proposed Min Condensing Boiler Efficiency (non-condensing below 20°F OSA)	
	85%
\$/therm natural gas	
	\$ 0.86
Gas Savings (mmBtu)	
	232
Gas Savings Cost	
	\$1,996
Total Savings (\$)	
	\$1,996

Notes: For this example, condensing boiler assumed 100% of existing boiler capacity. Actual capacities to be determined at design.

Code std max efficiency from: IECC 2015, page C-47, Table C403.2.3(5)

Determine Existing Boiler Heating Usage:

Usage was analyzed using utility billing data from 2/17/17 to 11/15/18

Assumptions and Approach:

1. The model of heating energy usage is based on utility natural gas data that is billed monthly.
2. Usage is modeled by a regression analysis; its parameters are functions of heating degree days (HDD).
3. TMY3 data is from Poughkeepsie Dutchess Co AP; date, time, and outdoor air dry bulb temperature
4. Excerpts below are from 8760 model

See: Building Load Determination section of report for more details on regression analysis

TMY3 Data Excerpt:

Date	Time	Dry-bulb (F)	HDhr @58°F base
1/1/2005	1:00	35.6	22.4
1/1/2005	2:00	33.8	24.2
1/1/2005	3:00	37.4	20.6
1/1/2005	4:00	39.2	18.8
1/1/2005	5:00	33.8	24.2
1/1/2005	6:00	46.4	11.6
1/1/2005	7:00	35.6	22.4
1/1/2005	8:00	44.6	13.4
1/1/2005	9:00	44.6	13.4
1/1/2005	10:00	51.8	6.2
1/1/2005	11:00	53.6	4.4
1/1/2005	12:00	55.4	2.6
1/1/2005	13:00	53.6	4.4
1/1/2005	14:00	51.8	6.2
1/1/2005	15:00	50	8
...

Regression analysis results:

therms/day = 6.1549 therms/HDD58 + 7.4944 therms/day

ECM 1a - Install Condensing Natural Gas Boiler**Determine Existing Building Load:**

Billing date range and Assumptions and Approach following approach above.

Load Therms = Existing usage therms * Existing efficiency

(existing eff assumed to be 76% seasonal avg)

Regression analysis results:

therms/day = 4.6777 therms/HDD58 +

5.6957 therms/day

Therms Usage by Regression -- Building Load Excerpt:

Date	Time	Therms
1/1/2005	1:00	5
1/1/2005	2:00	4,008
1/1/2005	3:00	2,537
1/1/2005	4:00	1,442
1/1/2005	5:00	658
1/1/2005	6:00	286
1/1/2005	7:00	193
1/1/2005	8:00	258
1/1/2005	9:00	418
1/1/2005	10:00	1,668
1/1/2005	11:00	2,000
1/1/2005	12:00	3,962
1/1/2005	13:00	22,482
1/1/2005	14:00	-

Building Load

Total Sum - Therms Monthly:	
Jan	5,054
Feb	4,008
Mar	2,537
Apr	1,442
May	658
Jun	286
Jul	193
Aug	258
Sep	418
Oct	1,668
Nov	2,000
Dec	3,962
Total	22,482

In a year of typical weather, existing system building load was estimated to be
22,482 therms

Apply 8760 model to a case of code standard efficiency boiler for baseline

Hourly usage = hourly load / code std efficiency where:

OAT for min assumed code std efficiency =		58
OAT below which code std eff is max =		20
OAT	effic	
20	82% m=	-0.0011
58	78% b=	0.8411

Therms Usage for Code Standard Excerpt:

Date	Time	Therms
1/1/2005	1:00	5.7
1/1/2005	2:00	6.2
1/1/2005	3:00	5.3
1/1/2005	4:00	4.9
1/1/2005	5:00	6.2
1/1/2005	6:00	3.2
1/1/2005	7:00	5.7
1/1/2005	8:00	3.6
1/1/2005	9:00	3.6
1/1/2005	10:00	1.8
1/1/2005	11:00	1.4
1/1/2005	12:00	1.0
1/1/2005	13:00	1.4
1/1/2005	14:00	1.8
1/1/2005	15:00	2.3
...

Code Std NG Usage

Total Sum - Therms Monthly:	
Jan	6,204
Feb	4,928
Mar	3,159
Apr	1,809
May	834
Jun	365
Jul	247
Aug	329
Sep	531
Oct	2,091
Nov	2,495
Dec	4,889
Total	27,881

In a year of typical weather, code standard natural gas usage was estimated to be
27,881 therms

ECM 1a - Install Condensing Natural Gas Boiler**Calculate Code-Minimum Natural Gas Boiler Usage:**

Hourly usage = hourly load / condensing boiler efficiency where:

OAT for maximum condensing efficiency =	58	F
OAT below which condensing stops =	20	F

OAT	effic		
20	85%	m=	0.0024
58	94%	b=	0.8026

Therms Usage -- Proposed Excerpt:

		Condensing Boiler:	
Date	Time	Efficiency	Therms
1/1/2005	1:00	89%	5.2
1/1/2005	2:00	88%	5.6
1/1/2005	3:00	89%	4.8
1/1/2005	4:00	90%	4.4
1/1/2005	5:00	88%	5.6
1/1/2005	6:00	91%	2.7
1/1/2005	7:00	89%	5.2
1/1/2005	8:00	91%	3.1
1/1/2005	9:00	91%	3.1
1/1/2005	10:00	93%	1.6
1/1/2005	11:00	93%	1.2
1/1/2005	12:00	93%	0.8
1/1/2005	13:00	93%	1.2
1/1/2005	14:00	93%	1.6
1/1/2005	15:00	92%	2.0
...

Proposed Usage

Total Sum - Therms Monthly:	
	Boiler
Jan	5,863
Feb	4,636
Mar	2,860
Apr	1,600
May	716
Jun	307
Jul	205
Aug	276
Sep	451
Oct	1,856
Nov	2,244
Dec	4,548
Totals	25,563

Savings Summary

System	Usage	Costs
	NG (Therms)	
Code Standard:	27,881	\$ 24,011
Proposed:	25,563	\$ 22,015
Savings	2,318	\$ 1,996

NIST BLCC 5.3-18: Comparative Analysis

Consistent with Federal Life Cycle Costing Methodology and Procedures, 10 CFR, Part 436, Subpart A FlexTech Study

Base Case: Code min boiler (ECM 1a) Alternative: ECM 1 - Install Condensing Natural Gas Boiler

General Information

File Name:	C:\Users\Bkelly\Documents\Projectfiles\Projects\FlexTech\L&SReports\Ulster County\UCOB\Utility Bills\BLCC5\BLCC5 - UCOB - fuel v.2.xml
Date of Study:	Tue Sep 17 12:30:20 EDT 2019
Project Name:	Ulster County Office Building
Project Location:	New York
Analysis Type:	FEMP Analysis, Energy Project
Analyst:	Brendan Kelly
Base Date:	April 1, 2019
Service Date:	April 1, 2020
Study Period:	30 years 0 months (April 1, 2019 through March 31, 2049)
Discount Rate:	3%
Discounting Convention:	End-of-Year

Comparison of Present-Value Costs PV Life-Cycle Cost

	Base Case	Alternative	Savings from Alternative
Initial Investment Costs:			
Capital Requirements as of Base Date	\$94,625	\$109,625	-\$15,000
Future Costs:			
Energy Consumption Costs	\$504,008	\$483,897	\$20,111
Energy Demand Charges	\$0	\$0	\$0
Energy Utility Rebates	\$0	\$0	\$0
Water Costs	\$0	\$0	\$0
Recurring and Non-Recurring OM&R Costs	\$0	\$0	\$0
Capital Replacements	\$0	\$0	\$0
Residual Value at End of Study Period	\$0	\$0	\$0
Subtotal (for Future Cost Items)	\$504,008	\$483,897	\$20,111
Total PV Life-Cycle Cost	\$598,633	\$593,522	\$5,111

Net Savings from Alternative Compared with Base Case

PV of Non-Investment Savings	\$20,111	Page 56	L&S Energy Services Inc.
- Increased Total Investment	\$15,000		

Net Savings \$5,111

Savings-to-Investment Ratio (SIR)

SIR = 1.34

Adjusted Internal Rate of Return

AIRR = 4.01%

Payback Period

Estimated Years to Payback (from beginning of Service Period)

Simple Payback occurs in year 17

Discounted Payback occurs in year 23

Energy Savings Summary

Energy Savings Summary (in stated units)

Energy	-----Average	Annual	Consumption-----	Life-Cycle
Type	Base Case	Alternative	Savings	Savings
Natural Gas	2,788.1 MBtu	2,556.3 MBtu	231.8 MBtu	6,721.4 MBtu

Energy Savings Summary (in MBtu)

Energy	-----Average	Annual	Consumption-----	Life-Cycle
Type	Base Case	Alternative	Savings	Savings
Natural Gas	2,788.1 MBtu	2,556.3 MBtu	231.8 MBtu	6,721.4 MBtu

Emissions Reduction Summary

Energy	-----Average	Annual	Emissions-----	Life-Cycle
Type	Base Case	Alternative	Reduction	Reduction
Natural Gas				
CO2	147,273.97 kg	135,029.75 kg	12,244.22 kg	355,040.44 kg
SO2	1,188.55 kg	1,089.73 kg	98.81 kg	2,865.29 kg
NOx	123.56 kg	113.29 kg	10.27 kg	297.88 kg

Total:

CO2	147,273.97 kg	135,029.75 kg	12,244.22 kg	355,040.44 kg
SO2	1,188.55 kg	1,089.73 kg	98.81 kg	2,865.29 kg
NOx	123.56 kg	113.29 kg	10.27 kg	297.88 kg

UCOB Boiler Replacement	
Ulster County Office Building	244 Fair Street
	Kingston, NY 12402
ECM 2 - Install Biomass Boiler with Condensing Natural Gas Boiler	
Existing Boiler Input Capacity (MBH ea.):	5,124
Proposed Biomass Boiler Output Capacity (MBH ea.):	3,074
Proposed Condensing Boiler Output Capacity (MBH ea.):	2,050
Bin Temp at Which 100% Load Occurs (deg F)	2.5
Bin Temp for Balance Point	57.5
Boiler Availability:	Heating season
Btus per Therm Conversion Factor:	100,000
Btus per Ton Pellets Conversion Factor:	16,000,000
Existing Boiler Efficiency (assumed)	76%
Proposed Biomass Boiler Efficiency (product literature)	86%
Proposed Condensing Boiler Efficiency (condensing above 20°F OSA)	94%
Proposed Condensing Boiler Efficiency (non-condensing below 20°F OSA)	85%
\$/therm natural gas	\$ 0.86
\$/therm biomass (pellets)	\$ 1.88
\$/ton biomass (pellets)	\$ 300
Gas Savings (mmBtu)	367.11
Gas Savings Cost	\$16,670
Pellet Use (tons)	98.03
Pellet Cost	\$29,409
Total Savings (\$)	(\$12,740)

Notes: For this example, the biomass boiler is assumed 60% capacity and the condensing boiler assumed 40% capacity of existing boiler capacity. Actual capacities to be determined at design.

Determine Existing Boiler Heating Usage:

Usage was analyzed using utility billing data from 2/17/17 to 11/15/18

Assumptions and Approach:

1. The model of heating energy usage is based on utility natural gas data that is billed monthly.
2. Usage is modeled by a regression analysis; its parameters are functions of heating degree days (HDD).
3. TMY3 data is from Poughkeepsie Dutchess Co AP; date, time, and outdoor air dry bulb temperature

See: Building Load Determination section of report for more details on regression analysis

4. Excerpts below are from 8760 model

TMY3 Data

Date	Time	Dry-bulb (F)	HDhr @58°F base
1/1/2005	1:00	35.6	22.4
1/1/2005	2:00	33.8	24.2
1/1/2005	3:00	37.4	20.6
1/1/2005	4:00	39.2	18.8
1/1/2005	5:00	33.8	24.2
1/1/2005	6:00	46.4	11.6
1/1/2005	7:00	35.6	22.4
1/1/2005	8:00	44.6	13.4
1/1/2005	9:00	44.6	13.4
1/1/2005	10:00	51.8	6.2
1/1/2005	11:00	53.6	4.4
1/1/2005	12:00	55.4	2.6
1/1/2005	13:00	53.6	4.4
1/1/2005	14:00	51.8	6.2
1/1/2005	15:00	50	8.0
...

Regression analysis results:

therms/day = 6.1549 therms/HDD58 + 7.4944 therms/day

ECM 2 - Install Biomass Boiler with Condensing Natural Gas Boiler
--

Determine Existing Building Load:

Billing date range and Assumptions and Approach following approach above.

Load Therms = Existing usage therms * Existing efficiency

Regression analysis results:

therms/day = 4.6777 therms/HDD58 + 5.6957 therms/day

Therms Usage by Regression -- Building Load Excerpt:

Date	Time	Therms
1/1/2005	1:00	6.1
1/1/2005	2:00	6.5
1/1/2005	3:00	5.6
1/1/2005	4:00	5.1
1/1/2005	5:00	6.5
1/1/2005	6:00	3.3
1/1/2005	7:00	6.1
1/1/2005	8:00	3.7
1/1/2005	9:00	3.7
1/1/2005	10:00	1.9
1/1/2005	11:00	1.4
1/1/2005	12:00	1.0
1/1/2005	13:00	1.4
1/1/2005	14:00	1.9
...

Building Load

Total Sum - Therms Monthly:	
Jan	5,054
Feb	4,008
Mar	2,537
Apr	1,442
May	658
Jun	286
Jul	193
Aug	258
Sep	418
Oct	1,668
Nov	2,000
Dec	3,962
Total	22,482

In a year of typical weather, existing system building load was estimated to be
22,482 therms

Apply 8760 model to existing system usage in a year of typical weather:

Hourly usage = hourly load / existing efficiency (76%)

Therms Usage by Regression -- Existing Excerpt:

Date	Time	Therms
1/1/2005	1:00	6.1
1/1/2005	2:00	6.5
1/1/2005	3:00	5.6
1/1/2005	4:00	5.1
1/1/2005	5:00	6.5
1/1/2005	6:00	3.3
1/1/2005	7:00	6.1
1/1/2005	8:00	3.7
1/1/2005	9:00	3.7
1/1/2005	10:00	1.9
1/1/2005	11:00	1.4
1/1/2005	12:00	1.0
1/1/2005	13:00	1.4
1/1/2005	14:00	1.9
1/1/2005	15:00	2.4
...

Existing NG Usage

Total Sum - Therms Monthly:	
Jan	6,649
Feb	5,273
Mar	3,338
Apr	1,897
May	866
Jun	376
Jul	253
Aug	339
Sep	550
Oct	2,195
Nov	2,631
Dec	5,213
Total	29,581

In a year of typical weather, existing system natural gas usage was estimated to be
29,581 therms

ECM 2 - Install Biomass Boiler with Condensing Natural Gas Boiler**Calculate Biomass Boiler and Condensing Natural Gas Boiler Usage:**

Hourly usage = hourly load / proposed equipment efficiency

% Load Sharing:

Biomass	60%
Boiler	40%

Condensing Boiler Efficiency Parameters

Outdoor air temperature (OAT, deg F) selections:

OAT for maximum condensing efficiency =

58 F

OAT below which condensing stops =

20 F

OAT	effic		
20	85%	m=	85%
58	94%	b=	94%

Therms Usage by Regression -- Proposed Excerpt:

Date	Time	Biomass:		Condensing Boiler:		Total
		Efficiency	Therms	Efficiency	Therms	Therms
1/1/2005	1:00	86%	3.2	89%	2.1	5.3
1/1/2005	2:00	86%	3.5	88%	2.2	5.7
1/1/2005	3:00	86%	3.0	89%	1.9	4.9
1/1/2005	4:00	86%	2.7	90%	1.7	4.5
1/1/2005	5:00	86%	3.5	88%	2.2	5.7
1/1/2005	6:00	86%	1.7	91%	1.1	2.8
1/1/2005	7:00	86%	3.2	89%	2.1	5.3
1/1/2005	8:00	86%	2.0	91%	1.3	3.2
1/1/2005	9:00	86%	2.0	91%	1.3	3.2
1/1/2005	10:00	86%	1.0	93%	0.6	1.6
1/1/2005	11:00	86%	0.8	93%	0.5	1.2
1/1/2005	12:00	86%	0.5	93%	0.3	0.8
1/1/2005	13:00	86%	0.8	93%	0.5	1.2
1/1/2005	14:00	86%	1.0	93%	0.6	1.6
...

Proposed Usage

Total Sum - Therms Monthly:		
	Biomass	Boiler
Jan	3,526	2,345
Feb	2,796	1,854
Mar	1,770	1,144
Apr	1,006	640
May	459	287
Jun	200	123
Jul	134	82
Aug	180	110
Sep	291	180
Oct	1,164	742
Nov	1,395	898
Dec	2,764	1,819
Totals	15,685	10,225

Savings Summary

System	Usage		Costs
	NG (Therms)	Pellets (Tons)	
Existing:	29,581		\$ 25,476
Proposed:			
Biomass	15,685	98.03	\$ 29,409
Cond boiler	10,225		\$ 8,806
Savings	3,671	(98.03)	\$ (12,740)

NIST BLCC 5.3-18: Comparative Analysis

Consistent with Federal Life Cycle Costing Methodology and Procedures, 10 CFR, Part 436, Subpart A FlexTech Study

Base Case: Existing NG Boiler

Alternative: ECM 2 - Install Biomass Boiler with Condensing Natural Gas Boiler

General Information

File Name:	C:\Users\Bkelly\Documents\Projectfiles\Projects\FlexTech\L&SReports\Ulster County\UCOB\Utility Bills\BLCC5\BLCC5 - UCOB - fuel v.2.xml
Date of Study:	Tue Sep 17 12:30:42 EDT 2019
Project Name:	Ulster County Office Building
Project Location:	New York
Analysis Type:	FEMP Analysis, Energy Project
Analyst:	Brendan Kelly
Base Date:	April 1, 2019
Service Date:	April 1, 2020
Study Period:	30 years 0 months (April 1, 2019 through March 31, 2049)
Discount Rate:	3%
Discounting Convention:	End-of-Year

Comparison of Present-Value Costs

PV Life-Cycle Cost

	Base Case	Alternative	Savings from Alternative
Initial Investment Costs:			
Capital Requirements as of Base Date	\$0	\$310,250	-\$310,250
Future Costs:			
Energy Consumption Costs	\$560,824	\$193,855	\$366,969
Energy Demand Charges	\$0	\$0	\$0
Energy Utility Rebates	\$0	\$0	\$0
Water Costs	\$0	\$0	\$0
Recurring and Non-Recurring OM&R Costs	\$0	\$0	\$0
Capital Replacements	\$0	\$0	\$0
Residual Value at End of Study Period	\$0	\$0	\$0
	-----	-----	-----
Subtotal (for Future Cost Items)	\$560,824	\$193,855	\$366,969
	-----	-----	-----
Total PV Life-Cycle Cost	\$560,824	\$504,105	\$56,719

Net Savings from Alternative Compared with Base Case

PV of Non-Investment Savings	\$366,969	Page 61	L&S Energy Services Inc.
- Increased Total Investment	\$310,250		

Savings-to-Investment Ratio (SIR)

SIR = 1.18

Adjusted Internal Rate of Return

AIRR = 3.58%

Payback Period

Estimated Years to Payback (from beginning of Service Period)

Simple Payback occurs in year 17

Discounted Payback occurs in year 23

Energy Savings Summary

Energy Savings Summary (in stated units)

Energy	-----Average	Annual	Consumption-----	Life-Cycle
Type	Base Case	Alternative	Savings	Savings
Natural Gas	2,958.1 MBtu	1,022.5 MBtu	1,935.6 MBtu	56,125.8 MBtu
Coal	0.0 MBtu	1,568.5 MBtu	-1,568.5 MBtu	-45,481.1 MBtu

Note: Annual Alternative MBtu in coal row is Pellets

Energy Savings Summary (in MBtu)

Energy	-----Average	Annual	Consumption-----	Life-Cycle
Type	Base Case	Alternative	Savings	Savings
Natural Gas	2,958.1 MBtu	1,022.5 MBtu	1,935.6 MBtu	56,125.8 MBtu
Coal	0.0 MBtu	1,568.5 MBtu	-1,568.5 MBtu	-45,481.1 MBtu

Emissions Reduction Summary

Energy	-----Average	Annual	Emissions-----	Life-Cycle
Type	Base Case	Alternative	Reduction	Reduction
Natural Gas				
CO2	156,253.77 kg	54,010.84 kg	102,242.92 kg	2,964,694.92 kg
SO2	1,261.02 kg	435.88 kg	825.13 kg	23,926.02 kg
NOx	131.10 kg	45.31 kg	85.78 kg	2,487.36 kg
Coal				
CO2	0.00 kg	Note: Biomass boiler emissions not known, see report.		
SO2	0.00 kg			
NOx	0.00 kg			

Total:

CO2	156,253.77 kg
SO2	GPI1,261.02 kg
NOx	131.10 kg

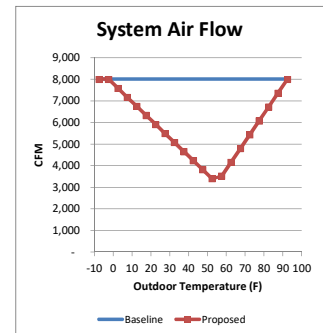
UCOB

ECM 3: AC-4R VAV Conversion

Convert AC-4R from constant volume to VAV by installing a Variable Frequency Drive

Input Parameters	Baseline System	Proposed System	Energy Savings
Fan HP	7.5	7.5	
Fan CFM	8,000	8,000	Electric Energy Savings (kWh) 34,591
Motor Full Load (% of Rate HP)	99.3%	99.3%	Total Demand kW Savings (12 month total) 16.4
Motor Efficiency	89.5%	91.7%	
Speed Control	N.A.	VFD	Annual kWh Cost Savings (\$) \$3,523
VSD Efficiency	N.A.	98.0%	Annual Peak Demand Savings (\$) \$159
Minimum VFD Operation	N.A.	40.0%	
VFD Power vs Flow Relationship			Total Savings \$3,681
kW = kWo * (%Flow) ³ / VFD efficiency, N =			
VFD Operation:		2.2 Year-round	

