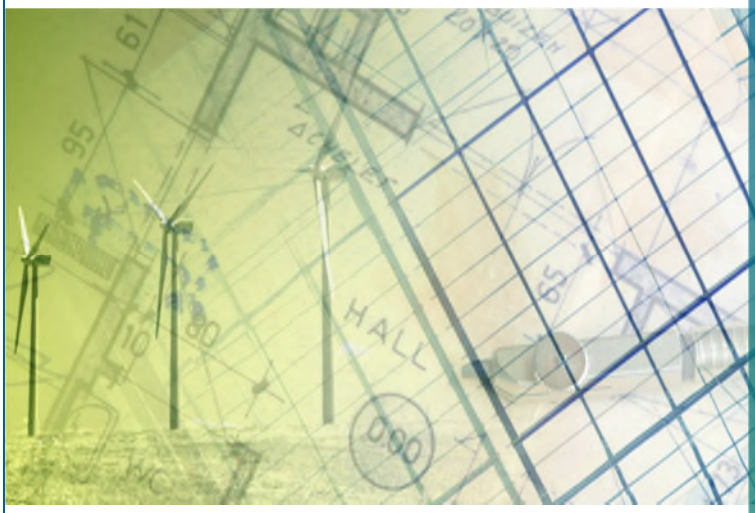
ENERGY SERVICES AGREEMENT



TOWN OF BERLIN

BERLIN, CONNECTICUT

Guaranteed Savings Reconciliation Report Year One

May 31, 2019

Submitted by:

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United Technologies

ENERGY SERVICES AGREEMENT

TOWN OF BERLIN

BERLIN, CONNECTICUT

GUARANTEED SAVINGS RECONCILIATION REPORT
YEAR ONE

May 31, 2019

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TOWN OF BERLIN
BERLIN, CONNECTICUT

GUARANTEED SAVINGS RECONCILIATION REPORT
YEAR ONE

Performance Period Dates Covered: March 1, 2018 to February 28, 2019

0. EXECUTIVE SUMMARY

0.1 Project Background

NORESCO is pleased to submit the Guaranteed Savings Reconciliation Report (GSRR) for Year One to the Town of Berlin (Berlin). NORESCO submitted the Investment Grade Energy Audit (IGA) Report to Berlin on dated November 30, 2015. This GSRR covers nine Energy Conservation Measures (ECMs). Originally 11 ECMs were proposed but ECM 5&6 were removed with Change Order No. 1 dated July 7, 2016 and Change Order No. 2 December 15, 2016.

- ECM-01: Lighting Improvements & Controls
- ECM-02: Direct Digital Control Energy Management System
- ECM-03: Variable Frequency Drives (VFDs) and Premium Efficiency Motors
- ECM-04: Cooler Controls
- ECM-07: Building Weatherization
- ECM-08: High Efficiency Condensing Boilers
- ECM-09: New Fan Coil and Air handling Units
- ECM-10 Solar Photovoltaics
- ECM-11: LED Streetlights

Berlin accepted the overall construction project by executing the Certificate of Final Acceptance dated March 3, 2018 which is attached hereto as ***Attachment 0A: Final ECM Acceptance*** This GSRR provides the verified savings for the First Guarantee Period based on as-built conditions and post-installation Measurement and Verification (M&V) activities. The First Guarantee Period covers the period from March 1, 2018 through February 28, 2019.

This Report summarizes the M&V activities and results that occurred during the First Guaranty Period including an overview of the project and its implemented ECMs, and descriptions of changes made since the original proposal.

Guaranteed Savings are the amount of avoided energy and operational costs that NORESCO has guaranteed to Berlin as specified in *Schedule* F in the Energy Services Agreement (ESA) and finalized in Change Order No. 4 effective date of September 30, 2017. The verified savings are the savings that NORESCO calculated for the First Guaranty Period as a result of as-built conditions and post-installation M&V activities.

0.1 First Guarantee Period Savings

Table 0-1 lists the proposed unit and cost savings by ECM as specified in the ESA. The proposed cost savings are calculated based on the Year One energy rates as determined per ESA Schedule F-2*: Baseline Energy rates* and escalated by *F-3 Energy Escalation Rates*. For ECM 10: Solar Photovoltaics, the guaranteed savings are 95 percent of the proposed savings calculated during the IGA.

TABLE 0-1: PROPOSED AND GUARANTEED YEAR ONE SAVINGS BASED ON ESA, DATED NOVEMBER 30, 2015

ECM No.	ECM Name	Electricity (kWh)	Natural Gas (CCF)	Proposed Savings ($)	Guaranteed Savings ($)
-01	Lighting Improvements & Controls	644,509	(746)	$120,891	$120,891
-02	Direct Digital Control Energy Management System	6,698	3,435	$3,182	$3,182
-03	Variable Frequency Drives and Premium Efficiency Motors	51,918	---	$8,430	$8,430
-04	Cooler Controls	20,816	---	$3,514	$3,514
-05	Plug Load Controls	25,840	---	$4,849	$4,849
-06	Computer Power Management	76,966	---	$13,505	$13,505
-07	Building Weatherization	7,702	3,565	$4,028	$4,028
-08	High Efficiency Condensing Boilers	---	15,428	$10,405	$10,405
-09	New Fan Coil and Air Handling Units	3,766	3,990	$3,100	$3,100
-10	Solar Photovoltaics	1,002,780	---	$186,714	$177,378
-11	LED Streetlights	---	---	($74,008)	($74,008)
Total		1,840,995	25,672	$284,610	$275,274

Numbers across columns or rows may appear to have small discrepancies when summed due to rounding.

Table 0-1A lists the revised guaranteed savings based on two Change Orders that were executed during the construction phase. Change Order No. 1, dated July 21, 2016, removed ECM-06 from the project. Change Order No. 2, dated December 15, 2016, removed ECM-05 from the project. These Change Orders were included as ***Attachment 0B*** in the Post Installation Report sent May 30, 2018. The Revised Guaranteed Savings for the project is shown below:

TABLE 0-1A: REVISED GUARANTEED SAVINGS BASED ON EXECUTED CHANGE ORDERS NO. 1 & 2

ECM No.	ECM Name	Electricity (kWh)	Natural Gas (CCF)
-01	Lighting Improvements & Controls	644,509	(746)
-02	Direct Digital Control Energy Management System	6,698	3,435
-03	Variable Frequency Drives and Premium Efficiency Motors	51,918	---
-04	Cooler Controls	20,816	---
-05	Plug Load Controls	---	---
-06	Computer Power Management	---	---
-07	Building Weatherization	7,702	3,565
-08	High Efficiency Condensing Boilers	---	15,428
-09	New Fan Coil and Air Handling Units	3,766	3,990
-10	Solar Photovoltaics	1,002,780	---
-11	LED Streetlights	---	---
Total		**1,738,189**	**25,672**
Year One Guaranteed Savings			**$256,920**

Numbers across columns or rows may appear to have small discrepancies when summed due to rounding.

Table 0-2 lists the Verified Year One savings per ECM based on the as-built conditions and the post-installation M&V activities.

TABLE 0-2: VERIFIED SAVINGS – YEAR ONE

ECM No.	ECM Name	Electricity (kWh)	Natural Gas (CCF)	Utility Savings ($)	Total Savings ($)
-01	Lighting Improvements & Controls	663,312	(763)	$124,074	$124,074
-02	Direct Digital Control Energy Management System	6,698	3,435	$3,182	$3,182
-03	Variable Frequency Drives and Premium Efficiency Motors	51,918	---	$8,430	$8,430
-04	Cooler Controls	20,816	---	$3,514	$3,514
-05	Plug Load Controls	---	---	$---	$---
-06	Computer Power Management	---	---	$---	$---
-07	Building Weatherization	7,702	3,565	$4,028	$4,028
-08	High Efficiency Condensing Boilers	---	15,428	$10,405	$10,405
-09	New Fan Coil and Air Handling Units	3,766	3,990	$3,100	$3,100
-10	Solar Photovoltaics	997,766	---	$176,496	$176,496
-11	LED Streetlights	---	---	($74,008)	($74,008)
Total		**1,751,978**	**25,655**	**$259,221**	**$259,221**

Numbers across columns or rows may appear to have small discrepancies when summed due to rounding.

PV Saving's degradation by 0.5% applied annually

Based on the as-built documentation and results of the M&V process, the verified savings for the First Guarantee Period is $259,221. This exceeds the Revised Guaranteed Savings of $256,920 by $2,301.

0.2 Energy Cost Summary

The baseline unit energy and water costs, as listed in Attachment F of the ESA, are included below in *Table 0-3* and the annual escalation rates are shown in *Table 0-4*. The baseline energy rates will be increased by the energy escalation percentages for each year by the applicable amount shown in *Table 0-4*. The Year One escalated energy rates are shown in *Table 0-5* and were calculated by escalating the baseline rates for one year.

TABLE 0-3: BASELINE ENERGY UNIT COSTS

Facility	Electricity Blended Rate ($/kWh)	Natural Gas ($/CCF)
Griswold Elementary School	$0.1821	$0.8692
High School	$0.1546	$0.8692
Hubbard Elementary School	$0.1670	$0.9860
McGee Middle School	$0.1842	$0.6487
Willard Elementary School	$0.1731	$0.7891
Art League	$0.1604	$---
Timberlin Golf Course	$0.1991	$1.0934
Highway, Facilities, Parks, Water, Departments	$0.1694	$1.1702
Library	$0.1691	$0.8620
Sage Park	$0.4724	$---
Senior Center	$0.1731	$1.6441
Town Hall & Police Department	$0.1414	$0.6062
South Kensington Fire Department	$0.1723	$1.0644

TABLE 0-4: ESCALATION RATES

Year	Electricity Blended Rate ($/kWh)	Natural Gas ($/CCF)
One	5.02%	5.02%
Two	4.00%	4.00%
Three	4.00%	4.00%
Four	4.00%	4.00%
Five	4.00%	4.00%
Six	4.00%	4.00%
Seven	4.00%	4.00%
Eight	4.00%	4.00%

Year	Electricity Blended Rate ($/kWh)	Natural Gas ($/CCF)
Nine	4.00%	4.00%
Ten	4.00%	4.00%
Eleven	4.00%	4.00%
Twelve	4.00%	4.00%
Thirteen	4.00%	4.00%
Fourteen	4.00%	4.00%
Fifteen	4.00%	4.00%
Sixteen	4.00%	4.00%
Seventeen	4.00%	4.00%
Eighteen	4.00%	4.00%
Nineteen	4.00%	4.00%

TABLE 0-5: YEAR ONE ENERGY RATES

Facility	Electricity Blended Rate ($/kWh)	Natural Gas ($/CCF)
Griswold Elementary School	$0.1912	$ 0.9128
High School	$0.1624	$0.9128
Hubbard Elementary School	$0.1754	$1.0355
McGee Middle School	$0.1934	$0.6813
Willard Elementary School	$0.1818	$0.8287
Art League	$0.1685	$---
Timberlin Golf Course	$0.2091	$1.1483
Highway, Facilities, Parks, Water, Departments	$0.1779	$1.2289
Library	$0.1776	$0.9053
Sage Park	$0.4985	$---
Senior Center	$0.1818	$1.7266
Town Hall & Police Department	$0.1485	$0.6366
South Kensington Fire Department	$0.1809	$1.1178

1. ECM-01: LIGHTING IMPROVEMENTS AND CONTROLS

1.1 Overview of M&V Plan

NORESCO used IPMVP Option A for this ECM.

This ECM saves energy by installing more efficient light fixtures that use less electricity than the existing fixtures. Existing 32-watt T-8 lamps were upgraded to 25- or 28-watt T-8 lamps with high efficiency ballasts, and many incandescent, HID and fluorescent fixtures were replaced with LED fixtures. Additional savings come from the installation of occupancy sensors in select locations, which automatically turn off lights when the areas are unoccupied.

NORESCO created a spreadsheet using the existing fixtures' measured electrical power (kW) for those fixtures that were measured and pre wattage tables for fixtures that were not measured, as well as operating hours to determine the energy consumed by existing lighting systems in use at the various buildings in the town of Berlin. This spreadsheet established baseline energy consumption for this ECM.

1.2 Savings Calculation Methodology

To calculate the proposed direct energy savings, fixtures were been grouped by baseline lamp and ballast combination (LBC), post-installation LBC, and hours of operation. Energy savings calculations for this ECM used data from the following sources:

- An on-site audit
- Measurements of energy consumption of existing and new fixtures
- Industry standard lighting wattage tables showing standard consumption of the LBCs that were not measured
- Data provided by facility personnel supported by data from lighting loggers (occupancy data, operating hours of fixtures)

Key parameters that affect baseline energy use include fixture energy consumption and operating hours. Building operating and occupant data was determined from lighting loggers that logged hours of lighting operation throughout the sites over an extended period of time. If any of these parameters could not be determined from these sources, NORESCO estimated the parameter based on standard engineering practices and experience.

For each line item in the inventory, the verified electric energy savings has been calculated using the following equations:

$$\mathrm{ES_{LTG}} = \left\{(\mathrm{P_{base}} * \mathrm{N_{base}}) - (\mathrm{P_{post}} * \mathrm{N_{post}})\right\} * \mathrm{H_{base}}$$

Where:

ES_{LTG}	*= Annual Energy Savings (kWh)*
P_{BASE}	*= Baseline Electrical Power (kW/fixture)*
N_{BASE}	*= Baseline Fixture Quantity*
P_{POST}	*= Post-installation Electrical Power (kW/fixture)*
N_{POST}	*= Post-installation Fixture Quantity*
H_{BASE}	*= Baseline Annual Operating Hours*

Annual hours of operation are the values shown for each entry in the comprehensive lighting audit and spreadsheet model. The total verified electric energy savings are the sum of the energy savings for each line item in the inventory.

To calculate the proposed lighting control savings, fixtures were grouped with other fixtures sharing the same baseline LBC group, post-installation LBC group, and hours of operation. The baseline and post-installation operating hours agreed to by both Parties for all lighting equipment is detailed in **Attachment 1B: Lighting Savings Summary**.

For each group of fixtures, energy savings from the new controls are calculated as follows:

$$ES_{CONTROLS} = \{(P_{post} * H_{base}) - (P_{post} * H_{post})\} * N_{post}$$

Where:

$ES_{controls}$	*= Energy savings, in kWh, for the on/off controls.*
P_{post}	*= Electrical power, in kW, per fixture for appropriate post-installation LBC group.*
H_{base}	*= Baseline annual operating hours defined by fixture's pre-hours group.*
H_{post}	*= Post-Installation annual operating hours defined by fixture's post hours group.*
N_{post}	*= Number of fixtures in representative post-installation LBC group.*

The associated interactive heating and cooling effects on electric consumption and natural gas usage are calculated using the following equations:

$$ES_{CLG} = ES_{LTG} \times LCC / (COP \times SC) \times WC / 52$$
$$P_{HTG} = (ES_{LTG} \times PS \times LCH \times SH \times WH/52 \times HFCF) / EFF_{HTG}$$

Where:

ES_{CLG}	*= Annual Interactive Cooling Energy Savings (kWh)*
P_{HTG}	*= Annual Interactive Heating Penalty*
LCC	*= Lighting Contribution to Cooling Load, as a percentage of total lighting energy use*
SC	*= Space Cooled, as a percentage of the total floor space*
COP	*= Cooling System Efficiency (COP)*
WC	*= Weeks of Cooling per year*
PS	*= Perimeter Spaces, as a percentage of the total floor space*
LCH	*= Lighting Contribution to Heating Load, as a percentage of total lighting energy use.*
SH	*= Space Heated, as a percentage of the total floor space*
WH	*= Weeks per year Heating*
HFCF	*= Heating Fuel Conversion Factor*
	= 0.03412 Therms per kWh for Natural Gas
	= 1.0 kWh per kWh for Electricity
EFF_{HTG}	*= Heating System Efficiency*

Lighting operations and maintenance savings were calculated using the number of replacement fixtures, fixture operating hours, and maintenance intervals of existing and new fixtures. These savings are for reductions in material replacements over the Guarantee Period and do not include labor savings. These calculations are detailed in Appendix 1 of the IGA Report.

Baseline M&V Activities

NORESCO measured baseline fixture wattages for a representative sample of fixtures from a number of pre-installation LBC groups. The pre-installation LBC groups measured were based on fixture quantities and hours of operation. The type and number of fixtures measured represented 91.2 percent of the total connected baseline lighting load. The hours of operation for each area's fixtures were determined via staff interviews and on-site observations supported with the data collected from the lighting loggers.

Post-Installation M&V Activities

Post-installation energy consumption was based on the calculations described above updated for as-built conditions. During the commissioning phase, NORESCO verified that the new lighting equipment is in accordance with the specifications described in the IGA.

The final as-built scope of work included 6,482 installed luminaires in 12 buildings. During the construction period, NORESCO identified some minor variations in luminaire counts and descriptions from the original IGA. These changes were minor and are consistent with variations that occur on most projects due to facility changes, areas that were inaccessible during the original audit, and minor auditing adjustments.

All luminaire retrofits were consistent with the technologies recommended in the IGA. A final walk-through and sign-off was conducted with facility personnel on a building-by-building basis. The following table identifies the types and quantities of retrofits that were included in this ECM.

TABLE 1-1: RETROFITS COMPLETED

Retrofit Type	Quantity
Centering Kit – T-8 Linear Fluorescent	37
Exit Sign	7
New Fixtures – LED (Exterior)	212
New Fixtures – LED (Interior)	255
New Reflectors – T-8 Linear Fluorescent	1,562
Plug-In – LED	19
Relamp & Reballast – T-5HO Linear Fluorescent	854
Relamp & Reballast – T-8 Linear Fluorescent	2,942
Retrofit Kits – LED	113
Screw-In – LED	481
Total	6,482
Audited Fixtures That Did Not Require a Retrofit	**618**

The following table identifies the as-built quantities of installed fixtures per building:

TABLE 1-2: BUILDING SUMMARY

Building Name	Pre Fixtures	Post Fixtures
Griswold ES	818	828
Hubbard ES	618	621
McGee MS	1,722	1,691
Willard ES	990	991
Art League	29	29
Timberlin Golf Course	157	157
Highway, Facilities, Parks	308	314
Library	646	646
Sage Park	83	83
South Kensington Fire Dept.	68	73
Senior Center	176	176
Town Hall & Police Department	842	873
Total	6,457	6,482

Verified savings have been calculated using the equations above based on post-installation fixture wattage measurements and the as-built quantities. ***Attachment 1A Hours Group Summary*** and **Attachment *1B Lighting Savings Summary and Building Summary*** detail the values used to derive the verified savings, while *Attachment 1D.2 Post-Installation M&V Field Notes* contains the field notes from the post-installation measurements performed at the sites. As shown in *Attachment 1D.1 Post Installation Results* and summarized in *Table 1-3* below these attachments were included in the Post Installation report sent May 31, 2018 and available upon request, measured wattages came in as expected or lower and coefficients of variation were less than 10 percent for each meter code. These measurements captured 82.2 percent of the total connected post-installation lighting load. Included in the attachments are summaries of the hours groups, retrofit quantities and savings, LBC groups and the savings resulting from the HVAC interaction analysis.