Occupied Period		Existing Operation (Baseline)				Proposed Operation				Annual kWh Savings
Ave. Bin Temp	No. of Hrs	CFM	Fan kW	Fan kWh	Annual kWh	CFM	Fan kW	Fan kWh	Annual kWh	
-7.5	0	8,000	-	-	0	8,000	-	-	0	0
-2.5	0	8,000	-	-	0	8,000	-	-	0	0.0
2.5	2	8,000	6.2	12	12	7,582	5.5	11	11	1.4
7.5	3	8,000	6.2	19	19	7,164	4.9	15	15	4.1
12.5	13	8,000	6.2	81	81	6,746	4.3	55	55	25.5
17.5	62	8,000	6.2	386	386	6,328	3.7	229	229	156.3
22.5	108	8,000	6.2	672	672	5,909	3.2	343	343	328.1
27.5	128	8,000	6.2	796	796	5,491	2.7	346	346	449.5
32.5	160	8,000	6.2	995	995	5,073	2.3	364	364	631.1
37.5	191	8,000	6.2	1,188	1,188	4,655	1.9	359	359	828.3
42.5	152	8,000	6.2	945	945	4,237	1.5	233	233	712.6
47.5	85	8,000	6.2	529	529	3,819	1.2	103	103	425.1
52.5	129	8,000	6.2	802	802	3,401	0.9	122	122	680.5
57.5	151	8,000	6.2	939	939	3,520	1.0	154	154	785.3
62.5	139	8,000	6.2	864	864	4,160	1.5	204	204	660.1
67.5	153	8,000	6.2	951	951	4,800	2.0	308	308	643.4
72.5	185	8,000	6.2	1,150	1,150	5,440	2.7	490	490	659.9
77.5	185	8,000	6.2	1,150	1,150	6,080	3.4	626	626	524.0
82.5	178	8,000	6.2	1,107	1,107	6,720	4.2	751	751	355.7
87.5	63	8,000	6.2	392	392	7,360	5.2	325	325	67.0
92.5	1	8,000	6.2	6	6	8,000	6.2	6	6	0.0
Total	2088			12,983	12,983			5,045	5,045	7,938



Unoccupied Period		Existing Operation (Baseline)				Proposed Operation				Annual kWh Savings
Ave. Bin Temp	No. of Hrs	CFM	Fan kW	Fan kWh	Annual kWh	CFM	Fan kW	Fan kWh	Annual kWh	
-7.5	2	8,000	6.2	12.4	12	8,000	6.2	12.4	12	0.1
-2.5	22	8,000	6.2	136.8	137	8,000	6.2	136.2	136	0.6
2.5	57	8,000	6.2	354.4	354	7,582	5.5	313.7	314	40.8
7.5	103	8,000	6.2	640.5	640	7,164	4.9	500.3	500	140.2
12.5	163	8,000	6.2	1,013.5	1,014	6,746	4.3	693.6	694	319.9
17.5	380	8,000	6.2	2,362.9	2,363	6,328	3.7	1,404.7	1,405	958.2
22.5	423	8,000	6.2	2,630.2	2,630	5,909	3.2	1,345.3	1,345	1,284.9
27.5	443	8,000	6.2	2,754.6	2,755	5,491	2.7	1,198.9	1,199	1,555.7
32.5	612	8,000	6.2	3,805.4	3,805	5,073	2.3	1,391.4	1,391	2,414.1
37.5	683	8,000	6.2	4,246.9	4,247	4,655	1.9	1,285.1	1,285	2,961.8
42.5	489	8,000	6.2	3,040.6	3,041	4,237	1.5	748.0	748	2,292.6
47.5	370	8,000	6.2	2,300.7	2,301	3,819	1.2	450.3	450	1,850.3
52.5	432	8,000	6.2	2,686.2	2,686	3,401	0.9	407.4	407	2,278.8
57.5	564	8,000	6.2	3,507.0	3,507	3,520	1.0	573.8	574	2,933.2
62.5	667	8,000	6.2	4,147.4	4,147	4,160	1.5	980.0	980	3,167.5
67.5	804	8,000	6.2	3,755.7	3,756	4,800	2.0	1,215.8	1,216	2,539.9
72.5	295	8,000	6.2	1,834.3	1,834	5,440	2.7	782.0	782	1,052.3
77.5	219	8,000	6.2	1,361.8	1,362	6,080	3.4	741.5	742	620.2
82.5	106	8,000	6.2	659.1	659	6,720	4.2	447.3	447	211.8
87.5	28	8,000	6.2	174.1	174	7,360	5.2	144.3	144	29.8
92.5	10	8,000	6.2	62.2	62	8,000	6.2	61.9	62	0.3
Total	6672			41,487	41,487			14,834	14,834	26,653

Peak Demand Savings		Proposed Operation				Peak kW Savings
Month	Temp (F)	Min/Max	CFM	Fan kW	Total kW	
Jan	-2.0	Min	8,000	6.2	6.2	0.1
Feb	-0.9	Min	8,000	6.2	6.2	0.2
Mar	19.6	Min	8,000	6.2	6.2	2.7
Apr	71.1	Max	8,000	6.2	6.2	3.8
May	91.9	Max	8,000	6.2	6.2	0.1
Jun	89.1	Max	8,000	6.2	6.2	0.8
Jul	91.0	Max	8,000	6.2	6.2	0.3
Aug	89.1	Max	8,000	6.2	6.2	0.8
Sep	86.0	Max	8,000	6.2	6.2	1.4
Oct	79.0	Max	8,000	6.2	6.2	2.6
Nov	19.0	Min	8,000	6.2	6.2	2.7
Dec	3.9	Min	8,000	6.2	6.2	0.9
Total Demand kW Savings (12 month total)						16.4

Formulas & Assumptions

$kW_o = 0.747 \text{ kW/HP} \times \text{HP} \times \text{load factor} / \text{motor efficiency}$...kW_o is all that's used for existing non-VFD conversion of HP to kW
 $\% \text{ flow} = \text{CFM} / 8,000 \text{ fan CFM}$

Assumes all HVAC equipment is operating to spec
 Assumes ancillary devices like dampers are working to spec

Proposed CFM as a function of bin temperature is from typical profiles found from experience with previous projects

NIST BLCC 5.3-18: Comparative Analysis

Consistent with Federal Energy Regulatory Commission Methodology and Procedures, 10 CFR, Part 436, Subpart A FlexTech Study

Base Case: Constant Air Volume - AC-4R

Alternative: ECM 3: AC-4R VAV Conversion

General Information

File Name:	C:\Users\Bkelly\Documents\Projectfiles\Projects\FlexTech\L&SReports\Ulster County\UCOB\Utility Bills\BLCC5\BLCC5 - UCOB - ECM-3.xml
Date of Study:	Mon Sep 16 15:54:45 EDT 2019
Project Name:	Ulster County Office Building
Project Location:	New York
Analysis Type:	FEMP Analysis, Energy Project
Analyst:	Brendan Kelly
Base Date:	April 1, 2019
Service Date:	April 1, 2020
Study Period:	30 years 0 months (April 1, 2019 through March 31, 2049)
Discount Rate:	3%
Discounting Convention:	End-of-Year

Comparison of Present-Value Costs

PV Life-Cycle Cost

	Base Case	Alternative	Savings from Alternative
Initial Investment Costs:			
Capital Requirements as of Base Date	\$0	\$48,200	-\$48,200
Future Costs:			
Energy Consumption Costs	\$30,178	\$11,727	\$18,451
Energy Demand Charges	\$221	\$221	\$0
Energy Utility Rebates	\$0	\$0	\$0
Water Costs	\$0	\$0	\$0
Recurring and Non-Recurring OM&R Costs	\$0	\$0	\$0
Capital Replacements	\$0	\$0	\$0
Residual Value at End of Study Period	\$0	\$0	\$0
	-----	-----	-----
Subtotal (for Future Cost Items)	\$30,399	\$11,948	\$18,451
	-----	-----	-----
Total PV Life-Cycle Cost	\$30,399	\$60,148	-\$29,749

Net Savings from Alternative Compared with Base Case

PV of Non-Investment Savings	\$18,451	Page 64	L&S Energy Services Inc.
- Increased Total Investment	\$48,200		

Net Savings - \$29,749

Savings-to-Investment Ratio (SIR)

SIR = 0.38

SIR is lower than 1.0; project alternative is not cost effective.

Adjusted Internal Rate of Return

AIRR = -0.24%

AIRR is lower than your discount rate; project alternative is not cost effective.

Payback Period

Estimated Years to Payback (from beginning of Service Period)

Simple Payback never reached during study period.

Discounted Payback never reached during study period.

Energy Savings Summary

Energy Savings Summary (in stated units)

Energy	-----Average	Annual	Consumption-----	Life-Cycle
Type	Base Case	Alternative	Savings	Savings
Electricity	12,983.0 kWh	5,045.0 kWh	7,938.0 kWh	230,174.8 kWh

Energy Savings Summary (in MBtu)

Energy	-----Average	Annual	Consumption-----	Life-Cycle
Type	Base Case	Alternative	Savings	Savings
Electricity	44.3 MBtu	17.2 MBtu	27.1 MBtu	785.4 MBtu

Emissions Reduction Summary

Energy	-----Average	Annual	Emissions-----	Life-Cycle
Type	Base Case	Alternative	Reduction	Reduction
Electricity				
CO2	5,240.83 kg	3,298.34 kg	1,942.50 kg	56,325.75 kg
SO2	15.43 kg	16.62 kg	-1.19 kg	-34.64 kg
NOx	5.56 kg	4.92 kg	0.64 kg	18.56 kg
Total:				
CO2	5,240.83 kg	3,298.34 kg	1,942.50 kg	56,325.75 kg
SO2	15.43 kg	16.62 kg	-1.19 kg	-34.64 kg
NOx	5.56 kg	4.92 kg	0.64 kg	18.56 kg

Appendix C – ECM Cost Estimates



Project Name: **Ulster County Office Building**

Project No.: _____

Calculated by:	MS
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Checked by: _____

Sheet No: 1 of 1

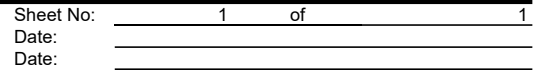
Date: _____

Date: _____

Measure: PFS 1 - Install Solar Thermal DHW

[illegible]

The costs noted above are estimates only and may be modified by changing conditions or the passage of time.



The costs noted above are estimates only and may be modified by changing conditions or the passage of time.



Project Name: **Ulster County Office Building**

Project No.: _____

Calculated by:	MS
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Checked by: _____

Sheet No: 1 of 1

Date: _____

Date: _____

Measure: PFS 3 - Install Cooling Energy Storage

[illegible]

The costs noted above are estimates only and may be modified by changing conditions or the passage of time.



Project Name: **Ulster County Office Building**

Project No.: _____

Calculated by:	MS
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Checked by: _____

Sheet No: 1 of 1

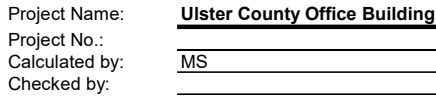
Date: _____

Date: _____

Measure: ECM 1 - Install a Condensing Natural Gas Boiler (existing conditions baseline)

[illegible]

The costs noted above are estimates only and may be modified by changing conditions or the passage of time.



Sheet No: 1 of 1
Date: _____
Date: _____

[illegible]

L&S Energy Services Inc.



Project Name: **Ulster County Office Building**

Project No.: _____

Calculated by:	MS
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Checked by: _____

Sheet No: 1 of 1

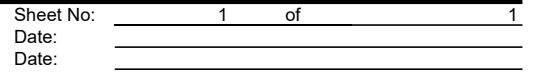
Date: _____

Date: _____

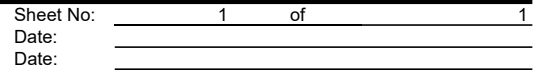
Measure: ECM 2 - Install a Biomass Boiler and a Condensing Natural Gas Boiler

[illegible]

The costs noted above are estimates only and may be modified by changing conditions or the passage of time.



The costs noted above are estimates only and may be modified by changing conditions or the passage of time.

[illegible]

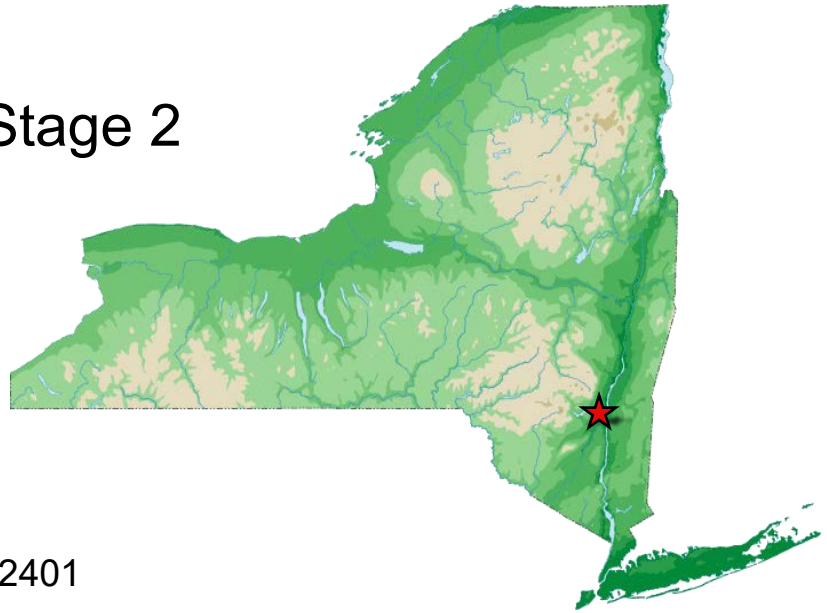
L&S Energy Services Inc.

Appendix D – NYSERDA/NYPA Geothermal Clean Energy Challenge



Geothermal Clean Energy Challenge

Advanced Report – Stage 2



Applicant: Ulster County
Address: 244 Fair St.
Kingston, NY 12401
Site Name: 244 Fair St.

Project Summary

This potential project was modeled as a single closed loop ground source heat pump (GSHP) system with 139 tons of cooling capacity that will serve the building listed on the next page with a total conditioned area of 62,396 square feet. The GSHP system is expected to serve an existing building that will require little to no significant interior modifications during installation to integrate with existing building HVAC systems, and this factor is reflected in the GSHP cost assumptions used in the model.

The analysis in this report is based on the results of a streamlined building energy model (BEM) using the supplemental data you provided for the building associated with your potential GSHP site. The BEM was used to fine-tune the energy load patterns and economic and technical results in this report. The Stage 2 results are very similar to the Stage 1 report. This means that energy load patterns assumed in Stage 1 are consistent with the more granular load modeling performed through the BEM in Stage 2. The positive economic results are driven by the combination of strong expected annual O&M savings and estimated capital costs for the GSHP system that are lower than many other applicants in this program.

As a reminder, the results presented in this report are preliminary, and a detailed feasibility assessment is a necessary next step in thoroughly exploring a GSHP project. Financial and technical support for conducting a detailed design study, including American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Level 2 targeted audits, site geotechnical testing and analyses, and schematic GSHP system design is available to eligible applicants in Stage 3 of the Geothermal Clean Energy Challenge.

Energy, Financial, and Environmental Savings Opportunities from GSHP Implementation

Buildings Included in the Site		
Building Name	Building Type	Building Conditioned Area (sqft)
Ulster County Office Building	Large Office	62,396

The tables below summarize the savings opportunities estimated for the site in terms of costs, energy and greenhouse gases when comparing the implementation of a ground source heat pump (GSHP) system to the existing (or planned) building HVAC systems.¹

Note: the value of the carbon emissions included in the table is not directly monetizable by the applicant, but rather reflects the overall value to society provided by the reduced carbon emissions. The value is not used as a factor in the economic analysis in this report. However, the benefits to society can be substantial, particularly when buildings consuming fuel oil switch to GSHP.

Volumetric Savings / Increases	
Annual Propane Savings	0 gallons
Annual Fuel Oil Savings	0 gallons
Annual Natural Gas Savings	2,511 [1000 ft ³]
Annual Electricity Increase	91,972 kWh
Annual GHG Emissions Reduction	118 metric tons (CO ₂ e)
Cost Savings (\$)	
Annual Energy Bill Savings	\$ 10,539
Annual O&M Savings ²	\$ 28,107
Investments & Incentives ³ (\$)	
Installed GSHP System Capital Costs (Est. Range)	\$ 1,056,364 - \$ 1,172,564
Avoided Capital Costs for Traditional HVAC System	\$ 240,934
NYSERDA Incentive Payment for GSHP System	\$ 166,389
Societal Value of Reduced Carbon Emissions ⁴	\$ 220,912

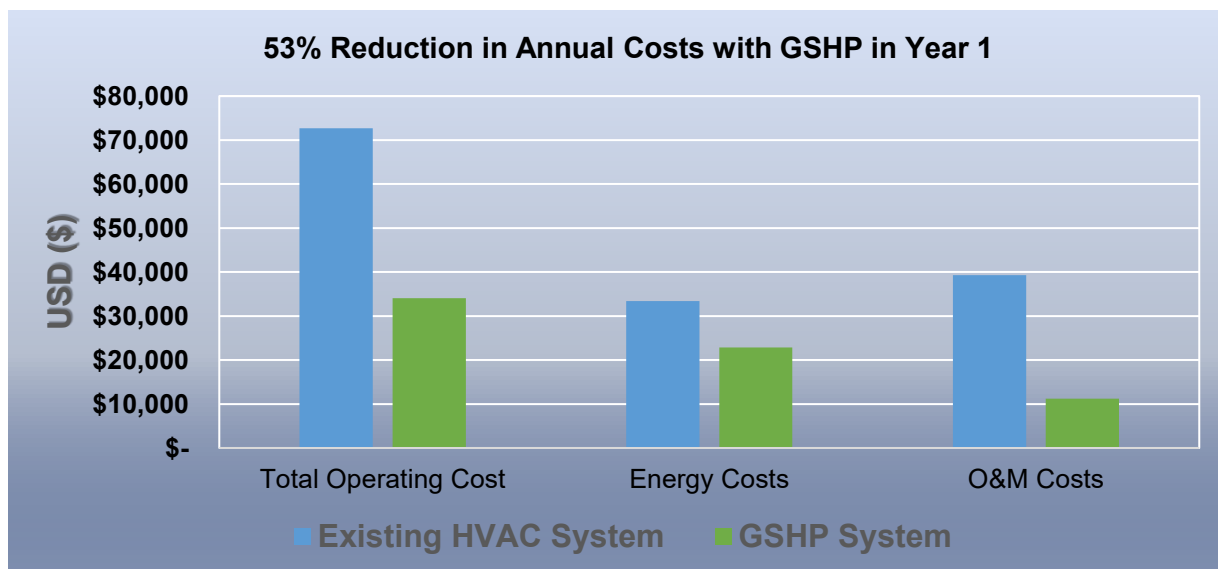
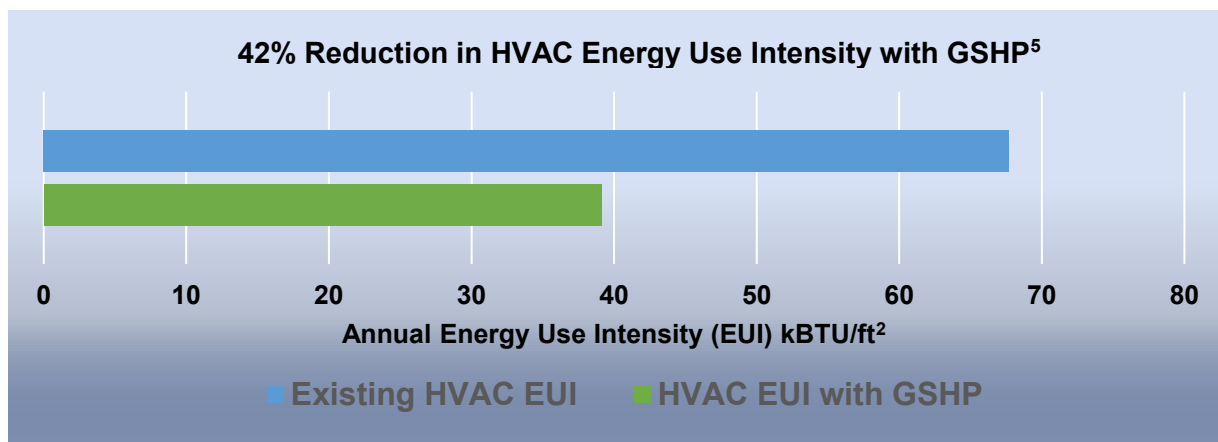
¹ The findings presented in this report are preliminary and should not be used as the sole basis for investment decisions.

² O&M savings include the savings associated with the avoided use of cooling towers at the site.

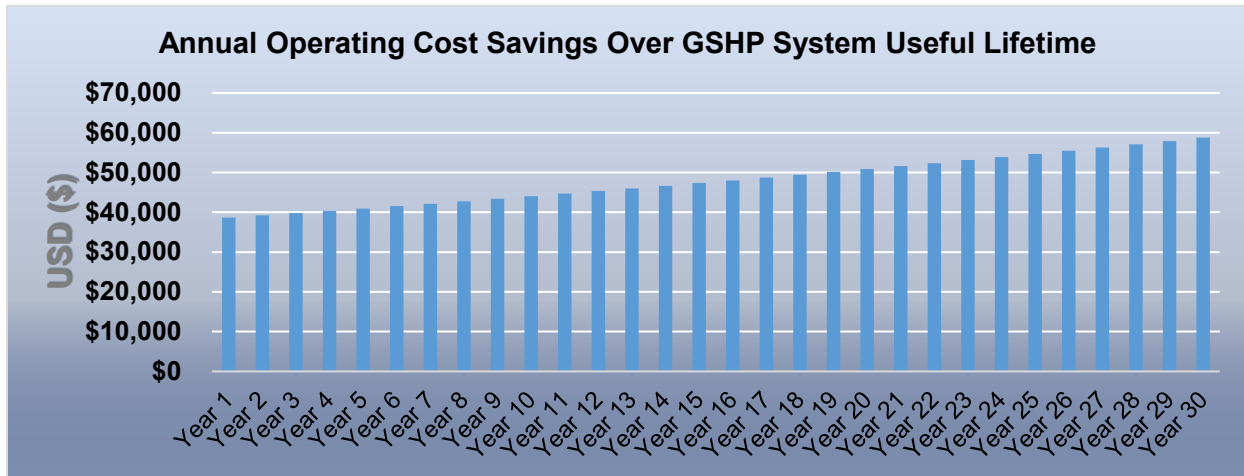
³ Estimated capital costs in this report reflect an expected range based on similar projects, but they may differ from the final minimum or maximum project costs that a GSHP site encounters in practice. Further incentives may also be available for GSHP systems through utility programs; contact your utility for more information. For-profit entities with sufficient tax liability may additionally be eligible for a 10% federal tax incentive on GSHP systems.