TABLE 1-3: POST-INSTALLATION MEASUREMENT SUMMARY

LBC Description	Total Population	Sample Size	Sample Mean (W)	Percent of Total Project Lighting Energy (%)	Sample Coefficient of Variation (%)
FO28 - 2 - 2LT ELEC HE HIGH - 1	1,284	3	59	22.43%	5.87%
FO28 - 2 - 2LT ELEC HE LOW - 1	1,711	3	41	19.31%	2.84%
FO28 - 3 - 3LT ELEC HE LOW - 1	293	3	61	4.96%	5.30%
FO28 - 4 - 4LT ELEC HE LOW - 1	286	3	82	6.46%	1.86%
FP54/T5HO-47W - 2 - - - 0	854	3	104	24.10%	3.33%
LED100 - 1 - LED - 1	185	3	102	4.97%	0.57%

Performance Period M&V Activities

Jeffery Lyskawa and Odean Barret, from NORESCO O&M, met with Town of Berlin to conduct the annual inspection of ECM-01 on March 20, 2019. No issues were noted during this inspection. For detailed information on the inspection, please see ***Attachment 0B: Year One O&M Inspection Report.***

2. ECM-02: DIRECT DIGITAL CONTROL ENERGY MANAGEMENT SYSTEM

2.1 Overview of M&V Plan

NORESCO used Option A for this ECM.

This ECM replaced pneumatic valves and actuators with direct digital control (DDC) components in the Town Hall. Savings are realized by reducing the runtimes of HVAC equipment during unoccupied hours, as well as the implementation of optimized space temperature setpoints.

2.2 Savings Calculation Methodology

Baseline energy consumption was calculated using the systems' fan motor horsepower, HVAC system efficiencies, as well as operational parameters such as hours of operation and temperature setpoints. NORESCO created a spreadsheet model based on these parameters, as well as local weather data to determine the baseline energy consumption. The equipment operating hours and temperature setpoints were modified in the post-installation model to calculate post-installation consumption. This was subtracted from the baseline consumption to determine the energy savings.

The following equations were used to calculate baseline and post-installation energy consumption:

$$q = 1.08 \cdot CFM \cdot \Delta T$$

Where:

q	*= AHU Heating Load (Btu/hr)*
1.08	*= Conversion Constant (Btu/CFM*hr*°F)*
CFM	*= AHU Air Flow (Cubic Feet per Minute)*
ΔT	*= Temperature Differential (°F)*

$$q = 4.5 \cdot CFM \cdot \Delta h$$

Where:

q	*= AHU Total Cooling Load (Btu/hr)*
4.5	*= Conversion Constant (pounds of dry air*min/CFM*hr)*
CFM	*= AHU Air Flow (Cubic Feet per Minute)*
Δh	*= Enthalpy Differential (Btu/pound)*

$$kW = Hp \cdot 0.746 \cdot LF \cdot VFD \div Eff.$$

Where:

kW	*= Motor Power (kW)*
Hp	*= Motor Hp (HP)*
0.746	*= Conversion Constant (kW/HP)*
LF	*= Motor Load Factor*
Eff	*= Motor Efficiency (%)*
VFD	*= % Motor Speed*

Energy savings for unoccupied temperature setbacks were calculated using the following equations:

Envelope Load MMBtu = (UA x (∑(OAT-Occupied Setpoint) x Occupied Hours + ∑(OAT-Unoccupied Setpoint) x Unoccupied Hours))/10^6

Infiltration Load MMBtu = (1.08 x Infiltration CFM x (∑(OAT-Occupied Setpoint) x Occupied Hours + ∑ (OAT-Unoccupied Setpoint) x Unoccupied Hours))/10^6

UA = 1/R-Value of Wall x Wall Area + 1/R-Value of Roof x Roof Area

Infiltration CFM = Building Area x 10 Feet Average Height x Building Air Changes Per Hour/60

Cooling kWh = (Envelope + Infiltration Load) x 10^6/12000 x kW/Ton Cooling Efficiency (Loads for Hours above Balance Point only)

Heating MMBtu = (Envelope + Infiltration Load)/ Heating Efficiency (Loads for Hours below Balance Point only)

Details of these calculations can be viewed in ***Attachment 2A New DDC EMS Savings Calcs***..

Baseline M&V Activities

NORESCO reviewed existing space temperatures, setpoints and schedules in the Energy Management System (EMS). A site audit was also performed to gather the existing equipment manufacturer specifications and nameplate data. Characteristics of baseline HVAC equipment were used to create the spreadsheet models with regards to heating and cooling loads and operating hours.

The following inputs were collected on site and used in the baseline models:

- Equipment nameplate data (capacity, efficiency class, etc.)
- Equipment type (water cooled, air cooled, etc.)
- Equipment configuration (primary pumping, primary secondary pumping, etc.)
- Building architectural, electrical, mechanical, plumbing, and structural drawings (blueprints)
- Thermal zone designations (mechanical floor plans)

Key parameters that affect baseline energy use include existing temperature setpoints, operating hours and building population. Building operating and occupant data was provided by town of Berlin staff. If any of these parameters could not be determined from these sources, NORESCO estimated the parameter based on standard engineering practices and experience.

Post-Installation M&V Activities

Post-installation M&V activities focused on ensuring that the new equipment was installed and commissioned properly. Successful completion of this commissioning process in accordance with the manufacturer's prescribed procedures verified the ability of the new equipment to perform as designed. Verified savings were calculated using the baseline model updated to reflect the installed improvements, including agreed upon setpoints and schedules.

NORESCO furnished and installed the following equipment as part of this ECM:

- A new DDC EMS in the Town Hall, which controls the new boilers, hot water pumps, chiller, cooling tower, chilled and condenser water pumps, six air handling units

(AHUs), including five new AHUs, reheat coils, and 90 vertical and ceiling-mount fan coil units.

- A new variable frequency drive (VFD) for AHU-7
- New DDC points associated with ECM-03, -08 and -09 have been installed and integrated with the existing building EMS.

During the commissioning process, the new controls and newly programmed operational strategies were inspected to confirm proper installation and programming and that the ECM is capable of achieving verified energy savings. Functional performance tests (FPTs) of each system were performed to verify operations of equipment based on new programming.

Performance Period M&V Activities

Jeffery Lyskawa and Odean Barret, from NORESCO O&M, met with Town of Berlin to conduct the annual inspection of ECM-02 on March 20, 2019. NORESCO noted some temperature changes in the controls settings and suggests reverting back to the original proposed settings to ensure that overall energy savings are met. For detailed information on the inspection, please see ***Attachment 0B: Year One O&M Inspection Report.***

3. ECM-03: VARIABLE FREQUENCY DRIVES AND PREMIUM EFFICIENCY MOTORS

3.1 Overview of M&V Plan

NORESCO used Option A for this ECM.

This ECM installed VFDs on constant volume pumps and fans at the Library and Town Hall. In addition, standard efficiency motors for the hot water pumps were replaced with premium efficiency motors. Savings for this ECM are realized by modulating pump and fan speeds to allow them to run below full speed whenever possible. Additional savings result from the installation of more efficient motors on hot water pumps which use less energy than the existing motors.

3.2 Savings Calculation Methodology

Baseline energy consumption was calculated using the existing pump and fan efficiencies and flow rates applied to a bin model of the buildings' heating and cooling loads. This model was updated with the proposed equipment and its performance specifications to calculate post-installation consumption. This was subtracted from the baseline consumption to determine the energy savings.

The following equations were used to calculate baseline and post-installation energy consumption:

$$\textit{Current Usage (kWh)} = (((\textit{Motor HP} \times 0.746) \times (\textit{current rpm \%})^3) + \textit{VFD kW}) \times \textit{operating bin hours}$$

$$\textit{Proposed Usage (kWh)} = (((\textit{Motor HP} \times 0.746) \times (\textit{proposed rpm \%})^3) + \textit{VFD kW}) \times \textit{operating bin hours}$$

$$\textit{Motor Energy Savings} = \textit{Current Usage (kWh)} - \textit{Proposed Usage (kWh)}$$

Details of these calculations can be viewed in ***Attachment 3A:*** **PE Motor & VFDs Savings Calc**..

Baseline M&V Activities

NORESCO reviewed existing EMS schedules to determine the baseline operating hours for the equipment included in this ECM. Site audits were also performed to gather the existing equipment performance specifications and nameplate data. This information was incorporated into the heating and cooling load bin models to calculate baseline energy consumption.

The following inputs were collected on site and used in the baseline models:

- Equipment nameplate data (capacity, efficiency class, etc.)
- Equipment type (water cooled, air cooled, etc.)
- Equipment configuration (primary pumping, primary secondary pumping, etc.)
- Building architectural, electrical, mechanical, plumbing, and structural drawings (blueprints)
- Thermal zone designations (mechanical floor plans)

Key parameters that affect baseline energy use include existing fan and pump power, temperature setpoints and operating hours, building populations, HVAC system efficiencies and building construction materials. Building operating and occupant data was provided by the town of Berlin staff. If any of these parameters could not be determined from these sources, NORESCO estimated the parameter based on standard engineering practices and experience.

Post-Installation M&V Activities

Post-installation M&V activities focused on ensuring that the new equipment was installed and commissioned properly. Successful completion of this commissioning process in accordance with the manufacturer's prescribed procedures verified the ability of the new equipment to perform as designed. Verified savings were calculated using the baseline model updated to reflect the installed improvements, including agreed-upon setpoints and schedules.

NORESCO furnished and installed the following equipment as part of this ECM:

- Premium efficiency motors and VFDs for AHU-1 and AHU-2 at the Peck Library.
- VFDs for the existing premium efficiency motors for AHU-7 in the Town Hall.
- Premium efficiency motors and VFDs on hot water pump motors in Peck Library and Town Hall.
- Control strategies for all the new VFDs and existing VFDs for AHU1, AHU-2, and AHU-7 in Peck Library and Town Hall respectively. In addition, added controls for the hot water pumps, chilled water pumps and condenser water pumps in Peck Library and Town Hall.

During the commissioning process, the new VFDs and controls were inspected to confirm proper installation and startup and that the ECM is capable of achieving expected energy savings.

Performance Period M&V Activities

Jeffery Lyskawa and Odean Barret, from NORESCO O&M, met with Town of Berlin to conduct the annual inspection of ECM 03 on March 20, 2019. No issues were noted during this inspection. For detailed information on the inspection, please see ***Attachment 0B: Year One O&M Inspection Report.***

4. ECM-04: COOLER CONTROLS

4.1 Overview of M&V Plan

NORESCO used Option A for this ECM.

This ECM upgraded the fan motors and controls on the walk-in coolers and freezers at the High School and McGee Middle School. This reduces energy consumption and increases the reliability of the evaporator fan motors and door heaters. Savings for this ECM are realized through reducing the runtime of the cooling systems to better match the cooling load, as well as by installing more efficient fans and reducing door heater runtimes.

4.2 Savings Calculation Methodology

Baseline energy consumption was calculated using the existing cooler and freezer fan motor efficiencies and operating hours. This model was updated with the proposed equipment and its performance specifications to calculate post-installation consumption. This was subtracted from the baseline consumption to determine the energy savings.

The following equations were used to calculate baseline and post-installation energy consumption:

$$\textit{Existing kWh} = [(\textit{Existing Fan HP} \times 0.746 \times \textit{Load Factor}) \times \textit{Existing Fan Run Hours}] + (\textit{Door Heater kW} \times \textit{Existing Heater Run Hours})$$

$$\textit{Proposed kWh} = [(\textit{Proposed Fan HP} \times 0.746 \times \textit{Load Factor}) \times \textit{Proposed Fan Run Hours}] + (\textit{Door Heater kW} \times \textit{Proposed Heater Run Hours})$$

Details of these calculations can be viewed in ***Attachment 4A: Walk-in Cooler Upgrades Savings Calcs.***

Baseline M&V Activities

Equipment audits were performed to gather the existing fan and heater efficiencies, as well as cooler and freezer operating hours. This information was incorporated into the models to calculate baseline energy consumption.

The following inputs were collected on site and used in the baseline models:

- Equipment nameplate data (capacity, efficiency class, etc.)
- Equipment type (water cooled, air cooled, etc.)
- Equipment configuration (primary pumping, primary secondary pumping, etc.)

Key parameters that affect baseline energy use include existing cooling systems fan power, cooler and freezer temperature setpoints and operating hours. If any of these parameters could not be determined from these sources, NORESCO estimated the parameter based on standard engineering practices and experience.

Post-Installation M&V Activities

Post-installation M&V activities focused on ensuring that the new equipment was installed and commissioned properly. Successful completion of this commissioning process in accordance with the manufacturer's prescribed procedures verified the ability of the new equipment to perform as designed. Verified savings were calculated using the baseline model updated to reflect the installed improvements, including agreed upon setpoints and schedules.

NORESCO furnished and installed the following equipment as part of this ECM:

- Replaced all non-electronically commutated motors that were being used for the evaporator units serving three walk in cooler / freezers in the High School and McGee Middle School with ECM motors.
- Installed a CoolTrol® control system to manage all walk in units as supplied by National Resource Management (NRM) in both the High School and McGee Middle School.

During the commissioning process, the new motors and controls were inspected to confirm proper installation and startup and that the ECM is capable of achieving expected energy savings

Performance Period M&V Activities

Jeffery Lyskawa and Odean Barret, from NORESCO O&M, met with Town of Berlin to conduct the annual inspection of ECM-04 on March 20, 2019. No issues were noted during this inspection. For detailed information on the inspection, please see ***Attachment 0B: Year One O&M Inspection Report.***

5. ECM-05: PLUG LOAD CONTROLS

This ECM was removed from the project under Change Order No. 2, dated December 15, 2016. Guaranteed savings associated with the ECM were removed.

6. ECM-06: COMPUTER POWER MANAGEMENT

This ECM was removed from the project under Change Order No. 1, dated July 7, 2016. Guaranteed savings associated with the ECM were removed.

7. ECM-07: BUILDING WEATHERIZATION

7.1 Overview of M&V Plan

NORESCO used Option A for this ECM.

This ECM installed improvements to the building envelopes at Willard Elementary School, Timberlin Golf Course, the Town Hall and Peck Memorial Library. Sealing the building envelope reduces infiltration of unconditioned air, which reduces HVAC costs and improves occupant comfort. NORESCO identified attic bypass areas, buck frame joints, window casings and several roof-wall intersections that benefited from improved caulking or insulation.

7.2 Savings Calculation Methodology

Baseline energy consumption was calculated with a spreadsheet model using ASHRAE formulas to calculate air leakage through window, attic, and roof–wall intersections as a function of gap widths and wind pressure. The savings are calculated by finding the energy cost of this infiltration due to the additional winter heating and summer cooling loads associated with unconditioned air entering the building. Local weather data including average temperature difference and wind speed are also used to calculate the air volume in cubic feet per minute (cfm). The baseline model was updated with the proposed building envelope improvements to calculate post-installation energy consumption. This was subtracted from the baseline consumption to determine the energy savings.

The following equations were used to calculate baseline and post-installation energy consumption, and detail how to calculate the additional energy required conditioning a given volume of air:

$$\textit{Energy Usage (Btu)} = 1.08 * \textit{Volume (cfm)} * \textit{Temperature Difference } (^{0}F) * \textit{Heating Hours}$$

$$\textit{Volume (cfm)} = \textit{Area (sq.in.)} * ((\textit{Stack Coeff.} * \textit{Avg. Temp. Diff}) * (\textit{Wind Coeff.} * \textit{Wind Speed}\hat{}2))^{1/2}$$

Details of these calculations can be viewed in ***Attachment 7A: Weatherization Savings Calcs***.

Baseline M&V Activities

During building audits, NORESCO identified areas that could benefit from improved weatherization. The existing insulating properties of these areas were estimated and resulting air infiltration rates were calculated. This information was incorporated into the model to determine baseline energy consumption.

Post-Installation M&V Activities

Post-installation M&V activities focused on ensuring that the new insulation was installed properly. Successful completion of this commissioning process in accordance with the manufacturer's prescribed procedures verified the ability of the new equipment to perform as designed. Verified savings were calculated using the baseline model updated to reflect the installed improvements, including agreed-upon setpoints and schedules.

NORESCO furnished and installed the following equipment as part of this ECM:

Willard Elementary School

- NORESCO sealed the joints at the buck frame and rough openings that were identified as pathways for air leakage.

Police Department/Town Hall

- NORESCO furnished and installed an approximately four to six-inch wide by two-inch deep bead of high-density spray polyurethane foam at the air leakage pathway.

Peck Library

- NORESCO blocked and sealed all air leakage pathways using a combination of the sealants and appropriate building materials such as drywall, backer rods, and rigid foam insulation.
- NORESCO caulked the non-operational components of the window jamb, casing or trim that were identified as pathways for air leakage; installed backer rod as required at large gaps.

Timberlin Golf Course

- NORESCO blocked and sealed all air leakage pathways using a combination of the sealants and appropriate building materials such as drywall, backer rods, and rigid foam insulation.

During the commissioning process, the new insulation materials and caulking were inspected to confirm proper installation and that the ECM is capable of achieving expected energy savings.

Performance Period M&V Activities

Jeffery Lyskawa and Odean Barret, from NORESCO O&M, met with Town of Berlin to conduct the annual inspection of ECM-07 on March 20, 2019. No issues were noted during this inspection. For detailed information on the inspection, please see ***Attachment 0B: Year One O&M Inspection Report.***

8. ECM-08: HIGH-EFFICIENCY CONDENSING BOILERS

8.1 Overview of M&V Plan

NORESCO used Option A for this ECM.

This ECM installed new, energy-efficient condensing hot water boilers and new boiler controls at McGee Middle School and the Town Hall. This reduces heating energy use and improves occupant comfort by more closely matching heating outputs to the building loads. Savings for this ECM result from improved boiler efficiencies compared to the existing equipment.

8.2 Savings Calculation Methodology

Baseline energy consumption for these units was calculated using the existing boilers' efficiencies based on recent combustion efficiency testing reports provided by the Customer. These efficiencies were applied to a bin model of the buildings' heating loads. This model was updated with the proposed equipment and its performance specifications to calculate post-installation consumption. This was subtracted from the baseline consumption to determine the energy savings.

Heating Savings (for each bin temperature) = Bin hours x heating load x (1/ existing efficiency – 1/ proposed efficiency)

Details of these calculations can be viewed in ***Attachment 8A: New Boilers Savings Calcs***.

Baseline M&V Activities

During the building audits, NORESCO gathered the nameplate data and manufacturer performance specifications for the existing boilers. This information was incorporated into the heating load bin models to calculate baseline energy consumption.