⁴ Societal cost of carbon (30 year net present value) calculated using EPA 3% average data in 2017 dollars (https://19january2017snapshot.epa.gov/climatechange/social-cost-carbon_.html)

Excluding NYSERDA Incentive	Including NYSERDA Incentive
GSHP Simple Investment Payback Period (Estimated Range)	
18 - 20 years	15 - 17 years
GSHP Net Present Value (Estimated Range over 30-year life)	
(-\$ 134,860) – (-\$ 18,660)	\$ 31,529 - \$ 147,729
GSHP Savings to Investment Ratio (Estimated Range)	
0.88 - 0.98	1.03 - 1.17

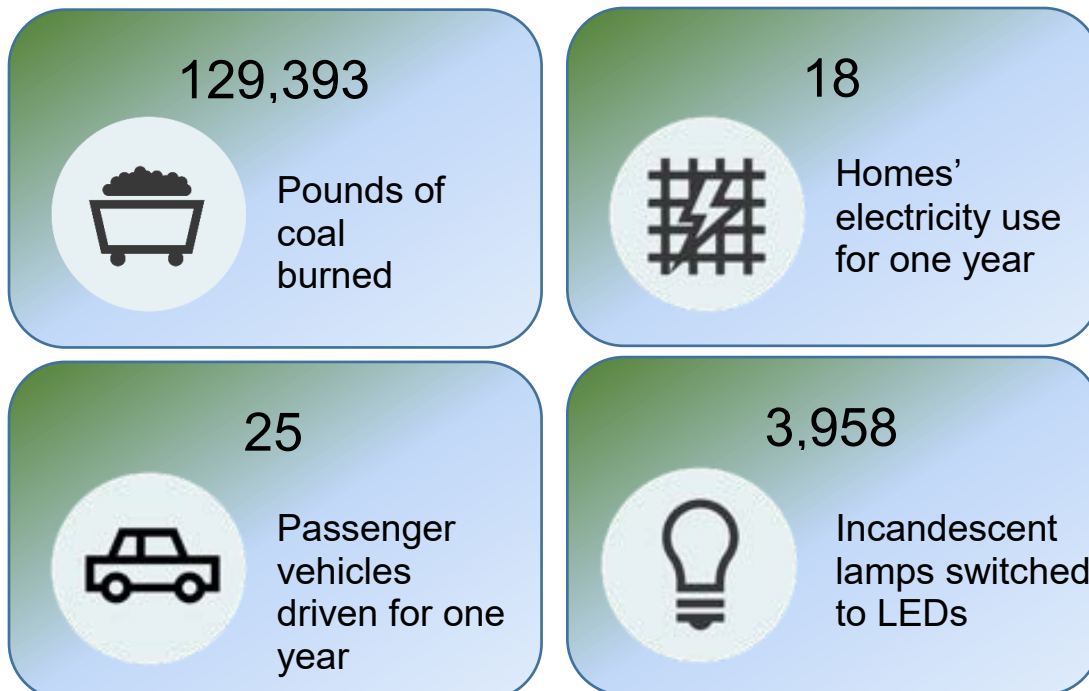


⁵ Energy Use Intensity is calculated based on source energy and encompassing all the energy used in delivering energy to a site, including power generation, transmission and distribution losses. (<https://www.governor.ny.gov/news/no-88-directing-state-agencies-and-authorities-improve-energy-efficiency-state-buildings>)



Greenhouse Gas Reduction Equivalencies

The annual carbon emissions reduction from the implementation of a GSHP system at your site can be translated to an equivalent reduction in any one of the following alternatives, including pounds of coal burned, electricity used by a home in one year, number of passenger vehicles driven in one year, and number of incandescent lightbulbs replaced with LED bulbs.⁶



⁶ EPA Greenhouse Gas Equivalencies Calculator (as of November 2018): <https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator>.

Environmental Permitting Considerations

Although GSHPs are clean energy technologies, some environmental factors should be considered to best manage the installation process. The following is an introductory, non-comprehensive list of considerations when GSHP boreholes are drilled:

- The drilling process can bring large amounts of ground water to the surface, and this water needs to be managed and disposed of in an appropriate manner. The volume, rate of flow, water quality, and local site conditions dictate the most appropriate approach. Most of the time, settling ponds with geotextile “silt fencing” and/or hay bales is sufficient, which allows an acceptable amount of slightly discolored water to run off via normal storm water drainage systems.
- GSHP projects in Western New York and the Southern Tier (counties west of the Catskill Mountains along the northern border of Pennsylvania) in particular may encounter pockets of natural gas, which must be handled with experience and caution.
- There are no state permits required for geothermal bore holes less than 500 feet deep. All bore holes deeper than 500 feet must apply for a permit from the Department of Environmental Conservation (DEC) for each hole. Local jurisdictions should also be contacted regarding specific requirements.
- Construction and grouting must be done in accordance with federal, state, and local regulations as well as current industry best practices to minimize contamination risk from either surface run-off or cross aquifer sources of contamination.

Additional considerations associated with each type of geothermal loop field can include:

Closed Loop	Open Loop	Standing Column
<p><i>Less than 500 feet:</i> No additional considerations</p> <p><i>Greater than 500 feet:</i> Must apply for DEC permit; permit may require drift monitoring and/or a bond to cover costs associated with abandonment.</p>	<p><i>Supply Well:</i> Must comply with water well permitting and construction requirements as regulated by the New York State Department of Health (DOH).</p> <p><i>Discharge Well:</i> Must be reviewed by DEC; if initial water quality meets discharge standards and nothing will be substantially added during use, the system is not required to obtain a discharge permit.</p>	<p>Must apply for DEC permit, which requires drift monitoring and a bond to cover abandonment costs.</p> <p>Due to the open nature of the borehole in which groundwater is recirculated, the water chemistry will change as geologic formations are dissolved. This can potentially increase the concentration of dissolved solids or salinity, which can impact the reliability of the heat exchange surfaces.</p>

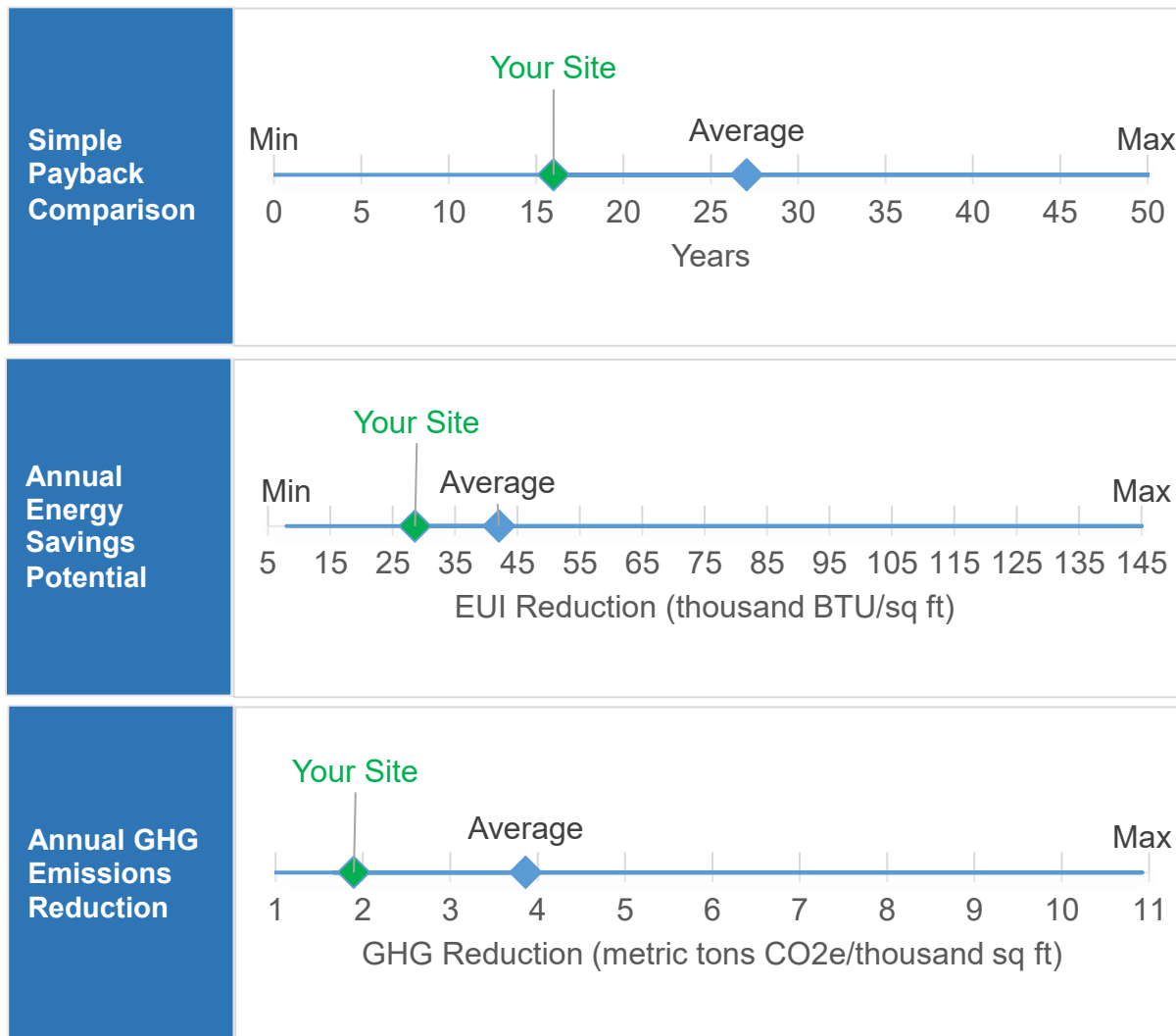
For more information on different types of GSHP loop fields and on environmental factors in GSHP system construction and operations, please see:

- NYPA’s *Geothermal Clean Energy Challenge* website:
<https://www.nypa.gov/about/geothermalchallenge>.
- NYSERDA’s *Renewable Heating and Cooling Policy Framework*:
<https://www.nyserda.ny.gov/-/media/Files/Publications/PPSER/NYSERDA/RHC-Framework.pdf>.

- NY-GEO, a nonprofit trade association dedicated to geothermal heating and cooling: <https://ny-geo.org/pages/frontpage>.
- U.S. Environmental Protection Agency's *Renewable Heating and Cooling* website: <https://www.epa.gov/rhc/geothermal-heating-and-cooling-technologies>.

Site Specific Considerations and Selection Criteria

A set of screening criteria was used to determine the most viable sites for the implementation of a GSHP system from those applying to the Geothermal Clean Energy Challenge. The criteria include a quantitative analysis of the technical and economic viability of a potential system and a review of important qualitative implementation factors for potential sites. Your site was one of the top-ranked sites selected to advance to Stage 2 of this Challenge. A description of each criteria is provided on the next page. The graphs below demonstrate how the benefits of a GSHP installation at your site compare to the benefits at other sites that applied. Your site is shown in green, compared with the minimum, maximum, and average values from the pool of applicants.



Screening Criteria	Description
Presence of a GSHP Champion	Is there an individual, or group of individuals, within the applicant organization that is significantly invested in making sure a GSHP system is installed at the site? This person can be a facility manager, board member, or any other influential individual. Often the presence of a champion can make or break whether a GSHP system is ultimately implemented.
Accessibility of Data for Screening Analysis	How responsive and forthcoming was the applicant during the facility engagement process? Were they able to provide data at the individual building level, or only at the campus level? Detailed building level data significantly improves the accuracy of the inputs used for the screening analysis and provides a higher level of confidence that the results from this first round economic screening are reliable.
Organizational Readiness to Implement	Does the applicant appear able and willing to pursue implementation of a GSHP system soon? Are there examples of previous or ongoing efficiency and renewable work funded by the applicant? Given the capital-intensive nature of a GSHP project, existing financial commitments for energy savings can help illustrate a readiness to undertake the investment required.
Sustainable Program Commitment	Does a GSHP system integrate into an existing sustainability program that the applicant has created (or is participating in)? Will the GSHP system be able to be tied to educational or community engagement work? A key goal of the Geothermal Clean Energy Challenge is to promote public awareness and education of GSHP systems within the State of New York.
Technical Viability	Are there any significant technical hurdles for implementation of a GSHP system at the site? Is there green or brown field space available on location?
Economic Benefits	Does the preliminary screening indicate that the installation of a GSHP system is financially attractive? The financial merit of the project is evaluated across three different standard financial metrics: Net Present Value (NPV), Savings to Investment Ratio (SIR) and Simple Payback Period.
Greenhouse Gas (GHG) Reductions	How significant are the estimated GHG reduction benefits? Is fuel switching from GHG intensive fuels such as fuel oil planned? GHG benefits are estimated based on reduction in annual metric tons of CO2 emissions.
Site Adds to Program Sectoral Diversity	Is the site part of a sector that is under-represented in the general applicant pool? If so, then the site is helping to add valued diversity to the types of facilities included in the program.
Site Adds to Program Geographic Diversity	Is the site part of a geographic region that is under-represented in the general applicant pool? If so, then the site is helping to add valued diversity to the types of facilities included in the program.



The New York Power Authority

In Cooperation with

Arcadis

**Geothermal Clean Energy Challenge
Stage 3 Report**

for

Ulster County Office Building

October 27, 2020

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Section 1
Executive Summary

EXECUTIVE SUMMARY

The Geothermal Clean Energy Challenge (Challenge) is a joint venture between the New York Power Authority (NYPA) and the New York State Energy Research and Development Authority (NYSERDA) to provide technical support, financial assistance, and implementation services to stimulate and finance the installation of best-in-class, large-scale geothermal systems, known as Ground Source Heat Pump (GSHP) systems. These systems reduce energy costs and greenhouse gas emissions. Increasing the use of these systems will play a major role in achieving Gov. Andrew M. Cuomo's Renewing the Energy Vision (REV) goal to reduce New York State's greenhouse gas emissions 40 percent by 2030. Stages 1 and 2 of the Challenge have been completed for the Ulster County Office Building (Office Building). Stage 3 of the Challenge 'Targeted Geothermal Audit & Conceptual Design' involves the production of audit-grade detailed design studies and business planning reports before large-scale geothermal systems are deployed.

Arcadis performed a detailed energy and geothermal audit for the Ulster County Office Building on January 21, 2020. The Office Building is located at 240 Fair Street, Kingston, New York. The purpose of the audit was to identify and evaluate cost-effective energy savings opportunities in conjunction with identifying the feasibility of implementing a GSHP system to provide heating and cooling at the Office Building.

As a result of the energy audit, ten ECMs were identified and recommended for the implementation. Of the identified ECMs, two have low or no implementation costs and eight have larger capital expenditures. The most substantial ECM analyzed was the ECM 8b, which included the replacement of the existing boilers and chiller with a hybrid GSHP system. The analysis included a geothermal test well, thermal conductivity test, review of existing mechanical systems, load reduction measures, existing mechanical system upgrades, and four bore field options. The test concluded that the office building has an average conductivity of 1.49 Btu/(hr-ft-F) based on the national range of soil thermal conductivity. Analyses of the geothermal test well thermal conductivity test results and the typical heating and cooling loads were completed to estimate a conceptual GSHP loop design. Other ECMs were identified to reduce the Office Building's energy use, but none were determined to have a substantial effect on reducing the size of the GSHP system. A geothermal heat exchanger grid of 5x12 boreholes (60 total) at 499 feet deep will meet the required design inlet water temperatures required during heating and cooling operations. In order to implement the new GSHP system, the GSHP would need to be integrated into the existing core mechanical systems providing heating and cooling for the building. Based on the loop capacity, preliminary estimates for design includes one 200-ton mag chiller, one 40-ton heat pump chiller, and a closed-circuit cooling tower to meet all of the building's cooling loads and two 800 MBH condensing boilers to meet the building's heating loads. The overall estimated cost of the GSHP system including

NYPA CPC project implementation fees would be \$2,663,804, or \$44,397 per well, with a simple payback period of 127 years.

Table 1: ECM Summary Table

ECM #	Measure Description	Energy Saved (kWh)	Demand Saved (kW)	Fuel Savings (therms)	Annual Dollars Saved	Estimated Costs for Implementation	Simple Payback Period (years)	CO2e Reduction (tonnes)
1	Stairwell fin tube radiation adjustment	0	0.0	84	\$78	\$0	0	0.499
2	Replace CFL with LED	1,881	0.3	-36	\$157	\$502	3	0.254
3	Install control to reduce run time on EF-3	1,096	0.0	1,034	\$1,153	\$6,638	6	6.411
4	Install control to reduce run time on EF-5	6,127	0.7	0	\$656	\$3,361	5	1.523
5	Install VFD on AHU HW Loop Pump	6,282	0.0	0	\$598	\$8,907	15	1.526
6	Replace existing drive on AC-1 and convert to DCV	39,360	11.4	0	\$4,252	\$70,525	17	9.787
7	Convert AC-4 to VAV with DCV	22,372	0.0	421	\$2,167	\$101,885	47	8.062
8.a.1	Replace existing boilers	0	0.0	6,359	\$5,938	\$550,750 ⁹	93	37.750
8.b.1	Replace existing chiller	11,248	13.4	0	\$7,520	\$570,806	76	2.797
8b	GSHP System with Upgraded Chillers and Boilers	41,773	0.0	18,470	\$20,942	\$2,663,804 ⁸	127	120.035
9	Controls Upgrade	71,066	0.0	7,112	\$12,277	\$58,220	5	59.891
10	Building Envelope Upgrade	27,968	0.0	5,347	\$7,211	\$677,935	94	38.697

Notes:

1. Assuming average energy values of \$0.07929/kWh (not including demand charges), demand value of \$8.30/kW, and a natural gas value of \$0.9338/therm from the most recent year of utility data.
2. There is not a summer peak demand savings for ECM8b but shoulder seasons provide savings.
3. ECMs were calculated independent of one another. Further measure interactions will be analyzed at the 60% design stage.
4. Project costs include NYPA CPC project implementation costs. Project costs were estimated using vendor quotes, driller quotes, and 2020 RS Means.
5. Refer to the Energy Conservation Measures section of the report for additional measure details.
6. The Simple Payback Periods were rounded to the nearest year in this Summary Table.
7. Currently available NYSERDA incentives of \$279,600 were included in this cost. There is no guarantee that these incentives will be available.
8. Currently available NYSERDA incentives of \$5,475 were included in this cost. There is no guarantee that these incentives will be available.

Section 2
Facility Description

FACILITY DESCRIPTION

The Office Building is in the Stockade District of historic Kingston approximately two miles west of the Hudson River. The surrounding area is primarily commercial and residential, with many buildings being preserved as historic landmarks.



Figure 1: Ulster County Office Building

Ulster County Office Building

The office building was constructed in 1964 and is 6-stories with a basement which total up to 62,396 square feet. These office spaces are occupied by a variety of County departments including the DMV, a records storage vault, financial offices and legislative spaces. The 6th floor houses a county executive meeting room with infrequent occupancy and other specialty offices. Many of these spaces have been renovated and reconfigured since its original construction which includes upgrades to the mechanical and electrical systems.

OCCUPANCY SCHEDULE

Typical occupancy is between 250 and 300 people. The building is typically occupied from 8:00 AM to 5:00 PM Monday through Friday. Employees can work outside of these windows as needed from 6:00AM to midnight. When the building is armed by security a midnight, general lighting is deactivated, and HVAC equipment is in unoccupied mode for the evening. When security disarms the building at 6:00AM, these systems are reenergized for the day. Specific controls and schedules for each type of equipment is noted in their respective sections.

LOCAL CLIMATE CONDITIONS

Since there are minimal internal heat loads in the Office Building, local climate has the largest impact on the Building's energy consumption. The building envelope is comprised of a curtain wall style system which is inherently inefficient, resulting in substantial heat loss and gains. Site weather patterns determine a typical meteorological year (TMY) and peak design conditions calculated by ASHRAE. These both have a large effect on energy calculations utilizing weather bin analysis and the peak loads that HVAC systems are designed for. The following are the ASHRAE design day conditions

for the Poughkeepsie, New York and were used as the basis for the energy calculations. The design parameters are:

Cooling Season Design Day: 88.4 degree F Dry Bulb / 72.3 degree F Wet Bulb

Heating Season Design Day: 8.4 degree F Dry Bulb

HEATING, VENTILATION AND AIR CONDITIONING

The Office Building is maintained between 70- and 74-degrees Fahrenheit (F) depending on the zone during occupied hours. During unoccupied hours in the heating season, a typical temperature setback of 65-degrees F is used. During the cooling season a typical temperature setback of 75-degrees F is used. Humidity is only actively controlled for AC-4 as it serves the vault area.

Dehumidification is controlled by regulation of the chilled water flow that supplies the chilled water coils in each AHU.

During the summer, the boilers are shut off to eliminate stand-by system losses and to prevent the building from unintentional simultaneous heating and cooling. Similarly, chilled water is shut off during the heating season. Even with these schedules, simultaneous heating and cooling does occur during the shoulder season when the systems overlap. Exact dates of when these systems are shut off annually are dependent on weather conditions, but the changeover periods are typically in October and May.

HEATING SYSTEM

Heating hot water (HHW) is provided by two natural gas fired Weil-McLain sectional cast iron boilers which were installed in 1988. The boilers are on an annual maintenance plan. They are at the end of their useful life and facility staff reported that the burners need continuous adjustments and excess air has become a greater issue. Two boilers are required to operate to meet the heating building load during times when the outdoor air temperature is 10 degrees F or lower. The boilers are controlled through the BMS and are enabled when the OA DB temperature drops below 58 degrees F and are in constant operation anytime the temperature is below 40 degrees F. During periods of lighter loads, the boilers are manually changed from lead to lag to balance hours of operation. The hot water supply (HWS) temperature is linearly reset based on OAT. At 0 degrees F the HWS is 180 degrees F and at 60 degrees F the HWS is at 120 degrees F.

Table 2: Boiler Plant Schedule

Tag	Manufacturer	Year Installed	Boiler Gas Input (MBH)	Boiler Water Output (MBH)	Description
No.1	Weil-McLain	1988	5,124	3,557	Gas Fired – Model 1688
No.2	Weil-McLain	1988	5,124	3,557	Gas Fired – Model 1688



Figure 2: Weil-McLain Boilers

The hot water produced by the boilers is supplied via three hot water pumps (HWP). One pump provides hot water to the AC units which utilize 3-way valves. The other two pumps provide hot water to the perimeter fin tube radiation which have 2-way valves. It is reported that the flow to Floor 5 and 6 is inadequate. The perimeter fin tube radiation units are controlled by unitary thermostats. Some areas are over or under heated due to a thermostat now being in a different room due to renovations. The northeast stairwell is in the corner of the building and contains fin tube radiation at intermediate landings between floors to maintain a setpoint temperature of approximately 70 degrees F. The units utilize self-contained thermostats with manual control via a dial on the enclosure. It was recognized that each unit was operating during the inspection and the upper portions of the stairwell were warmer than required as they are not typically occupied.