The following inputs were collected on site and used in the baseline models:

- Boiler nameplate data (capacity, efficiency class, etc.)
- Equipment configuration (primary pumping, primary secondary pumping, etc.)
- Building architectural, electrical, mechanical, plumbing, and structural drawings (blueprints)
- Thermal zone designations (mechanical floor plans)

Key parameters that affect baseline energy use include existing boiler efficiencies, temperature setpoints, building populations and operating hours. Equipment operating and occupant data were provided by town of Berlin staff. If any of these parameters could not be determined from these sources, NORESCO estimated the parameter based on standard engineering practices and experience.

Post-Installation M&V Activities

Post-installation M&V activities focused on ensuring that the new boilers and controls were installed, programmed and operating properly. Successful completion of this commissioning process in accordance with the manufacturer's prescribed procedures verified the ability of the new equipment to perform as designed. Verified savings were calculated using the baseline model updated to reflect the installed improvements, including agreed-upon setpoints and schedules.

NORESCO furnished and installed the following equipment as part of this ECM:

McGee Middle School

- Two new 5,000-MBH condensing boilers
- New condensing hot water heater
- Modified piping to create a primary/secondary hydronic piping arrangement.
- Integrated the boiler controls with the EMS per ECM-02.

Town Hall & Police Department

- Two new 3,000-MBH condensing boilers
- Modified piping to create a primary/secondary hydronic piping arrangement.
- Integrated the boiler controls with the EMS per ECM-02.

During the commissioning process, the new boilers, controls and programming were tested and inspected to confirm proper installation, startup and programming. This verified that the ECM is capable of achieving expected energy savings.

Performance Period M&V Activities

Jeffery Lyskawa and Odean Barret from NORESCO O&M met with Town of Berlin to conduct the annual inspection of ECM-08 on March 20, 2019. No issues were noted during this inspection. For detailed information on the inspection, please see ***Attachment 0B: Year One O&M Inspection Report.***

9. ECM-09: NEW FAN COIL AND AIR HANDLING UNITS

9.1 Overview of M&V Plan

NORESCO used Option A for this ECM.

This ECM installed new AHUs and fan coil units (FCUs) in the Town Hall. This decreases energy use while providing better occupant comfort. Savings for this ECM come from replacing old outdated AHUs and FCUs with newer more efficient equipment that can also be controlled by the new DDC system installed under ECM-02. This will allow the Customer to implement unoccupied temperature setbacks and shutdowns to reduce runtime of HVAC equipment.

9.2 Savings Calculation Methodology

Baseline energy consumption was calculated using the existing AHU and FCU efficiencies, as well as operational parameters such as hours of operation and temperature setpoints. NORESCO created a spreadsheet model based on these parameters, as well as local weather data to determine the baseline energy consumption. The equipment efficiencies, operating hours and temperature setpoints were modified in the post-installation model to calculate post-installation consumption. This was subtracted from the baseline consumption to determine the energy savings.

The following equations were used to calculate baseline and post-installation energy consumption:

$$q = 1.08 \cdot CFM \cdot \Delta T$$

Where:

q	*= AHU/FCU Heating Load (Btu/hr)*
1.08	*= Conversion Constant (Btu/CFM*hr*°F)*
CFM	*= AHU/FCU Air Flow (Cubic Feet per Minute)*
ΔT	*= Temperature Differential (°F)*

$$q = 4.5 \cdot CFM \cdot \Delta h$$

Where:

q	*= AHU/FCU Total Cooling Load (Btu/hr)*
4.5	*= Conversion Constant (pounds of dry air*min/CFM*hr)*
CFM	*= AHU/FCU Air Flow (Cubic Feet per Minute)*
Δh	*= Enthalpy Differential (Btu/pound)*

$$kW = Hp \cdot 0.746 \cdot LF \cdot VFD \div Eff.$$

Where:

kW	*= Motor Power (kW)*
Hp	*= Motor Hp (HP)*
0.746	*= Conversion Constant (kW/HP)*
LF	*= Motor Load Factor*
Eff	*= Motor Efficiency (%)*
VFD	*= % Motor Speed*

Energy savings for unoccupied temperature setbacks were calculated using the following equations:

Envelope Load MMBtu = (UA x (∑(OAT-Occupied Setpoint) x Occupied Hours + ∑(OAT-Unoccupied Setpoint) x Unoccupied Hours))/10^6

Infiltration Load MMBtu = (1.08 x Infiltration CFM x (∑(OAT-Occupied Setpoint) x Occupied Hours + ∑ (OAT-Unoccupied Setpoint) x Unoccupied Hours))/10^6

UA = 1/R-Value of Wall x Wall Area + 1/R-Value of Roof x Roof Area

Infiltration CFM = Building Area x 10 Feet Average Height x Building Air Changes Per Hour/60

Cooling kWh = (Envelope + Infiltration Load) x 10^6/12000 x kW/Ton Cooling Efficiency (Loads for Hours above Balance Point only)

Heating MMBtu = (Envelope + Infiltration Load)/ Heating Efficiency (Loads for Hours below Balance Point only)

Details of these calculations can be viewed in ***Attachment 9A: New HVAC Savings Calcs***.

Baseline M&V Activities

A site audit was performed to gather the existing AHU and FCU manufacturer specifications and nameplate data. Characteristics of baseline equipment were used to create the spreadsheet models with regards to heating and cooling loads and operating hours.

The following inputs were collected on site and used in the baseline models:

- Equipment nameplate data (capacity, efficiency class, etc.)
- Equipment type (water cooled, air cooled, etc.)
- Equipment configuration (primary pumping, primary secondary pumping, etc.)
- Building architectural, electrical, mechanical, plumbing, and structural drawings (blueprints)
- Thermal zone designations (mechanical floor plans)

Key parameters that affect baseline energy use include efficiencies of existing equipment, existing temperature setpoints, operating hours and building population. Building operating and occupant data was provided by town of Berlin staff. If any of these parameters could not be determined from these sources, NORESCO estimated the parameter based on standard engineering practices and experience.

Post-Installation M&V Activities

Post-installation M&V activities focused on ensuring that the new AHUs and FCUs were installed, programmed and operating properly. Successful completion of this commissioning process in accordance with the manufacturer's prescribed procedures verified the ability of the new equipment to perform as designed. Verified savings were calculated using the baseline model updated to reflect the installed improvements, including agreed-upon setpoints and schedules.

NORESCO furnished and installed the following equipment as part of this ECM:

- Replaced five pre-existing AHUs at the Town Hall with new units with features such as economizers, premium efficiency fan motors with variable frequency drives.
- Added new DDC controls under ECM-02 to include hot and chilled water coil control valves, 10-zone reheat coil control valves, and included new electronic thermostats with adjustable set point control and temporary override capability.
- Replaced the Town Hall vertical and horizontal-mount fan coil units with new, high efficiency cooling and heating terminal units.
- Integrated new digital controls for thermostats, hot and chilled water control valves and damper actuators, into the new building energy management system for the new fan coil units.
- Integrated all new equipment with the EMS included in ECM-02.

During the commissioning process, the new AHUs, FCUs, controls and programming were tested and inspected to confirm proper installation, startup and programming. This verified that the ECM is capable of achieving expected energy savings..

Performance Period M&V Activities

Jeffery Lyskawa and Odean Barret, from NORESCO O&M, met with Town of Berlin to conduct the annual inspection of ECM-09 on March 20, 2019. It was noted that AHU-3 and AHU-5 had loose and cracked belts that needed to be replace. NORESCO will check during the next inspection to ensure that these issues had been addressed. For detailed information on the inspection, please see ***Attachment 0B: Year One O&M Inspection Report.***

10. ECM-10: SOLAR PHOTOVOLTAICS

10.1 Overview of M&V Plan

NORESCO used Option A for this ECM.

This ECM installed solar photovoltaic (PV) arrays at McGee Middle School, Griswold, Hubbard and Willard Elementary Schools. The PV arrays generate electricity from a renewable resource and offset a portion of the purchased electric consumption and peak demand.

10.2 Savings Calculation Methodology

The energy savings associated with this ECM is equal to the net output of the PV arrays. NORESCO calculated the verified output of each array, net of array and inverter losses, using PVWatts®, an online software tool developed by the National Renewable Energy laboratory (NREL). PVWatts® calculates the monthly and annual verified output of the PV system based on parameters such as location, azimuth, tilt angle, and long-term historical weather data. It also accounts for PV array losses, inverter losses, and other miscellaneous power conditioning losses. For locations with detailed long-term weather data, PVWatts® can also provide hourly PV system output. The outputs from the calculations described above are shown in Appendix 1 of the IGA Report and included in ***Attachment 10A: PV Savings Calcs***.

The key assumptions used in the calculations are as follows:

- PV module performance and inverter efficiencies are based on typical manufacturers' data.
- The energy savings calculations use long-term solar irradiance and weather data interpolated from nearby weather stations in PVWatts®.

The equation used to determine the net output of the array is as follows:

$$E_{AC} = (H_t)\ (A_P)\ (h_P)\ (1 - L_P)\ (1 - L_C)\ (h_{inv})$$

Where:

E_{AC}	*= Net electric power produced (W-AC)*
Ht	*= Solar irradiance in the plane of the PV array (W/m2)*
AP	*= Area of the PV array (m2)*
hP	*= Average efficiency of PV array (%)*
LP	*= Miscellaneous PV array losses (%)*
LC	*= Other power conditioning losses (%)*
h_{inv}	*= Inverter efficiency (%)*

Baseline M&V Activities

The solar photovoltaic (PV) system generates electricity for the schools rather than reducing consumption from the baseline. The baseline energy for the PV system is the amount of purchased electrical energy consumption that will be offset by the total energy production from the PV system.

Post-Installation M&V Activities

NORESCO furnished and installed the following equipment as part of this ECM:

- Installation of PV array systems at Griswold Elementary, Willard Elementary, McGee Middle, and Hubbard Elementary schools. The as-built sizes of the arrays at each school compared to the systems specified in the IGA are in *Table 10-1*. The total AC capacity installed is seven percent larger than specified in the IGA.

TABLE 10-1: COMPARISON OF SOLAR PV SYSTEM SIZES FROM IGA TO AS-BUILT

	IGA (DC kW)	As-Built (DC kW)
Griswold	221	228
Hubbard	147	152
Willard	258	261
McGee	221	228
Total	847	869

- The PV system included DC to AC inverters, combiner boxes, AC and DC disconnects protective relays, grounding system, racking, controls, overcurrent protection, lightning protection as applicable, interconnecting wiring and conduits, display monitors for each building lobby, and network connections.
- Integrated the PV array systems with the Direct Digital Controls per ECM-02.

Post-installation energy use was based on short-term measurement and normalization of the PV system output. Successful completion of commissioning of the new equipment, in accordance with the manufacturer's prescribed procedures and with the ECM Commissioning Approach constituted verification of the ability of the new equipment to perform as designed.

Following commissioning, PV system AC power output, solar insolation, cell temperature and ambient temperature were measured for two weeks for each array to calculate the actual AC-DC derate factor. The measured data was used to normalize the system performance to STC: 1,000 W/m^2 plane-of-array irradiance and 25°C cell temperature. The measured performance data was normalized with the following equation:

$$P_{ACSTC} = P_{AC} \cdot \left(\frac{Irr_{STC}}{Irr} \right) / \left(1 - \left(T_{Cell} - 25 \right) \cdot T_{co-eff} \right)$$

Where:

P_{ACSTC}	*= Power output at STC (W-AC)*
P_{AC}	*= Power output measured (W-AC)*
Irr_{STC}	*= Solar irradiance at STC (1,000 W/m2)*
Irr	*= Solar irradiance measured (W/m2)*
T_{Cell}	*= Cell temperature measured or calculated (°C)*
T_{co-eff}	*= Temperature co-efficient of cell (approx 0.45% / °C)*

Only those measurements associated with irradiance greater than or equal to 800 W/m^2 were used for the normalization. If the post-installation P_{ACSTC} is equal to or greater than 95 percent of the proposed P_{ACSTC}, the post-installation performance will be verified and the installed PV systems will be capable of meeting or exceeding the proposed savings. The results of the normalized AC power output measurements are in *Table 10-2*. Post-installation P_{ACSTC} was calculated to be 663 W-AC for the entire system. This is greater than 95 percent of the expected output of 644 W-AC, meaning the proposed savings are verified to be met.

TABLE 10-2: COMPARISON OF MEASURED SOLAR PV AC PERFORMANCE IN COMPARISON TO IGA

	IGA Calculated AC Power	Measured Normalized AC Power
Griswold	168	198
Hubbard	112	129
Willard	196	162
McGee	168	174
Total	644	663

This measured derate factor was entered into PV Watts to determine the updated verified Savings based on the measured solar PV performance.

Based on the successful commissioning of this ECM and the performance calculation described above, the Year One verified cost savings are equal to the proposed savings.

Performance Period M&V Activities

Jeffery Lyskawa and Odean Barret, from NORESCO O&M, met with Town of Berlin to conduct the annual inspection of ECM-10 on March 20, 2019. It was noted that there is ongoing issues with the PV system at Willard Elementary School which may be due to a software issue. NORESCO will follow up with this issue to ensure that this issue has been addressed. For detailed information on the inspection, please see ***Attachment 0B: Year One O&M Inspection Report.***

11. ECM-11: LED STREETLIGHTS

11.1 Overview of M&V Plan

This ECM replaces exterior high pressure sodium streetlights with LED fixtures. This ECM is being implemented by the Town of Berlin and its contractor Tanko Lighting. Annual savings for this ECM were agreed-upon beforehand by the Town of Berlin and NORESCO and will be fixed for the Term as shown in *Table 11-1*.

11.2 Savings Calculation Methodology

Savings from this ECM will come from installation of more efficient light fixtures that use less electricity than the existing fixtures. Additional savings are realized by an electric rate reduction the Customer will receive by switching to new LED fixtures.

The Customer completed the work on this ECM as a separate project not being performed by NORESCO. Savings were calculated by the lighting subcontractor and have been reviewed and verified by NORESCO. Annual Savings have been agreed-upon by the Town of Berlin and NORESCO and are stipulated for the Guarantee Term at the amounts shown in *Table 11-1*

Baseline M&V Activities

Baseline quantities, fixture types, wattages and operating hours were provided by the lighting subcontractor.

Post-Installation M&V Activities

Post-installation energy consumption and utility rates have been agreed-upon by the Town of Berlin and NORESCO. NORESCO reviewed the as-built records from the Town's subcontractor to confirm that the project had been implemented as designed.

Performance Period M&V Activities

Jeffery Lyskawa and Odean Barret, from NORESCO O&M, met with Town of Berlin to conduct the annual inspection of ECM 11 on March 20, 2019. No issues were noted during this inspection. For detailed information on the inspection, please see ***Attachment 0B: Year One O&M Inspection Report.***

The following dollar amounts are the stipulated values of the Verified Savings associated with this ECM for the Term of the contract. These dollar amounts are the total energy consumption and rate savings, net of the Customer's equipment purchase cost, annual maintenance agreement with Tanko Lighting, and annual payments for the equipment purchased. The Tanko Lighting agreement is for four years, Year Five through Nineteen reflect full lighting savings for this ECM.

TABLE 11-1: GUARANTEED LED STREET LIGHTING SAVINGS

Year	ECM-11 Cost Savings ($)
One	($74,008)
Two	($75,270)
Three	($71,932)
Four	($71,605)
Five	$244,976
Six	$245,371
Seven	$248,845
Eight	$249,309
Nine	$252,852
Ten	$253,386
Eleven	$257,001
Twelve	$257,607
Thirteen	$261,295
Fourteen	$261,974
Fifteen	$265,736
Sixteen	$266,490
Seventeen	$270,327
Eighteen	$271,158
Nineteen	$157,184

The savings shown in *Table 11-1* have been provided by the subcontractor selected by the Town of Berlin and are fixed for the term of the contract. The Town of Berlin retains sole responsibility for the completion of the street light replacement project.

SECTION II: ATTACHMENTS

OVERALL PROJECT SUMMARY

OVERALL PROJECT SUMMARY

Attachment 0A: Final ECM Acceptance

ATTACHMENT H

CHANGE ORDER 4

Title: Town of Berlin Change Order 4

Contract Name: 142312 - Town of Berlin

Change Request No. 04

Customer: Town of Berlin, CT

Department: Public Works

Town of Berlin Contract Reference Number: 2015-08

Effective Date of Contract: 12/03/15

Effective Date of this Change: 09/30/2017

1. The Parties agree the project shall be changed as follows:	Price	Year 1 Guaranteed Savings
Retainage withheld due to water damages referenced in Invoice 16-171, for deductible $5,000.00 and abatement $5,596.80	($10,596.80)	N/A
Retainage withheld due to water damages referenced in Invoice 16-174 for abatement $3,880.00 and abatement $3,564.00 water mitigation and work repair is not included since it was covered in previous invoice 16-171.	($7,444.00)	N/A
Retainage withheld due to water damages referenced in Additional Paper and Water Damages Costs Document.	($5,767.06)	N/A

2. For all costs involved in this change, including extensions of time herein requested, NORESCO proposes to perform the work described in accordance with the provisions of this Agreement. The Customer and NORESCO agree that the deductions contained in this Change Order are in full settlement of all of its claims for property damages arising out of the water damage incidents occurring on or about 11/7/2016 and 11/20/16 (the "Water Incidents") and Customer agrees to release NORESCO from any and all present and future claims the Customer may have against NORESCO arising out of the Water Incidents.

   An extension of contract time of 0 calendar days to Final Completion and Substantial Completion Dates is requested.

3. Summary of Changes:

	Contract Price	Year 1 Guaranteed Savings
Contract Award	$ 8,785,701.00	$275,274.00
Previous Additions	$127,903.45	$0.00
Previous Deductions	-$71,133.00	-$18,354.00
Net Total	$ $ 8,842,471.45	$ 256,920.00
This Change - Additions	$0.00	$0.00
This Change - Deductions	-$23,807.86	$0.00

This Change - Subtotal	-$23,807.86	$0.00
Total	$ 8,818,663.59	$ 256,920.00

SIGNATURE PAGE TO FOLLOW

NORESCO Charles E. Puckhaber Jr.

Digitally signed by: Charles E. Puckhaber Jr.
DN: CN = Charles E. Puckhaber Jr. email = cpuckhaber@noresco.com C = US O = NORESCO OU = Construction
Date: 2017.11.13 14:34:55 -05'00'

By:_____

Title:_____

Date:_____

Customer

By:_____

Title: Acting Town Manager

Date: 3/15/18

ATTACHMENT E-2

FINAL ECM DELIVERY AND ACCEPTANCE CERTIFICATE

Customer hereby acknowledges Final Acceptance of all Energy Conservation Measures (the "ECMs") described in the applicable Attachment B to the Energy Services Agreement between Customer and NORESCO. The date of Final Acceptance is the date certified by the Customer that the Work has been installed, functionally tested and all punch-list items completed in accordance with the Contract Documents, so that the Customer has possession of the Work and can use it for its intended use. Customer hereby accepts the ECMs listed hereto after full inspection thereof as satisfactory for all purposes of the Agreement. Customer agrees to make the required payment(s) to NORESCO as set forth in Section 5 of the Energy Services Agreement and Attachment G of the Agreement.