Table 3: Hot Water Pump Schedule

Tag	Manufacturer	Motor HP	Pump Flow (GPM)	Location	Serves
P3-1	B&G	7.5	390	Basement	AHU
P4-1	B&G	2	84	Basement	South Fin Tube
P5-2	B&G	3	106	Basement	North Fin Tube

COOLING SYSTEM

Chilled water (CHW) is provided by a singled water-cooled York variable speed drive (VSD) centrifugal chiller which is approximately 15 years old and not yet at the end of its useful life. The chiller is located in the basement and the cooling tower is located on the roof. The Frick counterflow cooling tower is original to the building but is currently operating without issue as reported by the building engineer. The cooling tower utilize two fans and operate to maintain a set return condensing water temperature back to the chiller. It is drained and cleaned at the end of each cooling season.

Table 4: Chiller Plant Schedule

Tag	Manufacturer	Model	Year Installed	Size (tons)	Description
CH-1	York	YT	2005	300 (est)	Variable Speed Drive



Figure 3: York Chiller

CHW is supplied to the AC units via a loop by means of two constant speed pumps. Control is accomplished by 3-way valves. Condenser water is circulated between the chiller and cooling tower by means of two constant speed condenser water pumps (CWP). Pumps for both systems operate in a lead/lag sequence and a spare pump is available for redundancy.

Table 5: Chilled Water System Pump Schedule

Tag	Manufacturer	Motor HP	Pump Flow (GPM)	Location	Serves
P1-1	B&G	15	740	Basement	Chiller
P1-2	B&G	15	740	Basement	Chiller
P2-1	B&G	15	700	Basement	Cooling Tower
P2-2	B&G	15	700	Basement	Cooling Tower

AIR DISTRIBUTION

All air handling units contain chilled water (CHW) and hot water (HW) coils for cooling and heating, respectively. AC-1, 2, 3, and 5 were replaced in 1987. When replaced, AC-1, 3 and 5 were upgraded to include economizers and reheat coils. Each floor is separated into 4 major zones, with a cooling coil in the supply air duct of each zone which is supplied by a dedicated supply air ductwork that was originally designed as a hot/cold-deck multi-zone system, but these systems were retrofitted in 2003 to remove the hot/cold decks. As a result, only the cooling coils are used to for final tempering of zone supply air for cooling only.

AC-1 is in the basement and serves Floors 1 through 5. There is a manually operated variable speed drive on the supply fan motor that is used for balancing purposes and is typically manually adjusted between heating and cooling seasons to provide the proper airflow required. AC-2 is in the basement and serves the main lobby vestibule. The ductwork supplies air to the vestibule through floor discharges between the doors. This unit does not have outside air (OA) since it only recirculates air within the vestibule which receives OA via the doors. AC-3 is in the mechanical room behind the maintenance office and serves the basement. This unit has its own dedicated OA duct and has economizing capabilities that is manually operated by staff. AC-4R is in the basement next to AC-1 and shares a common OA plenum. This unit serves the document vault area that spans from the basement to Floor 3 and contains 3 coils; one direct expansion (DX), one CHW, and one HW. The DX coils are backups for when the chilled water system is off during the shoulder season. There are four condensing units that serve each of the DX coils. The unit utilizes hot water reheat coils for each zone, these reheat coils were previously electric. Each zone's ductwork has an independent electric steam generator for humidification. These are not currently being used as they have the tendency to over humidify and cause alarms. AC-5 is the only unit located on the rooftop and is dedicated to Floor 6. There is both a hot water and chilled water heat exchanger located on Floor 6 which separate the house's hydronic loops and the rooftop unit's glycol loops. Each glycol loop has its own dedicated circulation pump. The intent of this design is to avoid freezing but the glycol CHW is drained when the chiller is deenergized for the winter.

Table 6: Air Handling Unit Schedule

Tag	Manufacturer	Model	Location	Area Served	Cooling System Type	Heating System Type
AC-1	Unknown	Unknown	Basement	Floors 1-5	CHW	HHW
AC-2	Unknown	Unknown	Basement	Vestibule	CHW	HHW
AC-3	Carrier	39BA060D15	Basement	Basement	CHW	HHW
AC-4	Trane	MCCA021SDE	Basement	Vault	CHW/DX	HHW
AC-5	Unknown	Unknown	Roof	Floor 6	CHW	HHW

Note: AC units designated as "Unknown" did not have nameplates or other identifiable markings

Exhaust fans are integrated into the building's security system. When the security system is activated at night, exhaust fans are deactivated and vice versa in the morning when the security system is deactivated. No identifiable markings were located on the exhaust fan housings.

Table 7: Exhaust Fan Schedule

Tag	Location	Area Served
EF-1	Roof	Lavatories
EF-2	Roof	6 th Floor Legislative Conference Room
EF-3	Roof	Storage Riser
EF-4	1 st Floor	Generator Room
EF-5	Basement	Chiller Vault
EF-6	Roof	Janitor Closets

CONTROLS

The buildings HVAC system is controlled by a Johnson Controls Metasys Building Automation System (BAS) and the workstation is located in the basement maintenance office. The system has the capability to trend data but is not utilized to its full capabilities. A 3-degree F deadband has been programmed to reduce overlapping heating and cooling during the shoulder season. EmTech has taken over the maintenance of the system and has reported inaccuracies in some of the monitoring points. It appears that the system may not have been reconfigured accurately since the last renovation.



Figure 4: Johnson Controls Metasys Building Automation System

There are a mixture of direct digital controls (DDC) and pneumatic controls in operation throughout the building. A 1.5 HP, 80-gallon DeVilbiss compressed air system is located in the mechanical equipment room in the basement. The air compressor serves the pneumatic thermostats and control valves. It was observed to run for long periods of time and cycled frequently.



Figure 5: 1.5 HP DeVilbiss air compressor

BUILDING ENVELOPE

WALLS

The Building's exterior is curtain wall construction, consisting of glass windows and aluminum mullion framing members which make up the curtain wall. This is supported by a steel framed structure. The windows are single pane with insulated glazing and have not been upgraded since the original construction.

Due to the curtain wall's construction, maintaining comfort within the building around the perimeter is difficult due to the high conductive heat losses and gains due to thermal bridging through the aluminum framing and high infiltration rates.

Figure 6 shows the exterior view of the Documentation Vault area. This area spans from the basement to Floor 3 and is separated from the windows by concrete masonry unit (CMU) block. The first 2 floors appear to be cooler in color temperature than the 3rd floor since this floor is standard office space without a CMU barrier. The spandrel panels are also cooler in color temperature as they are more insulated than the single pane windows. Thermal bridging is apparent along all the aluminum framing.

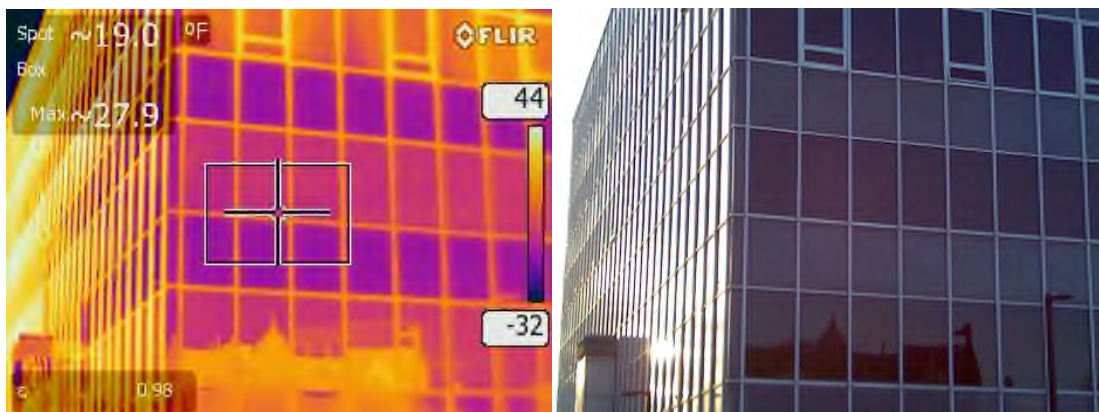


Figure 6: Southeast Envelope - Exterior View of Vault Area

Both main entrances have vestibules and are located on opposite ends of the building. The front entrance uses standard push/pull doors and the exterior doors were reported to break frequently due

to the wind. The rear entrance uses automatic sliding doors without air curtains. These automatic doors were observed to stay open for a longer period of time than necessary once activated. Due to frequent pedestrian traffic for the DMV at the front vestibule, both vestibule doors are often open at the same time allowing a large volume of unconditioned outside air to enter the 1st floor during occupied times creating an uncomfortable environment and increased loading of the HVAC system.

Figure 7 shows the front vestibule area which is cooler than the main lobby located to the right of the photo. The vestibule is functioning as a barrier to the outside air but there are still large losses through the standard lobby window assemblies.

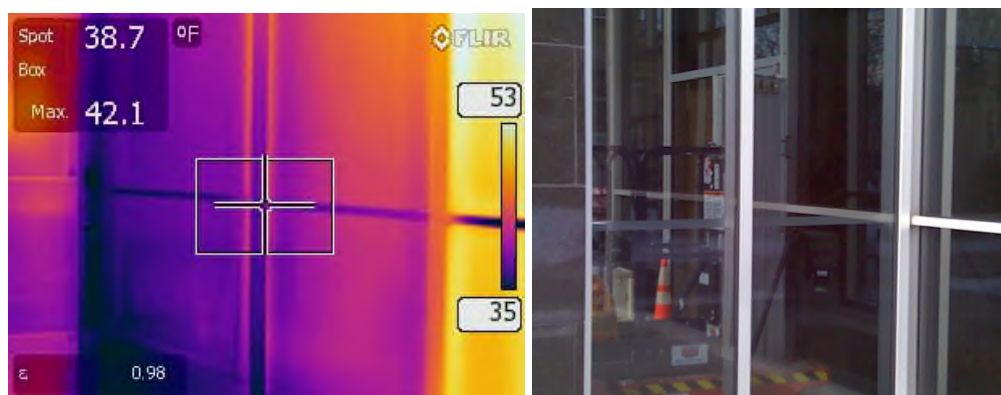


Figure 7: Northwest Envelope - Exterior View of Front Vestibule

ROOF

The existing black membrane rubber roof which is approximately 40 years old. The cooling tower, AC-5, and most of the exhaust fans are located on the rooftop. Funding has been approved for the replacement of the roof membrane. It is not known when the replacement will take place.

LIGHTING

INTERIOR

The light fixtures were recently upgraded to light emitting diode (LED) technology through a program with the building's utility provider, Central Hudson. Almost all the T8 linear fluorescent fixtures in offices, stairwells, mechanical rooms, and common areas were replaced with plug and play Philips InstaFit lamps. Many of the offices also utilize A/B switching which allows the occupancy to choose to only use half the number of lamps in their fixtures. This was observed to be commonly used by the occupants as the upgraded lamps have a higher lumen output. A small number of compact fluorescent light (CFL) cans and T8 fixtures were observed during the walkthrough. Exterior pole mounted lighting has been upgraded to Cree LED fixtures.

Hallway lighting is integrated into the building's security system. When the system is activated at night, all hallway lighting is deactivated and vice versa in the morning when the system is deactivated.

Independent office areas are switch controlled and some areas have been upgraded to utilize

occupancy sensors. Bathrooms also have ceiling mounted occupancy sensors. Staff are vigilant as almost all offices observed during the inspection had their lights off when they were unoccupied.



Figure 8: Typical LED Fixtures Located in Office Areas

EXTERIOR

Perimeter exterior lighting is present in the form of cobra head style LED streetlights and LED can style fixtures over the front entrance.



Figure 9: LED Streetlight in Parking Lot

DOMESTIC HOT WATER

An 80-gallon Bradford White water heater is located in the basement and is responsible for supplying domestic hot water (DHW) to the building. The hot water is delivered to each floor by a supply and return distribution loop with an aquastat.



Figure 10: 80-gallon Bradford White DHW Tank

MISCELLANEOUS

Typical office spaces contain computers, printers, task lighting, and vending machines. Printers are centralized and there is typically one per department. Due to the exterior wall construction, there is excessive heat loss at the perimeter zones and personal electric unit heaters are being used. There is approximately one kitchenette per department which typically contain a refrigerator, microwave, toaster oven, and coffee pot. There is a DMV data closet and telecom closet which are both cooled by dedicated split DX systems.

Section 3
Energy Baseline

ENERGY BASELINE

UTILITY ACCOUNTS AND BILLING

ELECTRICITY

The electric utility provider is Central Hudson Gas and Electric (CHG&E). The building is listed under Service Classification No. 2 (E200-E290) for General Service Commercial/Industrial with demand less than 1,000 kW. While delivery is charged by CHG&E, the building is supplied through Constellation Energy for with fixed supply rate of \$0.05844/kWh. Area (parking) lights are segregated from the other electric energy charges but on the same monthly bill. They are categorized as Service Classification No. 5 (E500) – Area Lighting Service. Since area lights are typically on during sundown, there are no demand charges for this service classification.

There are no opportunities to change rate class after a review of CHG&E's Summary of Proposed Monthly Electric Base Delivery Rates.

Table 8: Average Electricity Rates

Average Building Demand Rate (\$/kW)	Blended Building Rate (\$/kWh)	Non-Blended Rate Used for ECM Savings Calculations (\$/kWh)	Blended Area Lights Consumption Rate (\$/kWh)
8.30	0.106	0.07929	0.241

NATURAL GAS

Natural gas is charged on the same CHG&E bill as the electric charges. The building is listed under Service Classification No. 2 (G250-G450) Commercial and Industrial Rate for commercial and industrial heating, water heating, and cooking customers.

Table 9: Average Natural Gas Consumption Rate

Average Natural Gas Rate (\$/therm)
0.9338

ANNUAL ENERGY USE

The total energy use and energy baseline for the Office Building over the past two years is shown in Table 10.

Table 10: Annual Energy Use Summary

Bill Date Range	Annual Electricity Use (kWh)	Natural Gas Use (therms)	Annual Energy (MMBtu)	Energy Use Intensity (kbtu/sqft)	Energy Cost Intensity (\$/sqft)
November 2017 – October 2018	946,740	27,929	6,023	96.5	\$2.08
November 2018 – October 2019	875,860	27,130	5,701	91.4	\$1.89

Notes:

MMBtu = Million British thermal units

Kbtu = Thousand British thermal units

Sqft = square foot

ENERGY END USE BREAKDOWN

ENERGY

Figure 11 on the following page, displays the breakdown of energy (electricity and natural gas) by end user within the Office Building. Due to the lack of granularity for disaggregating loads like air compressors, office equipment, and data centers in eQuest, the energy end use breakdown was completed using ASHRAE Procedures for Commercial Building Energy Audits as well as data output from the eQuest energy model for accuracy. The top five energy intensive systems are space heating, lighting, cooling, and ventilation. The 2012 Commercial Building Energy Consumption Survey (CBECS) lists the top five systems based on energy intensity to be space heating, ventilation, computing, other, and lighting. Cooling may be higher on the list for this facility compared to CBECS due to the curtainwall envelope which allows more heat gain during the cooling season.

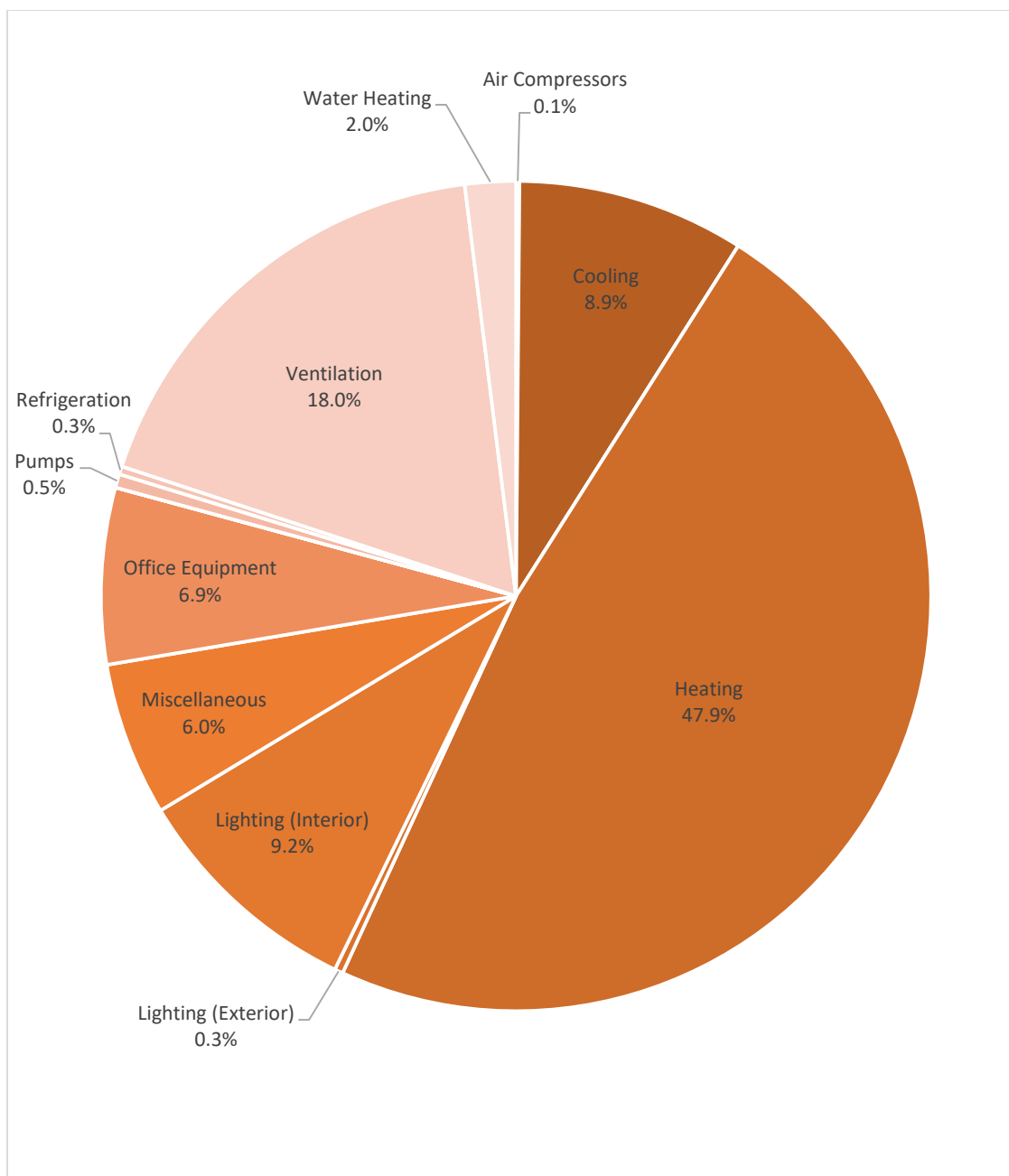


Figure 11: Estimated Annual MMBtu Usage by System Type

ELECTRIC ENERGY CONSUMPTION

The appropriate cooling degree days (CDD) were found by trial and error using regression analysis. The utility bills are invoiced mid-month which required the CDD to be customized to match that timeframe. The highest correlation to for electricity consumption and weather was at 61 degrees F. The building typically consumes between 55,000 and 76,000 kWh at baseload with the remaining spikes corresponding to temperature due to the large envelope load.

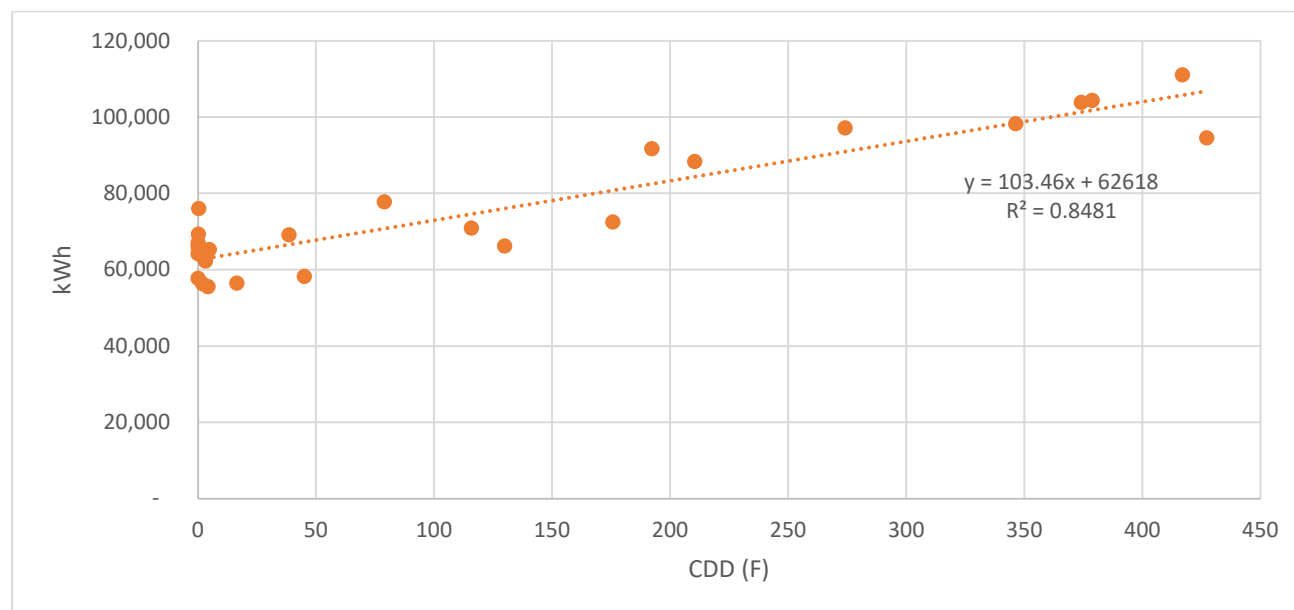


Figure 12: Regression Analysis for Electric Consumption and CDD

As cooling is provided by a chilled water system the electric energy consumption spikes during the summer. 2018 had a larger spike than 2019 but this is explained by the increase in the CDD for that timeframe. There are small spikes in December of each year which are likely due to the electric duct heaters for AC-4 and personal electric unit heaters in the office areas.