Date Accepted by Customer: 3/15/18

Accepted for: **Customer**

Accepted by: _____

Name: Jack Healy

Title: Acting Town Manager

Note: ECMs to which this Delivery and Acceptance Certificate relates is attached hereto.

OVERALL PROJECT SUMMARY

Attachment 0B: Year One O&M Inspection Report

NORESCO

NORESCO Project: 142312 Town of Berlin, CT
ECM No. & Name: -03: Variable Frequency Drives and Premium Efficiency Motors

NORESCO WO NO.: 133589
Inspected By: Jeffery Lyskawa & Odean Barrett
Completion Date: 3/20/2019

Inspections: *Inspect drives and motors for any maintenance issues and VFD drives for setting*

Unit Location	Bldg. Name	Unit No.	Manufacturer	Equipment Description	Model / Cat No.	Notes
Basment M.E.R (Boiler Room)	Peck Library	AHU-1 Supply	Trane Fan/Baldor Motor	7.5hp	213TC	Belt drive/No issue observed
Basment M.E.R (Boiler Room)	Peck Library	AHU-1 Return	Trane Fan/Baldor Motor	3 HP	182T	Belt drive/No issue observed
Basment M.E.R	Peck Library	AHU-2 Supply	Trane Fan/Baldor Motor	7.5hp	213TC	Belt drive/No issue observed
Basment M.E.R	Peck Library	AHU-2 Return	Trane Fan/Baldor Motor	3 HP	182T	Belt drive/No issue observed
Basment M.E.R (Boiler Room)	Peck Library	Hot Water Pump 1	Taco/ Balodor Motor	2 HP	B5B2CL0	No issue observed/Baldor Motor/2HP/Amp 6.5/Frame 145T
Basment M.E.R (Boiler Room)	Peck Library	Hot Water Pump 2	Taco/ US Electric Motor	2 HP	B5B2CL0	Baldor Motor/2HP/Amp 6.5/Frame 145T
Basment M.E.R (Boiler Room)	Town Library	AHU-1 Supply Fan	ABB Drive	7.5 HP	ACH550-VCR-024A-S+F267	Drive selected/bypass in auto/Speed 33.0hz/Amps 8.3
Basment M.E.R (Boiler Room)	Town Library	AHU-1 Return Fan	ABB Drive	3 HP	ACH550-VCR-012A-2+F267	Drive selected/bypass in auto/Speed 29.4hz/Amps 4.1
Basment M.E.R	Town Library	AHU-2 Supply Fan	ABB Drive	7.5 HP	ACH550-VCR-024A-S+F267	Drive selected/bypass in auto/Speed 33.3hz/Amps 7.8
Basment M.E.R	Town Library	AHU-2 Return Fan	ABB Drive	3 HP	ACH550-VCR-012A-2+F267	Drive selected/bypass in auto/Speed 28.0hz/Amps 7.8
Penthouse #401	Town Hall	AHU-7 Supply Fan	ABB Drive	7.5 HP	ACH550-VCR-024A-S+F267	Drive selected/bypass in auto/Speed 28.3hz/Amps 4.0
N/A	Town Hall	AHU-7 Return Fan	ABB Drive	3 HP	ACH550-VCR-012A-2+F267	Based on information received from head of HVAC department AHU-7 does not have a return fan

NORESCO Project: 142312 Town of Berlin, CT
ECM No. & Name: -04: Walk-In Cooler Upgrades

NORESCO WO NO.: 133589
Inspected By: Jeffery Lyskawa & Odean Barrett
Completion Date: 3/20/2019

Inspections: *Inspect Cooler/Freezer controls for operation*

Unit Location	Bldg. Name	Unit No.	Manufacturer	Model / Cat No.	Notes
Controller Outside of cooler by Entry doors	McGee MS	Walk in Freezer	458	GEX 21794	Verified 2 evaporator fans
Controller Outside of cooler by Entry doors	McGee MS	Walk inCooler	485	GEX 21795	Verified 1 Evaporator fan
Controller to the left of Cooler door on 2ndFloor	Berlin HS	Walk in Cooler	NRM-Cooltrol CCS2	RBA 41629, 41792	Verified 2 evaporator fans
Controller to the left of Freezer door on 2nd FL	Berlin HS	Walk in Freezer	NRM-Cooltrol CCS2	RBA 40352, 51691, 44276	Verified 3 evaporator fans
Controller to the right of freezer doors on 1st FL	Berlin HS	Walk in Big Freezer	NRM-Cooltrol CCS2	RBA 44217, 77219, 44362	Verified 3 evaporator fans
Controller to the right of freezer doors on 1st FL	Berlin HS	Walk in Big Freezer	NRM-Cooltrol CCS2	RBA 51239, 50172, 50170	Verified 3 evaportor fans
					Manufacturer/National Resource management

NORESCO Project: 142312 Town of Berlin, CT
ECM No. & Name: -07: Weatherization

NORESCO WO NO.: 133589
Inspected By: Jeffery Lyskawa & Odean Barrett
Completion Date: 3/20/2019

Inspections: *Inspect weatherization for condition*

Unit Location	Bldg. Name	Units	Notes
Attic Bypass Air sealing	Peck Memorial Library	411 SF	Removed ceiling tile and verified insulation in attic
Seal from Below	Peck Memorial Library	563 SF	Verified insulation in attic
Window Casing Sealing	Peck Memorial Library	3,786	Verified insulation on 72 window in library on 2nd floor, verified 8 insulated windows in community center (lower level)
Roof-Wall Intersection Air Sealing/ Block seal	Berlin Town Hall	81 SF	Insulation verified
Roof-Wall Intersection Air Sealing/ Seal	Berlin Town Hall	1,585 SF	Verified insulation on 2nd floor room # 7
Attic Bypass Air sealing, Above dropped ceiling on 2nd floor	Timberlin Golf Course	3,400 SF	Verified that attic was insulated with foam and tape insulation
Window Casing Sealing	Willard Elementary	6,211 SF	Verified 10 windows in RM# E11, 10 windows in E13, 9 window in E4, 5 windows in music room

NORESCO Project: 142312 Town of Berlin, CT
ECM No. & Name: -08: High Effciency Condensing Boilers

NORESCO WO NO.: 133589
Inspected By: Jeffery Lyskawa & Odean Barrett
Completion Date: 3/20/2019

Inspections: *Inspect boilers for operation*

Unit Location	Bldg. Name	Unit	Model	Notes
Boiler RM on 1st Floor	McGee Middle School	5,000 MB Condensing Boiler 1	FBN5000 B1 LEADER	Boiler is in stanby mode/system temp 132deg/ outlet 116deg/inlet water 93deg/delta T 23deg
Boiler RM on 1st Floor	McGee Middle School	5,000 MB Condensing Boiler 2	FBN5000 B2 member	Boiler running/Setpoint 185deg/outlet water temp 135feg/inlet water temp 130deg/system supply temp 133deg/delta T 5deg
Boiler RM on 1st Floor	McGee Middle School	Condensing Hot Water Heater	BTH-500A300	Tank temp 121deg/operating SP 140deg/differential 20deg
Boiler RM in basement	Town Hall	3,000 MPH Condensing Boiler 1	FBN3000 B1	Boiler Running/Setpoint 185deg/outlet water temp 137deg/inlet water temp 135deg/system supply temp 137deg/system return temp 133deg/delta T 2 deg
Boiler RM in basement	Town Hall	3,000 MPH Condensing Boiler 2	FBN3000 B2	Boiler is in stanby mode/system temp 136deg/ return temp 125deg/outlet water 112deg/inlet water 91deg/delta T 21 deg

NORESCO Project: 142312 Town of Berlin, CT
ECM No. & Name: -09: New Air-Handling Units and Fan Coil Units

NORESCO WO NO.: 133589
Inspected By: Jeffery Lyskawa & Odean Barrett
Completion Date: 3/20/2019

Inspections: *Inspect units for operation*

Unit Location	Bldg. Name	Unit	Model	Notes
Basement Storage	Town Hall	AHU 1	Daikin LAH007A 3HP	No issue observed
Basement Storage	Town Hall	AHU 3	Daikin LAH005AEH 3 HP	Belt is loose and cracked, needs to be replaced (A35)
Basement Storage	Town Hall	AHU 4	Daikin LAH005A 3 HP	No issue observed
Located above the ceiling in Town Clerk RM# 19	Town Hall	AHU 5	Daikin CAH003GHAC 3 HP	Belt is loose and cracked, needs to be replaced (A25)
Located above the ceiling in Town Clerk Tax	Town Hall	AHU 6	Daikin CAH003GdAC 3 HP	Based on units location in ceiling, a thourough physical inspection could not be done
Various Locations	Town Hall	FCU 1-91		FCU 9, 10, 36/No issue observed

NORESCO Project: 142312 Town of Berlin, CT
ECM No. & Name: -10: Solar Photovoltaics

NORESCO WO NO.: 133589
Inspected By: Jeffery Lyskawa & Odean Barrett
Completion Date: 3/20/2019

Inspections: *Inspect units for operation and proper maintenance*

Unit Location	Bldg. Name	Unit	Notes
Controller located outside next to boiler room	McGee MS	PV Array	Power 145.06kw/day yield 514.252 hwh/ operating as design. Verified a total of 6 solar PV inverter on roof- operating as designed.
Controller located outside on the East side of building	Hubbard ES	PV Array	Power 115.28kw/day yield 310.136 kwh/ operating as design. Verified a total of 4 solar PV inverter on roof- operating as designed.
Controller located outside on the East side of building	Griswold ES	PV Array	Power 28.33kw/day yield 13.848 kwh/ operating as design. Verified a total of 6 solar PV inverter on roof- operating as designed.
Controller located in Electrical RM #L5 basement	Willard ES	PV Array	Solar PV is not functioning which may be due to faulty software programming based on information received. The cluster controller is unable to communicate with grid . 7 inverter located on roof.