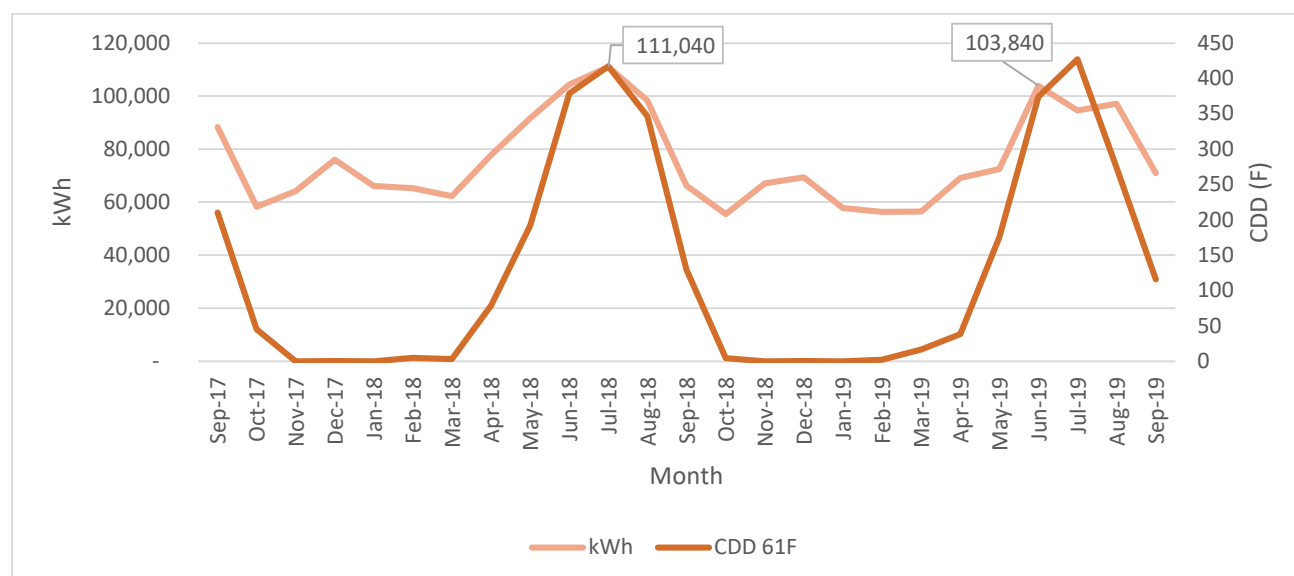


Figure 13: Past 2 Years of Electricity Consumption with CDD

ELECTRIC DEMAND

Understanding the demand portion of the electric bill is important since the demand cost for the building ranges from 17 to 28 percent of the total energy cost. The Office Building's peak demand profile ranges between 136 kW and 270 kW between November 2017 and October 2019, as shown in **Figure 14**. Small spikes are present in the winter which is likely due to the electric duct heaters on AC-4 and personal electric unit heaters throughout the building.

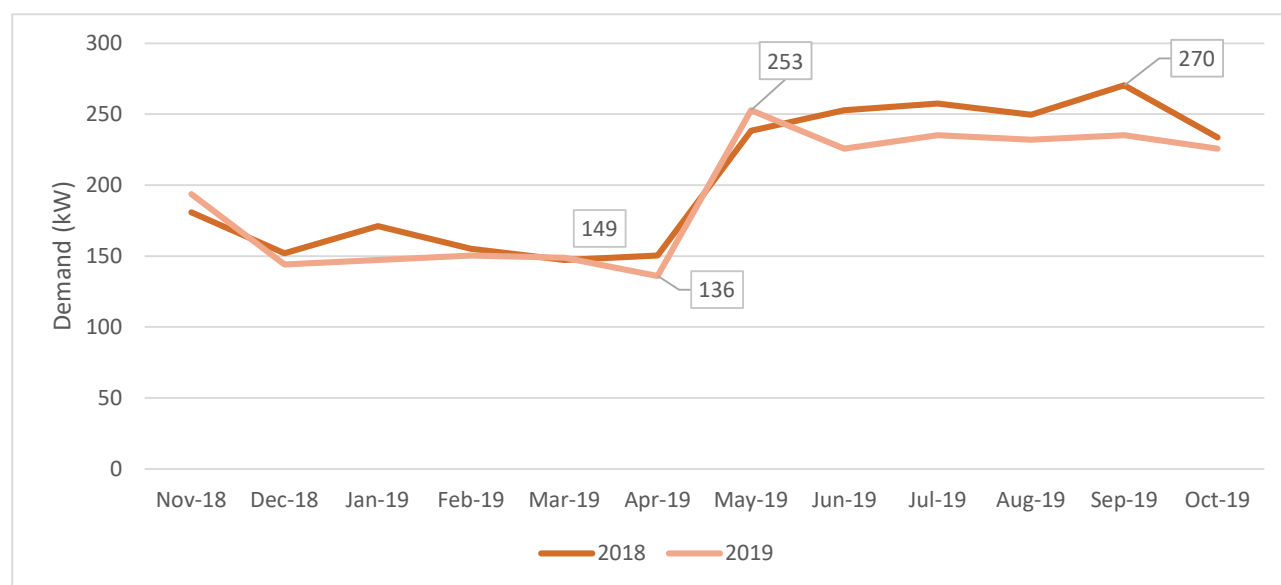


Figure 14: Peak Demand Profile

Table 11: Office Building Estimated Peak Demand Breakdown

End Use	kW	Percent (%)
Air Compressors	1.0	0.37%
Cooling	111.3	41.56%
Data Center/IT	1.0	0.37%
Lighting (Interior)	47.0	17.55%
Lighting (Exterior)	1.5	0.56%
Miscellaneous	32.7	12.21
Pumps & Aux.	16.5	6.16%
Ventilation	56.5	21.10%
Total Estimated	267.8	100%
Historical Billing	253.0	
Percent of Billing	105%	
Total per 1000 x sqft.	4.3	

NATURAL GAS CONSUMPTION

The appropriate heating degree days (HDD) were found by trial and error using regression analysis. Like with the CDD, the utility bills are invoiced mid-month which required the HDD to be customized to match that timeframe. The highest correlation to for natural gas consumption and weather was at 58 degrees F. The building typically consumes a very small amount of natural gas for hot water with most consumption corresponding to temperature due to the envelope, infiltration, and ventilation loads.

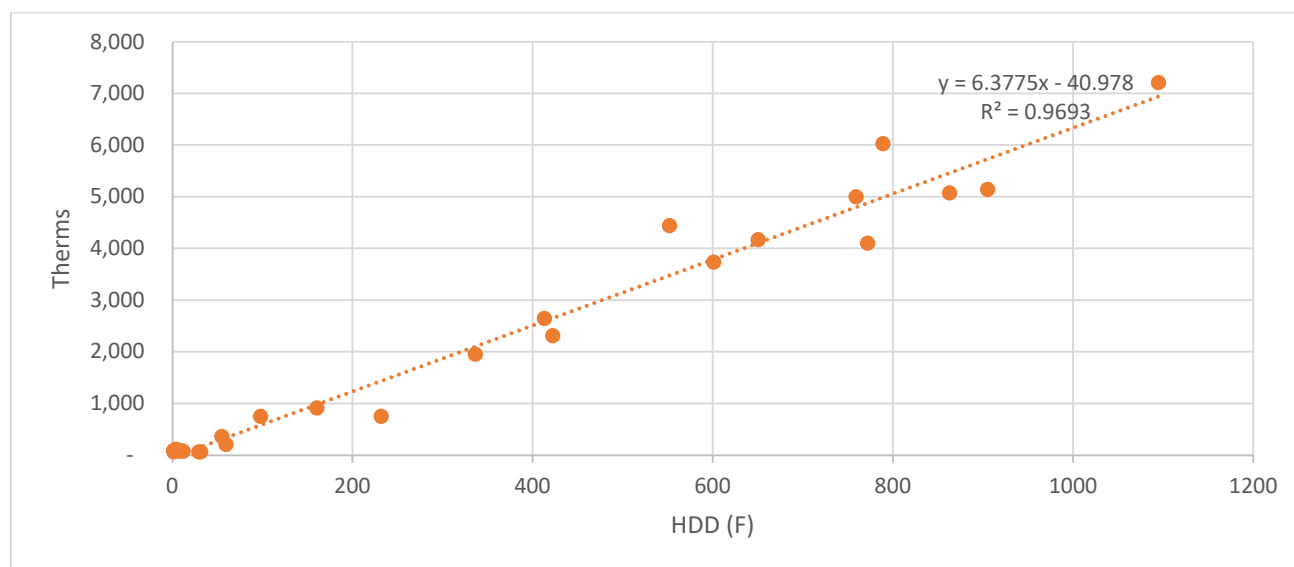


Figure 15: Regression Analysis for Natural Gas Consumption and HDD

As heating is provided by the hot water boilers the natural gas consumption spikes during the winter. 2018 had a larger spike than 2019 but this is explained by the increase in the HDD for that timeframe. The summer trends for domestic hot water consumption are consistent as this is only used for lavatory sinks and kitchenettes.

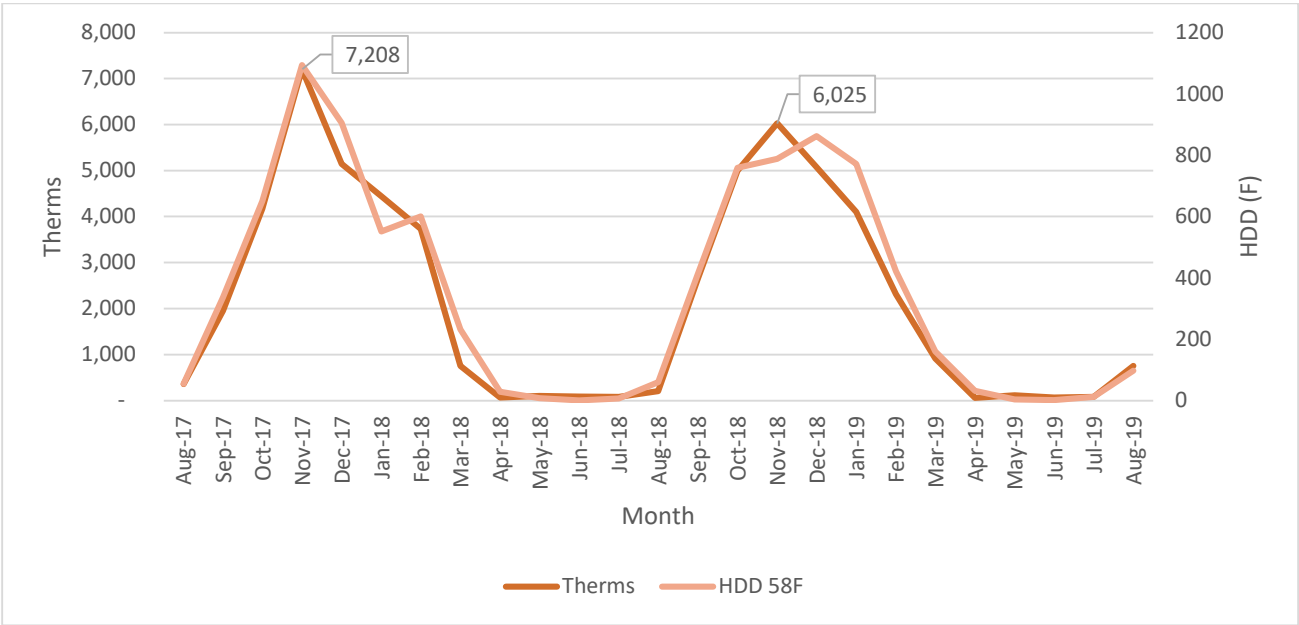


Figure 16: Past 2 Years of Natural Gas Consumption with HDD

Section 4
Energy Modeling Analysis

ENERGY MODELING ANALYSIS

The modeling program used for this analysis was eQuest, which was designed by James J. Hirsch & Associates. eQuest is a building energy use analysis tool that allows users to perform detailed comparative analyses of building designs and technologies using typical meteorological year (TMY3) data from the National Renewable Energy Laboratory (NREL). The program utilizes a combination of user inputs and software defaults to allow users to generate an accurate model of the building of study and provide estimates of energy consumption based on building envelope constructions, occupancy schedules, internal and external loads, and HVAC system operations and setpoints.

MODEL CREATION AND CALIBRATION

The baseline model was developed using eQuest's Schematic Design Wizard. The Schematic Design Wizard is intended for early-stage model development. Computer-aided design (CAD) drawings were imported into the program to accurately utilize the Office Building's exact layout. High level inputs including envelope constructions, interior finishes, windows and exterior doors, occupancy schedules, and HVAC equipment specifications and operations were entered into the model to establish a basic building footprint and building systems.

eQuest's Detailed Data Edit Mode was used to further refine the model's inputs. The Detailed Data Edit Mode allows users increased freedoms to revise operating schedules for fans, cooling, heating, occupancy, lighting, and miscellaneous equipment. Additionally, the Detailed Data Edit Mode allows further adjustment of envelope constructions for windows and skylights, doors, and building façade exteriors. The Detailed Data Edit Mode was utilized for the Office Building to provide greater detail on HVAC systems, building setpoints, building schedules, and sources of internal loads.

A model of the Office Building was generated based on data provided by Ulster County staff as well as data gathered during the site walkthrough. Where data was available, inputs were provided to eQuest, and where data was unavailable, ASHRAE and building code estimates or program defaults were used to generate an accurate model of the Office Building's operation and energy consumption. Calculated energy consumption was calibrated with utility bill data and ASHRAE's Procedures for Commercial Building Energy Audits tool to ensure the accuracy of the generated model.

PEAK LOAD CALCULATION

Simulation of the Office Building using eQuest provides a multitude of reports concerning energy consumption, heating and cooling loads for each zone, heating and cooling load components such as conduction through windows, ventilation, and internal heat gains, and HVAC loads. Peak heating loads

were calculated for just the hot water circulation loop that serves the heating coils assuming typical operation at the Office Building, as shown in Table 12.

Table 12: eQuest peak heating loads for the boiler during normal Office operation

Month	Heating Energy (MMBtu)	Maximum Heating Load (kBtu/h)
Jan	486	1,956
Feb	401	1,966
Mar	242	1,482
Apr	150	1,171
May	22	459
Jun	0	0
Jul	0	0
Aug	0	0
Sep	0	0
Oct	26	1,156
Nov	194	1,391
Dec	384	1,632

Similarly, peak cooling loads were calculated assuming typical operation at the Office Building, as shown in Table 13.

Table 13: eQuest peak cooling loads for during normal office operation

Month	Cooling Energy (MMBtu)	Maximum Cooling Load (kBtu/h)
Jan	0	0
Feb	0	0
Mar	0	0
Apr	0	0
May	77	1,488
Jun	226	1,936
Jul	247	1,725
Aug	291	1,712
Sep	89	1,516
Oct	22	1,538
Nov	0	0
Dec	0	0

Section 5
Energy Conservation Measures

ENERGY CONSERVATION MEASURES

ECMs were developed to support the Office Building in reducing overall energy consumption resulting in the reduction of heating and cooling loads in conjunction with design and construction of a GSHP system. In order to model energy consumption and calculate energy savings throughout the year, Microsoft Excel Bin analyses methods was performed for each measure, where appropriate. Of all the ECMs considered, seven had attractive payback periods, additional maintenance savings, or would be a reference for future projects when pricing becomes more reasonable. Project cost estimates were determined using manufacturer and distributor quotes as well as the 2020 RS Means handbook, with contingency added, as appropriate. Estimated accuracy of implementation costs is based on The Association for the Advancement of Cost Engineering's (AACE) Class 3 cost estimate. The expected accuracy range with a Class 3 cost estimate is between -10 percent and 30 percent of the calculated cost for implementation of each measure. A summary is provided in Table 14 below.

Table 14: ECM Summary Table

ECM #	Measure Description	Energy Saved (kWh)	Demand Saved (kW)	Fuel Savings (therms)	Annual Dollars Saved	Estimated Costs for Implementation	Simple Payback Period (years)	CO2e Reduction (tonnes)
1	Stairwell fin tube radiation adjustment	0	0.0	84	\$78	\$0	0	0.499
2	Replace CFL with LED	1,881	0.3	-36	\$157	\$502	3	0.254
3	Install control to reduce run time on EF-3	1,096	0.0	1,034	\$1,153	\$6,638	6	6.411
4	Install control to reduce run time on EF-5	6,127	0.7	0	\$656	\$3,361	5	1.523
5	Install VFD on AHU HW Loop Pump	6,282	0.0	0	\$598	\$8,907	15	1.526
6	Replace existing drive on AC-1 and convert to DCV	39,360	11.4	0	\$4,252	\$70,525	17	9.787
7	Convert AC-4 to VAV with DCV	22,372	0.0	421	\$2,167	\$101,885	47	8.062
8.a.1	Replace existing boilers	0	0.0	6,359	\$5,938	\$550,750 ⁹	93	37.750
8.b.1	Replace existing chiller	11,248	13.4	0	\$7,520	\$570,806	76	2.797
8b	GSHP System with Upgraded Chillers and Boilers	41,773	0.0	18,470	\$20,942	\$2,663,804 ⁸	127	120.035
9	Controls Upgrade	71,066	0.0	7,112	\$12,277	\$58,220	5	59.891
10	Building Envelope Upgrade	27,968	0.0	5,347	\$7,211	\$677,935	94	38.697

Notes:

1. Assuming average energy values of \$0.07929/kWh (not including demand charges), demand value of \$8.30/kW, and a natural gas value of \$0.9338/therm from the most recent year of utility data.
2. There is not a summer peak demand savings for ECM8b but shoulder seasons provide savings.
3. ECMs were calculated independent of one another. Further measure interactions will be analyzed at the 60% design stage.
4. Project costs include NYPA CPC project implementation costs. Project costs were estimated using vendor quotes, driller quotes, and 2020 RS Means.
5. Refer to the Energy Conservation Measures section of the report for additional measure details.
6. The Simple Payback Periods were rounded to the nearest year in this Summary Table.
7. Currently available NYSERDA incentives of \$279,600 were included in this cost. There is no guarantee that these incentives will be available.
8. Currently available NYSERDA incentives of \$5,475 were included in this cost. There is no guarantee that these incentives will be available.

ECM 1: STAIRWELL FIN TUBE RADIATION ADJUSTMENT

The northeast stairwell is heated by hot water fin tube radiation units located on the landings in between each floor. During the inspection it was noticed that the 6th floor was unnecessarily warmer than the floors below due to stratification. Most pedestrian traffic is through the elevators and the stairwells are not commonly used by staff. As each unit has a self-contained manual dial thermostatic control mounted on it, it is proposed to turn down the setpoints of units located on the upper floors. This is a no-cost measure so it can be done in small increments to test the changes and ensure satisfactory heating of all floors.

ECM 2: REPLACE CFLs WITH LEDs

Facility staff is in the process of upgrading the remaining CFL fixtures to LED technology. During the inspection a total of 32 can downlight fixtures were identified have 2 pin type CFL bulbs each. These 13W CFL lamps can easily be replaced by a comparable 8W LED lamp upon failure or before failure. No additional modifications to the fixture will be required. The calculations were completed assuming that all lamps were replaced at once.

ECM 3: INSTALL CONTROL TO REDUCE RUN TIME ON EF-2

EF-2 serves the 6th Floor Legislative Conference Room and is in operation even when meetings are not taking place. Since this fan is scheduled to run on a set schedule it is proposed to revise the schedule to make the existing occupied periods unoccupied which will be activated by ceiling mounted occupancy sensors within the space. Once the occupancy sensors are triggered, EF-2 will stay on for an hour from the last detected motion in the room. This will greatly reduce the amount of exhaust air from the space, saving on heating and cooling energy supplied from AC-5.

ECM 4: INSTALL CONTROL TO REDUCE RUN TIME ON EF-5

EF-5 serves the chiller vault in the basement to ventilate the space for safety. There is a refrigerant alarm in the space to alert the building engineer if there is a leak but the fan itself is manually controlled and currently kept in the 'on' position. The fan was found to be operating during the audit in heating season even though the chiller was not in use. If the fan is controlled by the refrigerant sensor instead of the manual switch, it will still be code compliant. The fan control integration into the refrigerant sensor will allow the fan to run only when a refrigerant leak is detected. Staff will still have the ability to override the fan control if work is being completed in the chiller vault. This retrofit will greatly reduce the ventilation within the space saving heating and cooling energy supplied from basement unit AC-3.

ECM 5: INSTALL VFD ON AHU HOT WATER LOOP PUMP

All AC units are served by the boiler by a hot water distribution loop, utilizing three-way control valves on the heating coils of the AC units. It is proposed to either convert the three-way valves to two-way valves or replace the three-way valves at each unit with a two-way valve and install a VFD on the HWP that serves the loop. The VFD will allow the pump to respond to unit demand based on system static pressure utilizing static regain controls. Due to the limited capabilities of the existing BMS system, the VFD will not be integrated into the system. It will be controlled locally at the panel, as required.

ECM 6: REPLACE EXISTING DRIVE ON AC-1 AND CONVERT TO DCV

AC-1 is the largest unit in the building and serves floors 1 through 5 except for the Vault areas. The outside air damper is maintained at 10 percent open during typical operation and only opens further when economizing. It is recommended to monitor CO2 through each floor's return air plenum and adjust outside air to maintain the minimum required by ASHRAE 62.1. This will allow for ventilation savings during early morning and evening periods when occupancy is typically at its lowest.

As the existing drive on AC-1 was installed to manually balance the supply air fan. It is sometimes adjusted by facility staff seasonally to accommodate changes in pressurization. It is recommended to replace this drive with a variable frequency drive which will be able to adjust based on the demand from each floor.

ECM 7: CONVERT AC-4 TO VAV WITH DCV

The vault area is served by AC-4 and typically has low occupancy due to the nature of the space. Each floor has its own dedicated supply air duct. It is recommended to retrofit the existing constant air volume (CAV) system to variable air volume (VAV) with additional DCV controls. This will allow the system to greatly reduce the volume of air it is currently delivering to the space which will reduce cooling and heating loads. Additionally, less ventilation air will require less dehumidification during the summer as well as less humidification in the winter.

ECM 8.a.1: REPLACE EXISTING BOILERS

The existing heating system is original to the Office Building's construction. Staff expressed interest in replacing the two existing boilers. Since these units are past their end of useful life, the baseline scenario for this ECM assumed replacement of the boilers with modular condensing boiler units. Modular condensing boilers are able to operate at a much higher efficiency than the existing boilers and would be more appropriately sized to the building load. This ECM assumed that the associated equipment like circulation pumps would be maintained but should be assessed for potential upgrades in design.

ECM 8.a.2: REPLACE EXISTING CHILLER

The existing chiller is approximately 15 years old but based on the buildings cooling appears to be oversized, therefore operates outside its optimal efficiency. As a result, the chiller was evaluated to be replaced with a high efficiency variable speed chiller. The savings for this ECM came from the increased efficiency of the new chiller but additional chiller plant optimization strategies should be assessed once in design. The other associated equipment like circulation pumps will be maintained but should also be assessed for potential upgrades in design.

ECM 8b: GSHP SYSTEM WITH UPGRADED CHILLERS AND BOILERS

GEOHERMAL SAMPLE WELL AND TESTING RESULTS

The geothermal test well in the Ulster County Office Building parking lot was initiated on January 31, 2020 and completed on February 3, 2020. The test well was drilled to 126-feet at a diameter of 8 inches and to 499-feet at a diameter of 6 inches. The test loop piping utilized 1.25-inch DR11 high-density polyethylene (HDPE). The formation makeup at the test well site consisted of sand from 0 to 110-feet and gray shale from 110 to 499-feet. The grout mixture was composed of 100-pounds TG Lite, 32-pounds of PowerTEC, and 30-gallons of water.

After sufficient curing of the grout, the thermal conductivity (TC) test was completed for 70.3 hours to determine ground thermal properties. The TC test was performed by injecting a known and constant heat power into the borehole heat exchanger and measuring the temperature response of the surrounding formation. This method is used to determine the undisturbed formation ground temperature, the TC, the borehole thermal resistance, and an estimate of thermal diffusivity (TD). In the test borehole, an average heat flux of 20.1 W/ft was injected into the heat exchanger.

Geothermal Resource Technologies Inc. (GRTI) completed the analysis of the TC test results. The loop temperature and input heat rate data were plotted against the natural log of elapsed time are shown below in **Figure 17**. The temperature versus time data was analyzed using the line source method in conformity with ASHRAE and IGSHPA guidelines. A linear curve fit was applied to the average of the supply and return loop temperature data between 10 and 48 hours. The slope of the curve fit was found to be 3.69 which was then used to calculate the TC.

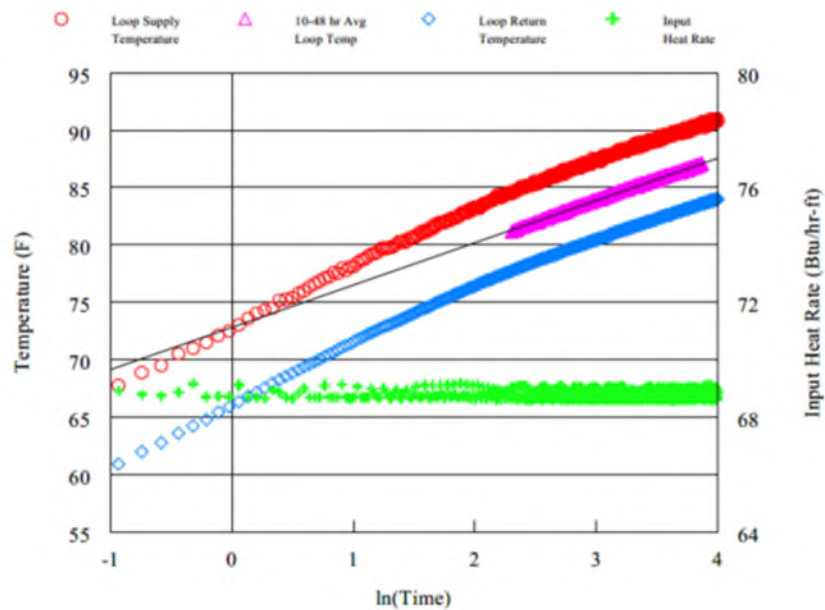


Figure 17: Thermal Conductivity Test Results

The resulting TC value of 1.49 Btu/hr-ft-°F calculated is considered average as the typical values range between 0.6 to 2.5 Btu/hr-ft-°F across the United States. A heat capacity value for shale was calculated from specific heat and density values for the formation. A weighted average of heat capacity values based on the indicated formation was used to determine an average heat capacity of 30.8 Btu/ft³-°F. A diffusivity value was then found using the calculated formation thermal conductivity and the estimated heat capacity. The thermal diffusivity for this formation was estimated to be 1.16 ft²/day. TD is more of a determining factor than TC for the balance of heating and cooling loads. Results of the thermal conductivity test are shown in **Table 15**.

Table 15: Thermal Conductivity Test Results

Parameter	Result	Unit
Thermal Conductivity	1.49	Btu/hr-ft-°F
Thermal Diffusivity	1.16	(ft ² /day)
Borehole Average Heat Capacity	30.8	Btu/ft ³ -°F
Undisturbed Ground Temperature	54.3 - 55.5	°F

GEOTHERMAL SYSTEM CONCEPTUAL DESIGN

Based on the site area restrictions and the existing constraints of the parking lot area, it is recommended to implement a vertical, closed-loop U-bend geothermal heat exchanger system. Four types of vertical, closed-loop options were assessed as part of the preliminary design. The primary difference between each option was bore depth, piping configuration and or piping material. Each option was analyzed to understand the best thermal transfer efficiency with the least implementation cost, resulting in the best return on investment. These options offered a unique perspective on how the various combinations

impacts the thermal efficiency and ultimately the quantity of bore holes required to meet a predetermined build heating and cooling load.

The four options analyzed were;

1. Single HDPE 1-1/4" U-Bend 499 foot depth: This is a typical option for vertical wells and does not require permitting due to the depth of the well. The test well was also drilled to 499 feet, so the well test results did not have to be extrapolated to estimate available resource. This option was selected due to cost, driller availability, and simplicity of the system.
2. Double 1-1/2" U-Bend 900 foot depth: This option utilizes a high-density polyethylene filled with highly conductive carbon-type nanoparticles which gives the material up to 75% higher thermal conductivity than the conventional HDPE option above. Since the material can improve drilling efficiency and provide additional savings over HDPE, it is proposed to drill to 900 feet which will require 21 bores which the parking lot can accommodate. The TD value used during analysis was conservative to account for any changes in thermal properties as the bore holes will be 400 feet deeper than the test well. It was ultimately not recommended due to the extrapolation in the available resource from the thermal conductivity report for the depth of the wells required, experienced drillers to install a system this depth, and the anticipated performance of the system.
3. Concentric 5"x3" Piping System - 1,610 foot depth: This option was analyzed as it would require only 11 bores. It was ultimately not recommended due to the extrapolation in the available resource from the thermal conductivity report for the depth of the wells required, experienced drillers to install a system this depth, and the anticipated performance of the system.
4. Concentric 7"x4" Piping System - 2,270 foot depth: This option was analyzed as it would require only 6 bores. It was ultimately not recommended due to the extrapolation in the available resource from the thermal conductivity report for the depth of the wells required, experienced drillers to install a system this depth, and the anticipated performance of the system.

There are four main types of geothermal configurations utilized for thermal heat transfer for the heating and cooling of commercial buildings, they are:

1. Vertical, closed loop system – vertical bore holes at varying depths utilizing u-bend piping in the bore hole connected by horizontal manifolds placed in horizontal trenches to connect the bore hole vertical piping system to the indoor mechanical systems. Since depth can be increased to accommodate additional load, less surface area is required for the bore field than other system types.
2. Horizontal, closed-loop system – horizontal piping which lays in shallow trenches connected by horizontal manifolds placed in the trenches to connect the bore field piping system to the indoor mechanical systems. As shallow trenches are cheaper than drilling vertical bore holes, a horizontal loop requires significantly more land area than is available at the Office Building.

3. Pond/lake, closed-loop system – thermal piping is submersed in a nearby body of water which is used as a thermal source and sink instead of the ground like Options 1 and 2. This is cheaper than the other options but was not considered for application at the Office Building due to the lack of access to a nearby body of water.
4. Open-loop system – instead of utilizing thermal piping to maintain a barrier between thermal sources and sinks like with the closed-loop systems, this system circulates the heat exchange fluid (typically water) that is already contained in the source. Expensive thermal piping is not required which saves on the initial capital cost for these project types and additional savings can be achieved using a surface body of water. This option was not considered at the Office Building as it requires the use of well or surface body water as the heat exchange fluid which is not available nearby the Office Building.

GEOTHERMAL DESIGN PARAMETERS

Due to the low amount of domestic hot water consumed on site the geothermal system will only be used to provide space conditioning for the building. The following table outlines the annual energy requirements of the building organized by heating and cooling. The system was sized using a combination of building demand and energy requirements so that the bore field would not be greatly oversized which would substantially increase the project cost and area required.

Table 16: Annual Building Energy Requirements

	Building Annual Cooling Requirement	Building Annual Heating Requirement
Space Conditioning Energy (kBtu)	1,129,481	2,498,473
Hot Water Generation Energy (kBtu)	---	0
Total Energy (kBtu)	1,129,481	2,498,473

Since the building is in a heating dominate climate, the ground energy will become unbalanced over time as more heat will be extracted from the ground then what is put back in. Due to this imbalance and cost of adding additional bores to only handle peak loads, a hybrid heat pump system is the most cost-effective arrangement to supplement peak loads and maintain bore field health. Due to the dominance of the heating season the hybrid arrangement will consist of two supplemental condensing hot water boilers which are sized to handle 20 percent of the load. The cooling season is not at risk for overheating the bore field as the cooling season is much shorter than the heating season, but during large cooling demands the bore field may have difficulty keeping up with peak cooling demand heat rejection capacity. As a result, it is proposed to use a cooling tower as a supplement for heat rejection during the cooling season which will work in conjunction with the bore field in the hybrid arrangement. Additional details about the operation of these systems during heating, cooling, and shoulder seasons are provided later in this report. The following table describes how the annual energy use requirements

of the Office Building are distributed between the GSHP, boilers, and cooling tower. The net ground energy is negative as the amount of heat extracted from the ground during the heating season is greater than the amount deposited during the cooling season.

Based on the calculated loads for heating and cooling, and to maintain bore field health the geothermal heat exchange grid will be installed to maintain an average spacing between bores of 20.0 feet on-center (OC). It is proposed that boreholes be drilled to approximately 499 feet deep to maintain the design inlet water temperatures described above. Upon further review with GRTI, the estimated TD is conservative and will potentially decrease (improve) as depth is increased.

The system geometry consists of 12 rows, with 5 bores per row, totalling in 60 bores for the field. The average column to column spacing is 20.0 feet for a single u-bend configuration. The bores will have a total one way length of 29,940 feet. The bores will be 5 inches in diameter with and the high TC HDPE piping will have a nominal diameter of 1.25 inches.

Due to land availability at the Office Building the only location for the bore field is the asphalt parking lot. The parking lot's total footprint is approximately 20,000 square feet which most will be utilized for the 60 bores. Due to the layout of the parking lot, a symmetrical grid will be difficult to achieve but the 20-foot spacing will be maintained. Using the same method prior to drilling the test well, the proposed conceptual heat exchange grid layout is predicated on the existing location of underground utilities. There is a small tolerance for bore locations that can be adjusted within a few feet to accommodate interferences. An overflow area was identified if underground utilities or other restrictions require boreholes to be relocated outside of the tolerance area. A conceptual layout of the proposed geothermal heat exchange grid with 60 bores is shown in **Figure 18**.



Figure 18: Heat Exchanger grid layout

The geothermal heat exchanger system selected was the single HDPE 1-1/4" U-Bend with 499-foot bores due to its cost, larger selection of available drillers, and simplicity of the system. To ensure that the geothermal heat exchanger design does not become too unbalanced, conservative spacing in the bore field was maintained based on industry standards. The system was designed based on the results of the thermal conductivity test and calculated heating and cooling loads which were estimated using a combination of eQuest building energy modelling software and spreadsheet calculations. Geothermal delivery supply water temperatures required for proper equipment operation and what the system design was predicated on are:

1. 40.0 degrees F minimum from the bore field to the heat recovery chillers in heating mode, and;
2. 80.0 degrees F maximum from the bore field to the heat recovery chillers in cooling mode.

The system design day was calculated first to compare the existing and proposed systems. It is the aggregated load for heating and cooling seasons including all constituent zones and hot water elements in the building. This is the loading profile for which the entire system is sized and is based on the worst-case season (heating or cooling) to ensure a conservative system design. The total capacity of the system is listed in the table below. Note that the existing heating capacity is for two boilers which are oversized and only at part load during peak conditions.

Table 17: Comparison of Existing and Proposed Systems

	Existing Cooling	Proposed Cooling	Existing Heating	Proposed Heating
Total Capacity (kBtuh)	3,600.0	2,050.4	7,114.0	1,745.0
Efficiency	0.582 IPLV (est.)	18.9 EER	80% (est.)	2.7 COP
Demand (kW)	180.1	108.2	<10	175.4

The circulating fluid for the loop would be 25 percent propylene glycol which gives the mixture a freezing temperature of approximately 14 degrees F. The system controls will ensure that the loop is kept above the freezing temperature. After system models were completed, final operating temperatures and flowrates for the system were established. Since the interior building loop is separated from the exterior loop, flows can be different based on demand within the building which can also save pump energy. Over a 5-year analysis period the long term soil temperatures will reach equilibrium temperature of 54.7 degrees F between the heating and cooling seasons. Temperature penalty describes the change in the deep earth temperature immediately surrounding the installed bore field after extended periods of system operation.

Table 18: Design Day Ground Loop Temperatures

Cooling Mode	Heating Mode
Unit Inlet 80.8 °F	Unit Inlet 41.6 °F
Unit Outlet 90.2 °F	Unit Outlet 36.6 °F

Calculations for peak flow were based on a block flow of 3 gpm per ton. The total bore field flow was calculated using the flow per path for 60 bores, with one path entering the bore field and one path leaving, for a total of 120 paths. Using the velocity and pipe characteristics, the head loss of the bore field was calculated to appropriately size the geoexchange source/sink pump located on the supply side loop. Operational system pressures in the heat exchanger loop will be between 20 and 30 psi and utilize a heat exchanger fluid with a mixture of 25 percent propylene glycol and 75 percent deionized or distilled water.

CONSIDERATIONS FOR MECHANICAL EQUIPMENT

Multiple layout options for new mechanical equipment were evaluated to be in either the existing mechanical space or in a new dedicated mechanical space located on the ground level outside. After evaluation, it was concluded that the new mechanical equipment will fit in the existing mechanical space in the basement. The proposed magnetic bearing chiller will be installed in the existing chiller vault. Since the existing chiller vault is located under the front lawn, it will be excavated so it can be

easily removed in one piece. Once all the large equipment is removed through the opening, all new mechanical equipment will be lowered into the basement including the new chiller and other large equipment.

BUILDING SYSTEM DESCRIPTION

The exterior heat exchange loops from the bore field will enter the building on the southwest side of the building into the existing chiller vault. The manifold will tie together the multiple loops and will be constructed for a low head design to reduce pump energy. The manifold will consist of digital temperature sensors, flow meters to assist in system balancing, and shut off valves. Specific manifold will be detailed during the 60 percent design. The existing HW and CHW piping systems serving the AC units and boilers will be re-piped as required to accommodate the new piping configuration for the heat pump system and will be sized to minimize system head loss. The new piping system will connect to the HW and CHW piping systems that leaves the mechanical room to serve the building will be maintained to reduce project cost.

The existing 300-ton chiller will be removed from the vault as it is being replaced with a new magnetic bearing (mag) chiller with heat recovery as a part of the new heat pump system. The associated chilled water pumps will be replaced from the adjacent space as well. In order to add supplemental heat rejection to the system, the current open evaporative cooling tower (the cooling tower is not adequate for this service) will be replaced with a closed-circuit cooling tower. This will provide a closed loop and not allow the condenser water loop to be exposed to the atmosphere. The intent is to utilize the associated condenser water pumps as a part of the hybrid system configuration.

Through preliminary sizing based on dimensions known at this stage, the vault will be able to house the equipment listed below.

Table 19: Chiller Vault New Equipment List

Type	Quantity	Make	Size
GSHP Manifold	1	TBD	TBD
Centrifugal Mag Bearing Chiller	1	TBD	200-tons

The remainder of the large equipment as noted below will be installed in the basement of the building after the existing 3,350 MBH boilers are removed. For the purposes of this 30 percent design, the proposed equipment will not require an expansion of the existing electric service as new equipment size is comparable.

Table 20: Remaining Basement Mechanical Room Equipment

Type	Quantity	Make	Size
Heat Pump Scroll Chiller	1	TBD	40-tons
Chiller Pumps	4	TBD	Varies
Pumps	4	TBD	Varies
Condensing Boilers	2	Camus	800 MBH
Boiler Pumps	2	TBD	TBD

Table 21: Design Chiller Heat Pump Inlet Load Temperatures

Cooling Mode (WB)	Heating Mode (DB)
Water to Air 67 °F	Water to Air 70 °F
Water to Water 55 °F	Water to Water 100 °F

The existing fan coil units (FCUs) and perimeter fin tube radiation (FTR) throughout the building are designed to utilize 180 degree F water to maintain temperature during a design heating day. As a result, these units will be maintained and will be on a 180 degree F hot water loop supplied by the supplemental condensing gas boilers during the heating season. The geothermal system itself is only capable of producing a maximum of 130-degree F water. The existing AC Units heating coils are designed to utilize 180 degree F hot water during the heating season and the cooling coils are designed to utilize 45-50 degree F chilled water during the cooling season to temper the AHU supply air to the spaces. Therefore, the heating coils do not have enough heating capacity at the lower heat pump loop temperature of 135 degree F. As a result, and to minimise system capital cost, the cooling coils will be re-piped for changeover duty so they can be used during the heating season for the low temperature hot water. This will expand the heat coil capacity and will work in conjunction with the existing hot water coils in the AHUs. Then during the cooling season, the cooling coils will be used for cooling service. As there was limited data available for the existing AC Units, airflows were estimated using coil temperature rise, and terminal unit airflow data.

SEASONAL OPERATION

OVERVIEW

The outdoor air temperature and the heating or cooling requirement of the building will determine if the GSHP system is either in the heating mode, cooling mode or simultaneous (heating and cooling) mode. The HVAC water side systems sequence of operation (SOO) will include a revised SOO for the core heating and cooling infrastructure which includes operation of the new GSHP system and integration into the existing hot water boiler and chilled water systems. The detailed SOO will need to be further developed and will be included as part of the 60 percent design documents.

The current water side operation of the buildings end terminal devices such as FTR, FCUs and Zone Cooling Coils will not change and will continue to be controlled as is by the existing controls and thermostats.

The HVAC's air side systems distribution and control will remain the same as is currently controlled. All outside air dampers on the AC units will be maintained under current sequencing based on building occupancy schedule. There may be minor adjustments in the control strategy as a result of the integration of the new GSHP system into the existing HVAC system.

HEATING SEASON

Based on an outdoor air temperature (OAT) of 50 degF +/- the GSHP will in a predominantly heating mode, where the new gas fired condensing boilers will be energized developing HW to serve the buildings FTR and FCU system on each floor. Based on the internal building temperature, the AC Units will be supplying 90 degree F +/- supply air to each floor. The GSHP will be in full heat mode, where heat will be extracted from the ground at a temperature of 36.6 degree F and distributed to the chiller heat recovery unit where the heat pump supply water temperature will be increased to the optimal temperature (max of 135 degree F) and distributed to each AC Unit coils. In this mode the AC Units heating and cooling coils will be used for heating the return air to the desired temperature based on the building requirements. energized and the heating or cooling requirement of the building. As the OAT drops to below 15 degree F +/- the heating requirements of the building will increase to the point where the new condensing boiler will not only provide 180 degree F HW for the FTR, etc, but also will supplement the heat pump loop to maintain a loop temperature of around 135 degree F to the AHU's as the bore field will not be able to maintain the required loop temperature required for heating. The 180 degree F heating loop will be on a temperature reset schedule, where the loop temp will be set on a sliding scale proportional to a corresponding OAT.

TRANSITIONAL OPERATION (HEATING & COOLING) – SHOULDER SEASON

As the season changes from Winter to Summer, the OAT rises and/or the buildings internal heat load increases there will be a need to provide both heating and cooling at the same time. In this scenario, there will be a small chiller that will be energized that provides chilled water to the cooling loop while the heat pump loop is still in the heating mode along with the 180 degree F loop which will allow for both heating and cooling to occur at the same time.

As the season changes from Summer to Winter, the OAT decreases and/or the buildings internal heat load decreases there will be a need to provide both heating and cooling at the same time. In this scenario, the main chiller will be deenergized and the small chiller will be energized to provide chilled water to the cooling loop which will allow for both heating and cooling to occur at the same time. The heat pump loop will operate in heating mode along with the 180 degree F loop for FTR operation.

COOLING SEASON

As the OAT rises above 65 degree F +/- and becomes a cooling only operation, the heating boilers are deenergized and the chiller generates chilled water a distributes to the AC Units cooling coil and interior zone cooling coils to maintain zone cooling setpoints. The heat from the chiller condenser is rejected to the GSHP loop which is maintained at 90.2 degree F and rejected to the ground through the bore field. In this mode, the control strategy is more in-line with a traditional chilled water system, except heat is rejected to the ground as opposed to the evaporative cooling tower. The one caveat to this is that we have incorporated a closed-circuit cooler (replaces the open cooling tower), where this will be used for heat rejection during peak cooling design periods working in parallel with the GSHP heat rejection system. This strategy will reduce the bore field heat saturation over the course of the cooling season.

DETAILED COST ESTIMATE

Material costs were estimated to +/- 20% based on vendor quotes and 2020 RS Means and labor costs were estimated as a percentage of the material cost. Separate cost estimates were provided for the GSHP system's source-side and supply-side. On the source-side cost estimates were provided for drilling 60 boreholes to 499-feet deep, casing for each borehole, all associated HDPE looping, grouting for each borehole, and tie-in of all boreholes together and tie-in to the mechanical equipment. Additional costs were estimated for excavation and trenching as well as pumps to pump the heat exchange fluid.

On the supply-side cost estimates were provided for the installation of two new high temp heat pump units with a heat pump coil for the chilled water or hot water operation as well as pumps to circulate the chilled water or hot water between the AHUs and the heat pumps. Based on existing loads and capacity of the GSHP loop, preliminary estimates determined that the installation of one 200-ton magnetic bearing multi-stack chiller, one 40-ton multi-stack scroll heat pump chiller, and a closed circuit cooling tower would meet the cooling loads of the Building. Additionally, two 800 MBH condensing boilers would meet the heating loads of the Building. An adder for a new mechanical space to house new equipment was included in the implementation cost, but based on the existing mechanical room layout, it appears use of the existing mechanical could be viable (see Mechanical Room Plan).

Including all required work for the GSHP measure (ECM 8b), the final cost per well for 60 wells is \$47,886. Costs were estimated using a combination of driller and vendor estimates as well as RS Means.

Table 22: ECM8b - GSHP Summary

Summary of Estimated System Costs	
Source-Side	\$ 820,000
Supply-Side	\$ 813,144
Demolition	\$ 95,000
Total	\$ 1,728,144
% Markup	10%
Project Cost	\$ 1,900,958
Net Project Cost*	\$ 2,873,187
Cost/Well	\$ 47,886

*Note: Net Project Cost includes all NYPA CPC costs, before financing

LIFE CYCLE COST ANALYSIS

A 20-year life-cycle cost analysis (LCCA) was completed by NYPA and is included here for reference. The LCCA compared the base case ECMs 8.a.1 – Boilers and 8.a.2 – Chillers to the alternative ECM 8.b. – GSHP. This analysis assumed that the boilers in ECM 8.a.1 were replaced immediately at Year 0, and the chillers would be replaced at Year 10 (assumes 10 years of useful life remaining). ECM 8.b.1 was assumed to be fully installed at Year 0 and there would no major component replacements over the 20-year analysis period. The energy cost was escalated at based on the Energy Information Administration's (EIA) energy price projects for NYS over the 20-year period. The BLCC analysis uses a 2.5% discount rate provided by the Federal Energy Management Program (FEMP) to account for inflation for renewable energy projects. The analysis also uses a variable energy escalation rate provided by the Department of Energy (DOE). There were no operation and maintenance (O&M) savings credited in the analysis, assuming that comparable O&M is required in the base case and alternate scenarios. Due to the substantially higher initial capital cost of the GSHP and low cost of natural gas, the total present value life-cycle cost was negative \$242,176.

	Base Case	Alternative	Savings from Alternative
Initial Investment Costs Paid By Agency:			
Capital Requirements as of Base Date	\$985,795	\$3,456,022	-\$2,470,227
Future Costs:			
Recurring and Non-Recurring Contract Costs	\$0	\$0	\$0
Energy Consumption Costs	\$1,392,236	\$1,155,660	\$236,576
Energy Demand Charges	\$0	\$0	\$0
Energy Utility Rebates	\$0	\$0	\$0
Water Costs	\$0	\$0	\$0
Recurring and Non-Recurring OM&R Costs	\$0	\$0	\$0
Capital Replacements	\$0	\$0	\$0
Residual Value at End of Study Period	-\$77,529	-\$2,069,004	\$1,991,475
	-----	-----	-----
Subtotal (for Future Cost Items)	\$1,314,707	-\$913,344	\$2,228,051
	-----	-----	-----
Total PV Life-Cycle Cost	\$2,300,503	\$2,542,678	-\$242,176

Figure 19: Life Cycle Comparison of Present-Value Costs

ECM 9: CONTROLS OPTIMIZATION

Original commissioning documentation could not be obtained, and it is uncertain if commissioning was originally completed for the Office Building. If the hybrid GSHP system is installed, the entire system will be commissioned to ensure that is functioning according to the design intent. If it is decided to not proceed with the hybrid GSHP system, it is still recommended to optimize the existing controls and retro-commission the existing building systems for the following reasons:

- Energy savings
- Restoring equipment function to original operation
- Reduction of occupant complaints
- Increased equipment life
- Improved indoor air quality
- Updated O&M requirements

This will also result in an updated baseline for the Office Building's operation that can be utilized for ongoing commissioning as well as future energy audit and design projects. Energy savings and cost estimates for this measure were based on studies completed by ASHRAE, PNNL, and Energy Star using a dollar per square foot metric.

ECM 10: BUILDING ENVELOPE UPGRADE

Due to the Building's curtain wall construction, maintaining comfort within the building around the perimeter is difficult due to the high conductive heat losses and gains due to thermal bridging through the aluminum framing and high infiltration rates. The windows are single pane with insulated glazing and have not been upgraded since the original construction. It is proposed to install a curtainwall retrofit window system that will reduce convective and conductive heat transfer from the windows. This type of system was selected due to its simplicity to install and lower capital cost compared to completely overhauling the existing envelope. The system can be installed during normal operating hours with minimal disruption to daily activities and does not change the exterior appearance of the building as it is installed from the inside. Although this will not solve all the comfort issues reported by staff, it will reduce them along with reducing the heating and cooling loads served by mechanical equipment.

Section 6
Next Steps

REVIEWED BUT NOT RECOMMENDED CAPITAL IMPROVEMENTS

A number of potential ECMs were not currently recommended due to high cost, low savings, or installation difficulty.

IMP 1: BUILDING LIGHTING CONTROL RETROFIT

The common area hallway lighting for each floor is integrated into the building's security system. The security system is deactivated at 6AM turning the lights on and deactivated at midnight turning all of the lights off. If the system is deactivated at any point after midnight, it forces all of the common area lighting back on in the building no matter what floor the individual is accessing. It is proposed to install an occupancy sensor control at the light panel relay of each floor so that the fixtures are energized only when an occupant is present. The length of time that the fixtures stay active during occupied periods can be adjusted so they do not turn off prematurely. This will also allow the light schedule to be adjusted to an earlier time as there is infrequent occupancy on most floors after typical business hours. However, due to the high cost of replacement and a recent LED fixture retrofit, this measure is not recommended for implementation.

IMP 2: STAIRWELL LIGHT SENSOR RETROFIT

There are two linear LED fixtures per floor, one at the floor entrance and the other at the landing between floors. To comply with lighting code, these fixtures are energized 24/7 for emergency egress purposes. A minimum level of illumination can be maintained with once fixture energized at a time during unoccupied periods of time. It is proposed to install an occupancy sensor on the landing fixtures to deenergize them when the building is unoccupied. The fixtures at the floor level will remain unchanged. However, due to the high cost of replacement and a recent LED fixture retrofit, this measure is not recommended for implementation.

IMP 3: FRONT ENTRANCE VESTIBULE MODIFICATIONS

The front entrance experiences a high volume of foot traffic as it is the main entrance for the DMV. There are two sets of double swinging doors to enter the vestibule and an additional two sets to enter the lobby. It was reported by facility staff that the outermost doors are frequently damaged due to wind and have difficulties closing, allowing more air into the vestibule. Additionally, the three supply air diffusers from AC-2 are located on the floor of the vestibule in between the doors and the four return air registers are located toward the ceiling on the opposite side. It is proposed to reconfigure the supply air diffusers so that they are above the doors to act as an air curtain to keep unconditioned air from

entering the vestibule. The existing diffusers will have to be replaced for an option that will increase the velocity and direct the supply air appropriately.

Due to the cost of this measure it was not recommended for implementation. Any modifications to these areas should be completed to satisfy occupant comfort and O&M purposes. Other modifications such as revolving doors were investigated but are not recommended due to the expense as well.

IMP 4: REAR ENTRANCE AIR CURTAIN

The rear entrance has a small vestibule with double automatic sliding doors on each end. Since they are timed to close, they are often both open at the same time as the vestibule is short. This allows outside air to enter the building. Outside air infiltrates at a faster rate when the front doors are open at the same time. To counteract this, air curtains should be installed above the sliding doors to reduce the amount of infiltration.

Like the front vestibule, this measure is cost and savings prohibitive. Other modifications such as revolving doors were investigated but are not recommended due to the expense as well.

IMP 5: INSTALL VFD ON CHILLED WATER PUMP

All AC units are served by the chiller via a chilled water loop and three-way valves. It is proposed to replace the three-way valves at each unit with a two-way valve and install a VFD on the CHWP that serves the loop. The VFD will allow the pump to respond to unit demand based on system pressure. The chiller manufacturer was contacted in order to assess the required pressure and flows in the evaporator of the unit. There was only a small amount of room to reduce the flow and the chiller already has VSD capability. Due to these reasons, the pump turn down using a VFD would be minimal thus the savings would be minimal.

BEST PRACTICE OPPORTUNITIES

REPLACE AC-4 STEAM GENERATORS WITH ULTRASONIC TECHNOLOGY

The existing electric steam generators on AC-4 are not active as there are issues with over humidifying the vault spaces. Instead, the humidity can float during the winter as less humidity is preferred compared to too much. It is proposed that the existing steam generators be removed and that ultrasonic humidifiers be installed in each floor of the vault. It is recommended that these units be supplied with deionized water to reduce future O&M cost but at a higher initial cost. These units will allow for humidity to be controlled independently within each space which can differ based on occupancy and stratification at the common stairwell. Since the steam generators are not currently in operation, there will be no energy savings for this measure, and it is considered a best practice.

Manufacturers report that ultrasonic humidifiers use as little as 1/10th the energy of comparable steam generators.

AC UNIT SCHEDULE REVISIONS

The AC units have an occupied schedule from 6AM to midnight during weekdays and it was reported that county staff sometimes occupy the facility during the evening hours. It is recommended to take a work hour survey of all employees to judge if schedule revisions can be implemented. Since this is a no cost ECM, any revisions to the building schedules will result in immediate energy savings.

ROOF REPLACEMENT

Funding has also been secured to replace the roof which is original to the building. It is recommended to consider any upgrading the roof type at this stage as it will be cost prohibitive to retrofit before the next future replacement. All components of the roof should be inspected, and insulation should potentially be replaced.

COMPRESSED AIR

The existing air compressor serving the pneumatic controls is past the end of its useful life and should be replaced as a part of a future capital cost project. The associated air dryer was replaced recently. Additionally, staff should use ultrasonic leak detection equipment to tag the location of compressed air leaks. Regularly checking for and repairing leaks located within the compressed air system can provide electricity savings and reduce operation of the air compressors. Lower compressor operation also results in lower maintenance costs.

TURN OFF COMPUTER EQUIPMENT OVERNIGHT

If computers are left on overnight, they will continue to draw power. The Office Building can utilize the built-in Task Scheduler program on Microsoft Windows computers to set up a daily repeating task of shutting down the computer overnight. This will reduce the overnight phantom load as well as reduce the run time of the computer, resulting in less wear-and-tear on computer components.

MAINTAIN CLEAN AIR FILTERS AND INTAKES

Regularly cleaning the intake screen and providing clean filters to each AC unit could reduce the overall system pressure drop and decrease the load on the supply fans.

Section 7
Measurement and Verification Procedure

MEASUREMENT AND VERIFICATION PROCEDURE

Measurement and verification for GSHP systems is recommend to use Option D—Calibrated Computer Simulation in the “M&V Guidelines: Measurement and Verification for Performance-Based Contracts”. Option D recommends the use of computer simulation software to establish baseline energy consumption of the existing facility’s operation by calibrating model outputs with monthly utility data. A separate simulation with the GSHP retrofit measure can be completed to establish energy savings compared to the existing baseline. The GSHP simulation should be calibrated with spot measurements of equipment during the performance period to ensure that actual operating parameters conform to the original design operating parameters. If the actual operation differs from the design operation, the GSHP simulation should be adjusted to reflect actual operation. Example of spot measurements to be logged during the performance period attempt to ascertain equipment efficiency, system performance, and bore field performance and might include:

1. Water temperatures entering and leaving the heat pump
2. Ambient outdoor temperature
3. Supply and return load water temperatures for water-to-water GSHP systems
4. Heat pump unit input kW

Section 8
Energy Analysis Methodology

ENERGY ANALYSIS METHODOLOGY

The basic methodology behind the energy analysis in this report follows the following steps.

1. Annual bills were reviewed and aggregated into a final number. This number was compared with similar building types to understand the relative efficiency of the building. The monthly use was plotted for the two years to understand annual trends. As there were no major anomalies identified, the utility bills were an accurate means of annual energy consumption for the Office Building.
2. Electric and natural gas utility bills were disaggregated through equipment runtime estimation. Lighting counts and runtime were used to establish lighting use. Hot water heating consumption was determined as the sole source of natural gas consumption onsite. Office equipment was counted and noted for utilization during the energy audit to develop use estimates.
3. ECMs savings were then developed through Microsoft Excel® Bin Analysis, percentage-based estimates, and equipment literature. ECM savings were then vetted by comparing them to disaggregated energy use by system and adjusted if necessary, to provide a reliable result.

Project #:	30040573					
Project Name:	Ulster County Office Building					
Engineer:	Arcadis Consulting					
Measure:	Proposed Chiller Design to Alternate Chiller Design					
Alternate Design:						
Location:	Description:	Qty:	Material:	Labor:	Unit Price:	Ext. Price:
Supply-Side	200-ton Mag Bearing Multi-Stack Chiller	1	\$264,000.00	\$ 79,200.00	\$343,200.00	\$343,200.00
Supply-Side	40-ton Multi-Stack VME Scroll Heat Pump Chiller	1	\$106,500.00	\$ 31,950.00	\$138,450.00	\$138,450.00
					Total Cost:	\$481,650.00
					Mark-Up 10%	\$ 48,165.00
					Project Cost:	\$529,815.00

Ground Loop Design

Borehole Design Project Report - 7/2/2020

Project Name: Ulster County Office Bldg	
Designer Name: Brian Urlaub	
Date: 7/1/2020	Project Start Date: 7/1/2020
Client Name: Arcadis	
Address Line 1:	
Address Line 2:	
City:	Phone:
State:	Fax:
Zip:	Email:

Calculation Results

Design Method:	Design Day	COOLING	HEATING
Total Bore Length (ft):		29940.0	29940.0
Borehole Number:		60	60
Borehole Length (ft):		499.0	499.0
Ground Temperature Change (°F):		-0.3	-0.3
Unit Inlet (°F):		80.8	41.6
Unit Outlet (°F):		90.2	36.6
Total Unit Capacity (kBtu/Hr):		2050.4	1745.0
Peak Load (kBtu/Hr):		2050.4	1643.2
Peak Demand (kW):		108.2	175.4
Heat Pump EER/COP:		18.9	2.7
System EER/COP:		18.9	2.7
System Flow Rate (gpm):		512.6	410.8

Input Parameters

Fluid		Soil	
Flow Rate	3.0 gpm/ton	Ground Temperature:	55.0 °F
Fluid:	25.0% Propylene Glycol	Thermal Conductivity:	1.49 Btu/(h*ft*°F)
Specific Heat (Cp):	1.01 Btu/(°F*lbm)	Thermal Diffusivity:	1.16 ft^2/day
Density (rho):	62.4 lb/ft^3		
Piping			
Pipe Type:		1 1/4 in. (32 mm)	
Flow Type:		Turbulent - SDR11	
Pipe Resistance:		0.104 h*ft*°F/Btu	
U-Tube Configuration:		Single	
Radial Pipe Placement:		Average	
Borehole Diameter:		5.00 in	
Grout Thermal Conductivity:		1.20 Btu/(h*ft*°F)	
Borehole Thermal Resistance:		0.198 h*ft*°F/Btu	

Input Parameters (Cont.)

Pattern	Modeling Time Period															
Vertical Grid Arrangement: 12 x 5 Borehole Number: 60 Borehole Separation: 20.0 ft Bores Per Circuit: 1 Fixed Length Mode: On Grid File: None	Prediction Time: 5.0 years Long Term Soil Temperatures: <i>Cooling:</i> 54.7 °F <i>Heating:</i> 54.7 °F															
Default Heat Pumps	Optional Hybrid Loads															
Manufacturer: Chillit Chillers LLC C6H-40T Series Design Heat Pump Inlet Load Temperatures: <i>Cooling (WB)</i> <i>Heating (DB)</i> Water to Air: 67 °F 70 °F Water to Water: 55 °F 100 °F	<table style="width: 100%; border-collapse: collapse;"> <tr> <th></th><th style="text-align: center;">Cooling</th><th style="text-align: center;">Heating</th></tr> <tr> <td>Geo Peak (%)</td><td style="text-align: center;">80%</td><td style="text-align: center;">79%</td></tr> <tr> <td>Geo Total (%)</td><td style="text-align: center;">80%</td><td style="text-align: center;">79%</td></tr> <tr> <td>Hybrid Peak (%)</td><td style="text-align: center;">20%</td><td style="text-align: center;">21%</td></tr> <tr> <td>Hybrid Total (%)</td><td style="text-align: center;">20%</td><td style="text-align: center;">21%</td></tr> </table>		Cooling	Heating	Geo Peak (%)	80%	79%	Geo Total (%)	80%	79%	Hybrid Peak (%)	20%	21%	Hybrid Total (%)	20%	21%
	Cooling	Heating														
Geo Peak (%)	80%	79%														
Geo Total (%)	80%	79%														
Hybrid Peak (%)	20%	21%														
Hybrid Total (%)	20%	21%														
Extra kW	Loads File															
Pump Power: 0.0 kW Cooling Tower Pump: 0.0 kW Cooling Tower Fan: 0.0 kW Additional Power: 0.0 kW	<i>Ulster Co Load Profile 7.1.20.zon</i>															
Loads																
<div style="display: flex; justify-content: space-between; align-items: flex-start;"> <div style="width: 60%;"> <p style="text-align: center;">Design Day Loads</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: center;"><i>Time of Day</i></th><th style="text-align: center;"><i>Heat Gains (kBtu/Hr)</i></th><th style="text-align: center;"><i>Heat Losses (kBtu/Hr)</i></th></tr> </thead> <tbody> <tr> <td style="text-align: center;">8 a.m. - Noon</td><td style="text-align: center;">27.7</td><td style="text-align: center;">1643.2</td></tr> <tr> <td style="text-align: center;">Noon - 4 p.m.</td><td style="text-align: center;">2050.4</td><td style="text-align: center;">691.7</td></tr> <tr> <td style="text-align: center;">4 p.m. - 8 p.m.</td><td style="text-align: center;">27.7</td><td style="text-align: center;">691.7</td></tr> <tr> <td style="text-align: center;">8 p.m. - 8 a.m.</td><td style="text-align: center;">27.7</td><td style="text-align: center;">691.7</td></tr> </tbody> </table> </div> <div style="width: 35%; padding-top: 10px;"> <p>Annual Equivalent Full-Load Hours</p> <p><i>COOLING</i> 551 <i>HEATING</i> 1520</p> <p>Days Occupied per Week: 5.0</p> </div> </div>		<i>Time of Day</i>	<i>Heat Gains (kBtu/Hr)</i>	<i>Heat Losses (kBtu/Hr)</i>	8 a.m. - Noon	27.7	1643.2	Noon - 4 p.m.	2050.4	691.7	4 p.m. - 8 p.m.	27.7	691.7	8 p.m. - 8 a.m.	27.7	691.7
<i>Time of Day</i>	<i>Heat Gains (kBtu/Hr)</i>	<i>Heat Losses (kBtu/Hr)</i>														
8 a.m. - Noon	27.7	1643.2														
Noon - 4 p.m.	2050.4	691.7														
4 p.m. - 8 p.m.	27.7	691.7														
8 p.m. - 8 a.m.	27.7	691.7														
Monthly Loads on Next Page																

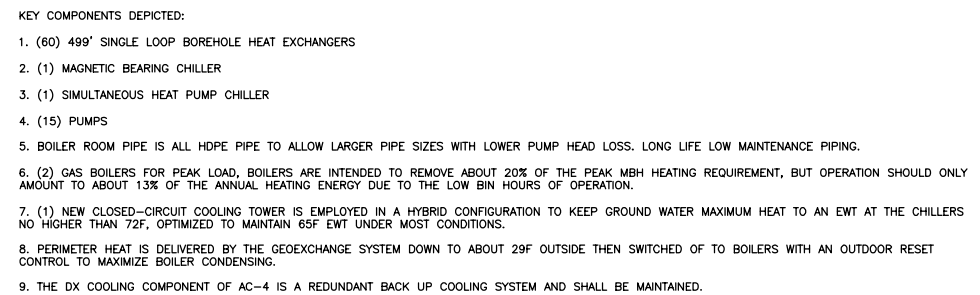
Monthly Loads Data							
	Cooling				Heating		
	Total	(kBtu)	Peak	(kBtu/hr)	Total	(kBtu)	Peak (kBtu/hr)
January	0		0		542533		1643
February	0		0		451165		1643
March	0		0		379697		1292
April	0		0		245760		989
May	106334		1874		43839		628
June	259331		2050		0		0
July	282596		2050		0		0
August	317724		2050		0		0
September	128110		1992		0		0
October	35386		1936		90547		1283
November	0		0		304595		1125
December	0		0		440337		1643
Total	1129481				2498473		
Hours at Peak			3.0				3.0

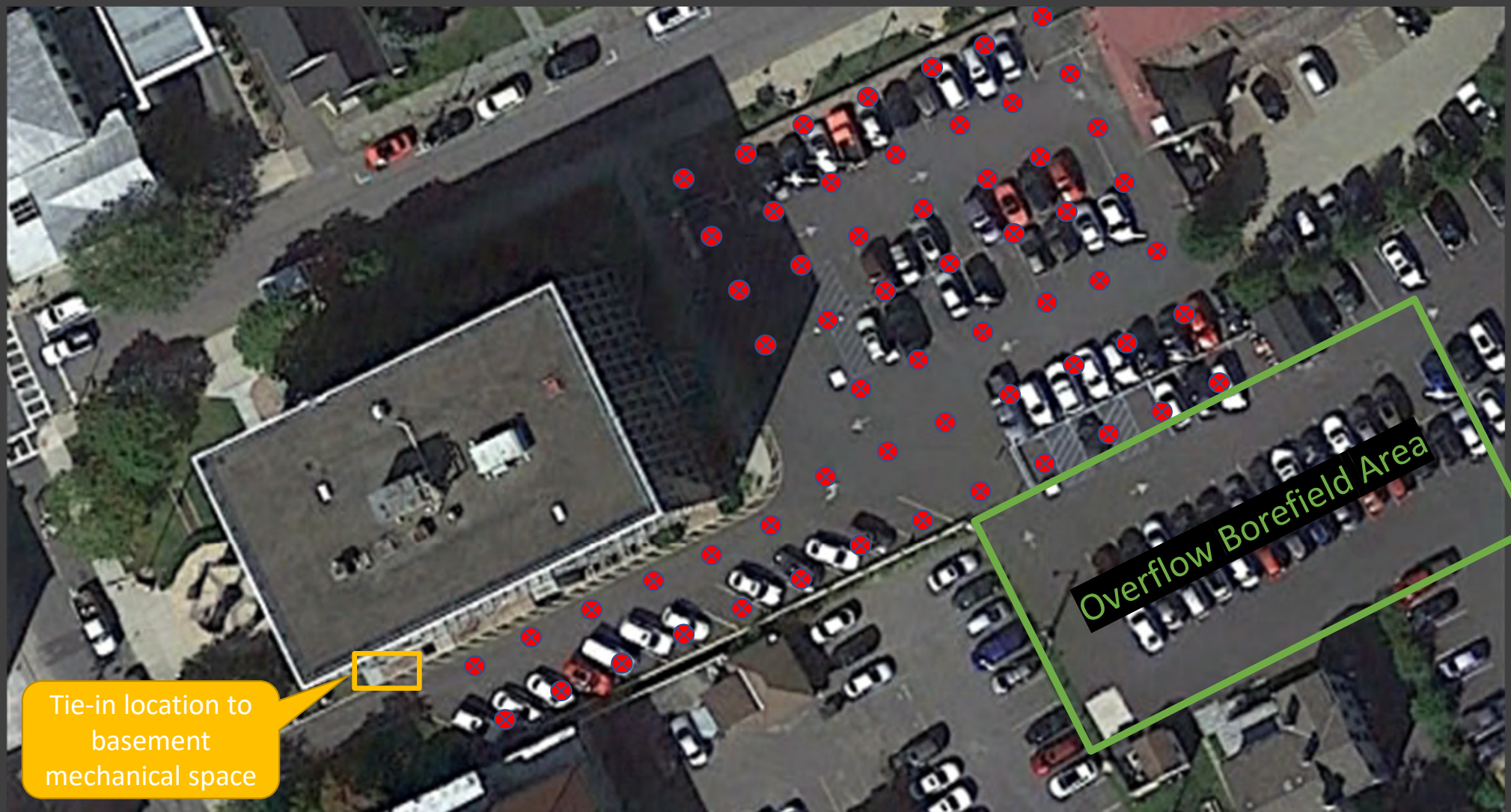
Hourly Loads Data

Included: None

Filename: None

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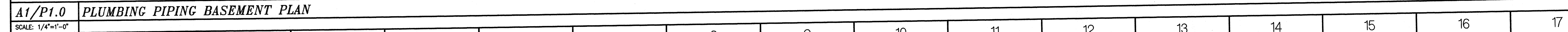




Tie-in location to
basement
mechanical space

Overflow Borefield Area

R	
P	
O	
N	
M	
L	
K	
J	
H	
G	
F	
E	
D	
C	
B	
A	



Soil	Designed	RFS	Project No.	2315
	Drawn	MEH	CAD File No.	
	Checked	RFS	MADWG/2003/2315/2315P/2315PP/2315P10	
	Scale	1/4"=1'-0"	Drawing No.	
	Date	SEPTEMBER 19, 2003		

P1.0

3
OF
3



ARCADIS

Design & Consultancy
for natural and
built assets

Project #: '30040573

Project Name: Ulster County Geothermal

Engineer: Chris Muller

Measure: ECM 8b - GSHP Compared to Baseline ECM8a

Savings Type	Peak Baseline	Peak Proposed	Savings
kW*	134.0	-69.2	\$ 394.25
kWh	187,398	-145,625	\$ 3,312.17
therms	23,272	-4,802	\$ 17,247.09
Total			\$ 20,953.51

*kW cost savings calculated separately as monthly savings vary

Load Reductions	
Cooling (MMBtu)	Heating (MMBtu)
143	1,847

Incremental Cost Analysis				
		Baseline ¹	Proposed ²	Incremental Cost Difference
\$	Implementation Cost	\$ 520,300.00	\$ 1,900,957.96	\$ 1,380,657.96

Summary of Incremental Cost Savings	
Total Implementation Incremental Cost	\$ 1,380,657.96
Annual Cost Savings	\$ 19,793.94
Simple Payback Period	69.8

Notes:

1. The Baseline Implementation Cost assumes the replacement of both boilers and the chiller, including labor.
2. The Proposed Scenario Implementation Cost assumes the replacement removal of the existing boilers and chiller, as well as the installation of all GSHP components, including all costs associated with the loop as well as the mechanical equipment



FORMATION THERMAL CONDUCTIVITY TEST & DATA ANALYSIS

TEST LOCATION **Ulster County Office Building
Kingston, NY**

TEST DATE January 31 – February 3, 2020

ANALYSIS FOR **Wragg Well Drilling & Pump Service LLC
172 Baker Road
Roxbury, CT 06783
Phone: (860) 354-1989**

TEST PERFORMED BY **Wragg Well Drilling & Pump Service LLC**

EXECUTIVE SUMMARY

A formation thermal conductivity test was performed on the geothermal bore at the Ulster County Office Building site at 244 Fair St. in Kingston, New York. The vertical bore was completed on January 20, 2020 by Wragg Well Drilling & Pump Service. Geothermal Resource Technologies' (GRTI) test unit was attached to the vertical bore on the afternoon of January 31, 2020.

This report provides an overview of the test procedures and analysis process, along with plots of the loop temperature and input heat rate data. The collected data was analyzed using the "line source" method and the following average formation thermal conductivity was determined.

Formation Thermal Conductivity = 1.49 Btu/hr-ft-°F

Due to the necessity of a thermal diffusivity value in the design calculation process, an estimate of the average thermal diffusivity was made for the encountered formation.

Formation Thermal Diffusivity $\approx 1.16 \text{ ft}^2/\text{day}$

The undisturbed formation temperature for the tested bore was established from the initial loop temperature data collected at startup.

Undisturbed Formation Temperature $\approx 54.3\text{-}55.5^\circ\text{F}$

The formation thermal properties determined by this test do not directly translate into a loop length requirement (i.e. feet of bore per ton). These parameters, along with many others, are inputs to commercially available loop-field design software to determine the required loop length. Additional questions concerning the use of these results are discussed in the frequently asked question (FAQ) section at www.grti.com.

TEST PROCEDURES

The American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) has published recommended procedures for performing formation thermal conductivity tests in the ASHRAE HVAC Applications Handbook, Geothermal Energy Chapter. The International Ground Source Heat Pump Association (IGSHPA) also lists test procedures in their Design and Installation Standards. GRTI's test procedures meet or exceed those recommended by ASHRAE and IGSHPA, with the specific procedures described below:

Grouting Procedure for Test Loops – To ensure against bridging and voids, it is recommended that the bore annulus is uniformly grouted from the bottom to the top via tremie pipe.

Time Between Loop Installation and Testing – A minimum delay of five days between loop installation and test startup is recommended for bores that are air drilled, and a minimum waiting period of two days for mud rotary drilling.

Undisturbed Formation Temperature Measurement – The undisturbed formation temperature should be determined by recording the loop temperature as the water returns from the u-bend at test startup.

Required Test Duration – A minimum test duration of 36 hours is recommended, with a preference toward 48 hours.

Data Acquisition Frequency - Test data is recorded at five minute intervals.

Equipment Calibration/Accuracy – Transducers and datalogger are calibrated per manufacturer recommendations. Manufacturer stated accuracy of power transducers is less than $\pm 2\%$. Temperature sensor accuracy is periodically checked via ice water bath.

Power Quality – The standard deviation of the power should be less than or equal to 1.5% of the average power, with maximum power variation of less than or equal to 10% of the average power.

Input Heat Rate – The heat flux rate should be 51 Btu/hr (15 W) to 85 Btu/hr (25 W) per foot of installed bore depth to best simulate the expected peak loads on the u-bend.

Insulation – GRTI's equipment has 1 inch of foam insulation on the FTC unit and 1/2 inch of insulation on the hose kit connection. An additional 2 inches of insulation is provided for both the FTC unit and loop connections by insulating blankets.

Retesting in the Event of Failure – In the event that a test fails prematurely, a retest may not be performed until the bore temperature is within 0.5°F of the original undisturbed formation temperature or until a period of 14 days has elapsed.

DATA ANALYSIS

Geothermal Resource Technologies, Inc. (GRTI) uses the "line source" method of data analysis to determine the thermal conductivity of the formation. The line source method assumes an infinitely thin line source of heat in a continuous medium. A plot of the late-time temperature rise of the line source temperature versus the natural log of elapsed time will follow a linear trend. The linear slope is inversely proportional to the thermal conductivity of the medium. Applying the line source method to a u-bend grouted in a borehole, the test must be run long enough to allow the finite dimensions of the u-bend pipes and the grout to become insignificant. Experience has shown that approximately ten hours is required to allow the error of early test times and the effects of finite borehole dimensions to become insignificant.

In the analysis of the data from the formation thermal conductivity test, the average temperature of the water entering and exiting the u-bend heat exchanger was plotted versus the natural log of elapsed testing time. Using the Method of Least Squares, linear coefficients were calculated that produce a line that fit the data. This procedure was repeated for various time intervals to ensure that variations in the power or other effects did not produce inaccurate results.

The calculated results are based on test bore information submitted by the driller/testing agency. GRTI is not responsible for inaccuracies in the results due to erroneous bore information. All data analysis is performed by personnel that have an engineering degree from an accredited university with a background in heat transfer and experience with line source theory. The test results apply specifically to the tested bore. Additional bores at the site may have significantly different results depending upon variations in geology and hydrology.

Through the analysis process, the collected raw data is converted to spreadsheet format (Microsoft Excel®) for final analysis. If desired, please contact GRTI and a copy of the data will be made available in either a hard copy or electronic format.

CONTACT: Galen Streich
Regional Managing Engineer
Elkton, SD
Ph: 866-991-4784
gstreich@grti.com

(AS PROVIDED BY WRAGG WELL DRILLING & PUMP SERVICE LLC)

DRILL LOG

Note: Bore produced approx. 3 gpm water at 200 ft.

THERMAL CONDUCTIVITY TEST DATA

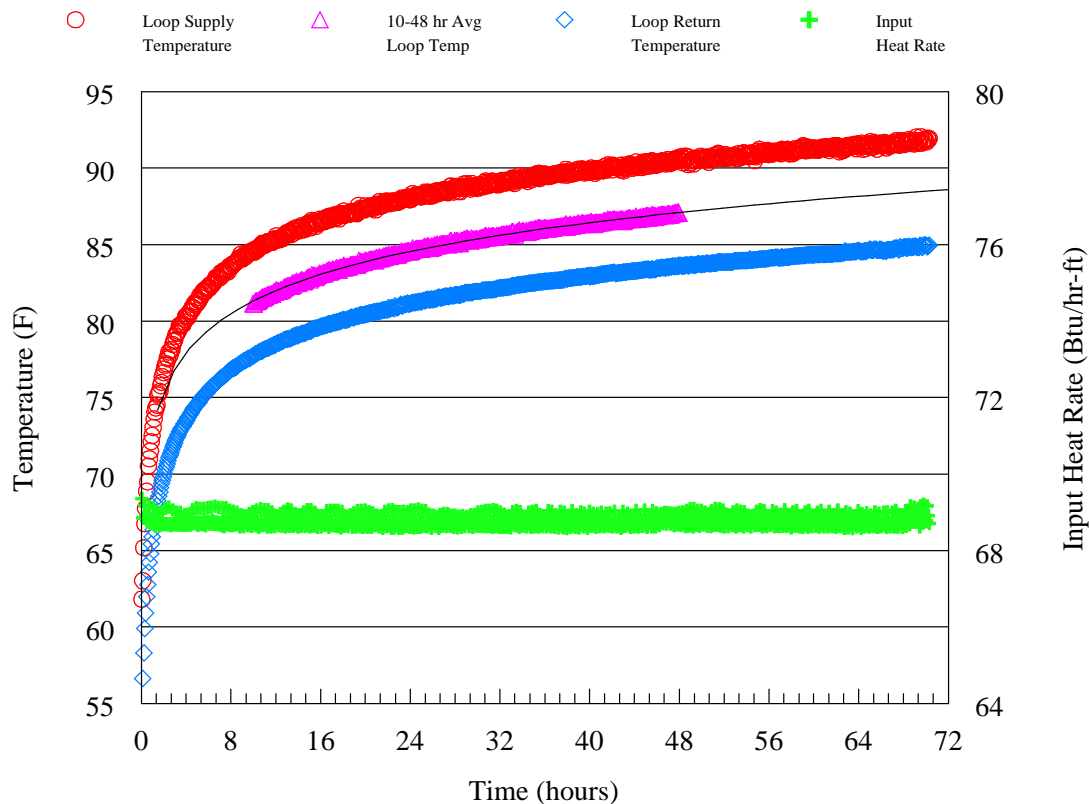


FIG. 1: TEMPERATURE & HEAT RATE DATA VS TIME

Figure 1 above shows the loop temperature and heat input rate data versus the elapsed time of the test. The temperature of the fluid supplied to and returning from the U-bend are plotted on the left axis, while the amount of heat supplied to the fluid is plotted on the right axis on a per foot of bore basis. In the test statistics below, calculations on the power data were performed over the analysis time period listed in the Line Source Data Analysis section.

SUMMARY TEST STATISTICS

Test Date	January 31 – February 3, 2020
Undisturbed Formation Temperature	Approx. 54.3-55.5°F
Duration	70.3 hr
Average Voltage	238.9 V
Average Heat Input Rate	34,316 Btu/hr (10,057 W)
Avg Heat Input Rate per Foot of Bore	68.8 Btu/hr-ft (20.1 W/ft)
Circulator Flow Rate	9.9 gpm
Standard Deviation of Power	0.22%
Maximum Variation in Power	0.47%

LINE SOURCE DATA ANALYSIS

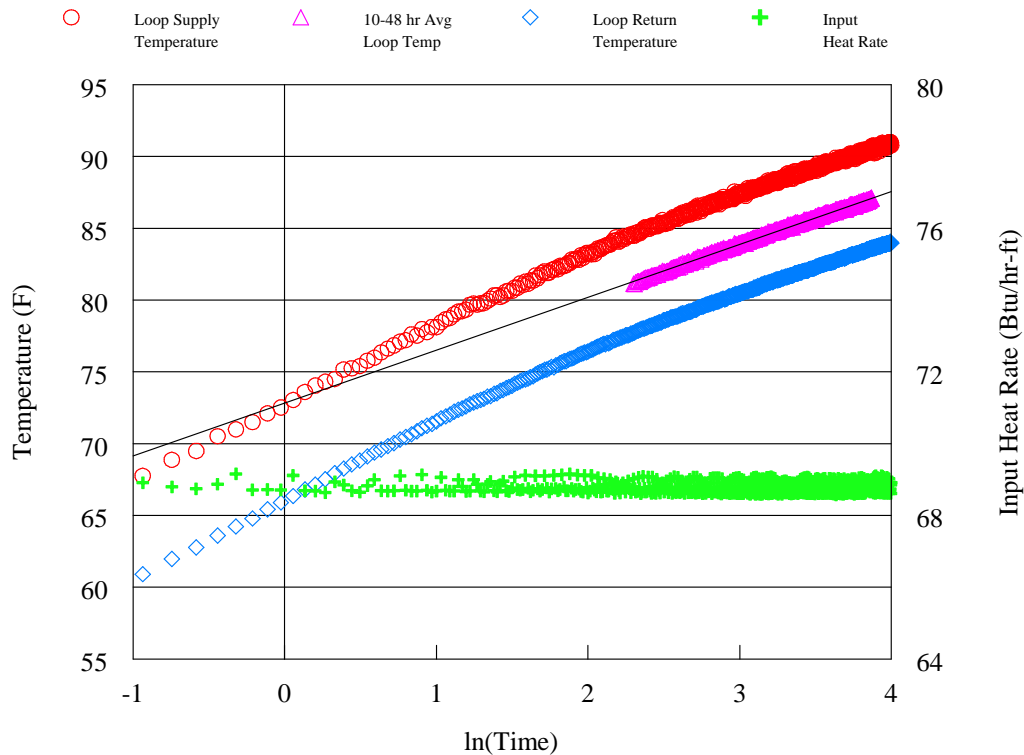


FIG. 2: TEMPERATURE & HEAT RATE VS NATURAL LOG OF TIME

The loop temperature and input heat rate data versus the natural log of elapsed time are shown above in Figure 2. The temperature versus time data was analyzed using the line source method (see page 3) in conformity with ASHRAE and IGSHA guidelines. A linear curve fit was applied to the average of the supply and return loop temperature data between 10 and 48.0 hours. The slope of the curve fit was found to be 3.69. The resulting thermal conductivity was found to be **1.49 Btu/hr-ft-°F**.

THERMAL DIFFUSIVITY

The reported drilling log for this test borehole indicated that the formation consisted of sand and shale. A heat capacity value for shale was calculated from specific heat and density values listed by Kavanaugh and Rafferty¹. A weighted average of heat capacity values based on the indicated formation was used to determine an average heat capacity of 30.8 Btu/ft³-°F for the formation. A diffusivity value was then found using the calculated formation thermal conductivity and the estimated heat capacity. The thermal diffusivity for this formation was estimated to be **1.16 ft²/day**.

¹Stephen P. Kavanaugh and Kevin Rafferty, Geothermal Heating and Cooling: Design of Ground-Source Heat Pump Systems (Atlanta: ASHRAE, 2014), 75.

CERTIFICATE OF CALIBRATION

GRTI maintains calibration of the datalogger, current transducer and voltage transducer on a regular schedule. The components are calibrated by the manufacturer using recognized national or international measurement standards such as those maintained by the National Institute of Standards and Technology (NIST).

FTC Unit 207

DA Unit 60

PRIMARY EQUIPMENT		
COMPONENT	CALIBRATION DATE	CALIBRATION DUE DATE
Datalogger	7/14/2017	7/14/2020
Current Transducer	7/14/2017	7/14/2020
Voltage Transducer	7/14/2017	7/14/2020

GRTI periodically verifies the combined temperature sensor/datalogger accuracy via a water bath. Temperature readings are simultaneously taken with a digital thermometer that has been calibrated using instruments traceable to NIST.

DATE	8/13/2019			
THERMOCOUPLE 1 (°F)	32.3 32.3 32.3			
THERMOCOUPLE 2 (°F)	32.2 32.2 32.2			
THERMOCOUPLE 3 (°F)	32.2 32.1 32.2			
THERMOCOUPLE 4 (°F)	32.2 32.1 32.2			
DIGITAL THERMOMETER (°F)	32.3 32.3 32.3			

PE3 Action: Government Building Energy Audits

8 Points

10 Points

12 Points

16 Points



BRONZE PRIORITY



SILVER PRIORITY

A. Why is this action important?

Energy use in buildings is often the largest source of energy consumption and greenhouse gas (GHG) emissions within government operations. Buildings contain heating, ventilation and air conditioning (HVAC) equipment, lighting, information technology equipment, appliances, motors, and pumping equipment. All of these consume energy and provide many opportunities for improved energy efficiency and cost savings. Especially for local governments that own older buildings, energy audits are an important step in identifying inefficiencies and developing plans for improvement. Reducing GHG emissions and using taxpayer money efficiently are key goals of the Climate Smart Communities (CSC) program.

B. How to implement this action

The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) has developed a phased approach to auditing a building's energy use that consists of three auditing levels: A Level-1 audit is a preliminary assessment involving a walk-through and review of the facility's utility bills for the previous two or three years and other operating data. A Level-2 audit is an energy survey and analysis. A Level-3 audit (sometimes referred to as an investment-grade audit) provides detailed project cost and savings calculations for identified improvement projects.

To obtain points under this CSC action, local governments must conduct ASHRAE Level-2 or Level-3 audits of their buildings. The Level-2 audit includes the same preliminary assessment of a Level-1 audit, but then evaluates the building energy systems in detail to define a variety of potential energy-efficiency improvements. This evaluation should include the building envelope, lighting, HVAC equipment, domestic hot water, plug loads, and compressed air and process uses (for manufacturing, service, or processing facilities). Level-2 audits summarize existing conditions, recommend energy conservation measures (ECMs), and provide estimated cost and payback information for those measures. When implemented, these ECMs can help a local government realize significant energy and cost savings while also reducing its GHG emissions.

A local government may choose to audit one building at a time or conduct an audit of several buildings. This action is focused on the critical first step of completing audits. Other CSC actions award credit for implementation of specific measures. To implement this action, the local government should take the following steps:

1. Research options for technical and financial assistance. Local utility companies might have an audit program. Consider the [FlexTech Program](#) available through the New York State Energy Research and Development Authority (NYSERDA). The New York Power Authority (NYPA) Customer Energy Solutions team also offers support for building [assessments](#).
2. Determine the scope of the audits. Consider focusing on the buildings that consume the most energy.
3. Identify a certified energy auditor.
4. Carry out the building energy audits.
5. Obtain a summary audit report, complete with ECM recommendations from the auditor for each building or set of buildings audited.

An energy audit may also be conducted as the first phase of an energy performance contract. An energy performance contract is a financing mechanism that uses the savings from energy efficiency upgrades to finance the cost of the improvements. If a local government is considering pursuing a performance contract, credit for this CSC action could be achieved through the energy audits completed under that contract, provided the audits are the Level-2 or Level-3 type.

C. Time frame, project costs, and resource needs

Building energy audits are often low-cost or free for local governments through resources provided by utilities or NYSERDA. The time frame involved will largely depend on the number of facilities owned by the local government and the method of funding the audits. Facilities staff should be available to guide the energy auditor through the building(s) and will likely be required to provide building information and utility bills to the auditor.

D. Which local governments implement this action? Which departments within the local government are most likely to have responsibility for this?

This CSC action is applicable to any local government that owns and operates buildings. Facilities managers or public works department staff would likely be responsible for implementing building energy audits.

E. How to obtain points for this action

Points are obtained for this action by conducting Level-2 or Level-3 audits at one or more local government buildings. The percentage of buildings audited can be calculated based on either the simple percentage of buildings, or the percentage of square footage of the total building portfolio.

	POSSIBLE POINTS
ASHRAE Level-2 energy audit completed at 10% of buildings	8
ASHRAE Level-2 energy audit completed for 25% of buildings	10
ASHRAE Level-2 energy audit completed for 50% of buildings	12
ASHRAE Level-2 energy audit completed for 75% of buildings	16

F. What to submit

Provide copies of the ASHRAE Level-2 (or Level-3) energy audit report for each building (or group of buildings) where an audit was performed. Be specific as to which type of audit was performed for which building. Audits must have been conducted within seven years prior to the application date. If several buildings were audited, local governments may submit a summary report as long as it provides the key findings and recommendations for each facility.

As background for calculating the percentage of buildings audited, submit a listing of all buildings owned by the local government. If the percentage is based on square footage, include the square footage of each building.

All CSC action documentation is available for public viewing after an action is approved. Action submittals should not include any information or documents that are not intended to be viewed by the public.

G. Links to additional resources or best practices

- [NYSERDA FlexTech Program](#)
- [NYPA Customer Energy Solutions Building Assessments](#)
- [US DOE Pacific Northwest National Laboratory A Guide to Energy Audits](#)
- [Database of State Incentives for Renewables & Efficiency](#)
- [DEC CSC Reduce Utility Bills for Municipal Facilities and Operations](#)

H. Recertification requirements

The recertification requirements are the same as the initial certification requirements.