NORESCO Project: 142312 Town of Berlin, CT
ECM No. & Name: -11: LED Street Lights

NORESCO WO NO.: 133589
Inspected By: Jeffery Lyskawa & Odean Barrett
Completion Date: 3/20/2019

Inspections: *Check Lighting stock*

Unit Location	Bldg. Name	Unit	Notes
Town Street Lights	Town Wide	LED Street Lights	Verified approximately 370 LED streets light

ECM-1: LIGHTING IMPROVEMENT AND CONTROLS

ECM-1: LIGHTING IMPROVEMENT AND CONTROLS

Attachment 1A: Hours Group Summary

TOWN OF BERLIN - BERLIN, CONNECTICUT
ECM-1: LIGHTING IMPROVEMENTS AND CONTROLS
Attachment 1A: Hours Group Summary

Hours Type	Hours / Day	Days / Year	% Contribution to Demand Charge	Hours Pre	Controls	Notes
A	24.0	365.0	100%	8,760		
EXT	12.0	365.0	0%	4,380		
EXT LOW	4.0	78.0	0%	312		Sport Lights - 4 hours/day X 3 days/week X 26 weeks/year
ACT	12.2	220.0	100%	2,680	31%	
ACT 60	7.3	220.0	100%	1,602		
CLASS	8.8	220.0	95%	1,934	22%	
CLASS 75	6.6	220.0	95%	1,453		
HALL	15.5	220.0	100%	3,410	5%	
HALL 95	15.1	220.0	100%	3,311		
KIT	9.0	220.0	95%	1,980	25%	
KIT75	6.8	220.0	95%	1,485		
MECH	4.0	220.0	60%	880	25%	
MECH75	3.0	220.0	60%	660		
OFF	6.5	220.0	90%	1,434	5%	
OFF 95	6.2	220.0	90%	1,360		
OPEN	13.5	220.0	90%	2,974	18%	
OPEN 82	11.1	220.0	90%	2,446		
PRR	2.0	220.0	80%	440	25%	
PRR75	1.5	220.0	80%	330		
RR	10.0	220.0	100%	2,200	25%	
RR75	7.5	220.0	100%	1,650		
STG	3.0	220.0	70%	660	25%	
STG75	3.0	220.0	70%	660		
TWN ART	3.0	104.0	90%	312		Art League is assumed at 3 hours a day twice a week
TWN CC	13.9	260.0	100%	3,617	9%	Community Center M-Th 10-8, F 10-5, Sat 10-4 plus hour for set up
TWN CC 91	12.7	260.0	100%	3,291		
TWN CC OFF	12.0	260.0	90%	3,118	20%	
TWN CC OFF 80	9.6	260.0	90%	2,492		
TWN CC RR	6.0	260.0	70%	1,560	25%	
TWN CC STG	3.0	260.0	70%	780	25%	
TWN CC STG 75	2.3	260.0	70%	585		
TWN FIRE	6.0	156.0	70%	936	25%	Fire Station assumed at 3 days / week, 6 hours / day
TWN GLF	14.0	274.0	90%	3,836	25%	Gold Course is open 6:30-6:30 Spring through Fall, plus an hour before and after to set up
TWN GLF 75	10.5	274.0	90%	2,877		
TWN GRG	9.0	260.0	75%	2,340	25%	Highway, Facilities, Parks M-W 8:30-4:30, Th 8:30-7, F 8:30-1 plus 30 before and after
TWN GRG 75	6.8	260.0	75%	1,755		
TWN GRG OFF	8.0	260.0	90%	2,080	25%	
TWN GRG OFF 75	6.0	260.0	90%	1,560		

TOWN OF BERLIN - BERLIN, CONNECTICUT
ECM-1: LIGHTING IMPROVEMENTS AND CONTROLS
Attachment 1A: Hours Group Summary

Hours Type	Hours / Day	Days / Year	% Contribution to Demand Charge	Hours Pre	Controls	Notes
TWN HLL	12.9	260.0	100%	3,348	10%	Main Town Hall M-W 8:30-4:30, Th 8:30-7, F 8:30-1 plus 30 before and after
TWN HLL 90	11.6	260.0	100%	3,013		Board of Ed. M-F 8-4:30
TWN HLL MCH	4.0	260.0	60%	1,040	25%	
TWN HLL MCH 75	3.0	260.0	60%	780		
TWN HLL OFF	9.0	260.0	90%	2,340	25%	
TWN HLL OFF 75	6.8	260.0	90%	1,755		
TWN HLL PRR 75	1.5	260.0	80%	390		
TWN HLL RR	7.4	260.0	100%	1,924	25%	
TWN HLL RR 75	5.6	260.0	100%	1,452		
TWN HLL STG	3.0	260.0	70%	780	25%	
TWN HLL STG 75	2.3	260.0	70%	585		
TWN LIB	14.5	286.0	100%	4,142	89%	Library M-W 8:30-4:30, Th 8:30-7, F 10-5, Sat 8:30-1 plus hour for set up
TWN LIB 11	1.6	286.0	100%	449		
TWN LIB OFF	14.6	286.0	90%	4,166	12%	
TWN LIB OFF 88	12.8	286.0	90%	3,658		
TWN LIB RR	2.9	286.0	70%	827	41%	
TWN LIB RR 59	1.7	286.0	70%	492		
TWN LIB STG	3.0	286.0	70%	858	25%	
TWN POL	22.0	365.0	100%	8,030	20%	Police M-F 8-4 (Offices)
TWN POL 80	17.6	365.0	100%	6,424		
TWN POL OFF	9.0	365.0	90%	3,285	25%	
TWN POL OFF 75	6.8	365.0	90%	2,464		
TWN POL PRR	3.0	365.0	80%	1,095	30%	
TWN POL PRR 70	2.1	365.0	80%	767		
TWN POL RR 75	4.5	365.0	100%	1,643		
TWN POL STG	5.0	365.0	70%	1,825	25%	
TWN POL STG 75	3.8	365.0	70%	1,369		
TWN PRK	4.0	78.0	70%	312	25%	Sage Park concessions 2 days / week, 4 hours / day, 3 seasons (est)
TWN PRK 75	3.0	78.0	70%	234		
TWN SNR CTR	8.5	260.0	90%	2,210	25%	Senior Center M-F 8:30-4
TWN SNR CTR 75	6.4	260.0	90%	1,658		

ECM-1: LIGHTING IMPROVEMENT AND CONTROLS

Attachment 1B: Lighting Savings Summary and Building Summary

TOWN OF BERLIN - BERLIN, CONNECTICUT
ECM-1: LIGHTING IMPROVEMENTS AND CONTROLS
Attachment 1B: Lighting Savings Summary

	Lighting Energy Savings	Lighting Controls Energy Savings	Cooling Energy Savings	Total	
				Energy Savings	Dollar Savings
Demand (kW)	175.0	5.5	12.3	192.8	$0
Energy (kWh)	621,602	15,091	26,619	663,312	$124,746
Heating Penalty (MMBtu)			(78.2)		($672)
Other					
Total Savings					**$124,074**

TOWN OF BERLIN - BERLIN, CONNECTICUT
ECM-1: LIGHTING IMPROVEMENTS AND CONTROLS
Attachment 1B: Building Summary

	Building	Sensor kWh Savings / Yr	HVAC (Heating) Interaction MMBtu/yr Savings	Totals	MMBtu Penalty	Natural Gas (CCF)
1	Griswold ES	689	(8.25)	74,461.051	(8)	(80)
2	Hubbard ES	1,599	(7.10)	48,934.561	(7)	(69)
3	McGee MS	1,115	(11.18)	95,494.230	(11)	(109)
4	Willard ES	5,150	(14.67)	104,514.743	(15)	(143)
5	Art League	0	(0.06)	661.553	(0)	(1)
6	Timberlin Golf Course	472	(4.37)	33,406.997	(4)	(43)
7	Highway, Facilities, Parks	2,681	(6.22)	69,137.621	(6)	(61)
8	Library	3,385	(10.35)	66,915.929	(10)	(101)
9	Sage Park	0	(0.09)	20,370.648	(0)	(1)
10	South Kensington Fire Dept.	0	(0.38)	9,430.509	(0)	(4)
11	Senior Center	0	(1.75)	17,160.730	(2)	(17)
12	Town Hall & Police Department	0	(13.75)	122,823.348	(14)	(134)
	Totals	**15,091**	**(78.17)**	**663,311.920**	**(78.173)**	**(762.665)**

Note: The kWh shown above are only for the light fixtures that were surveyed.

ECM-2: DIRECT DIGITAL CONTROL ENERGY MANAGEMENT SYSTEM

ECM-2: DIRECT DIGITAL CONTROL ENERGY MANAGEMENT SYSTEM

Attachment 2A: New DDC EMS Savings Calculations

TOWN OF BERLIN - BERLIN, CONNECTICUT
ECM-2: DIRECT DIGITAL CONTROL ENERGY MANAGEMENT SYSTEM
Attachment 2A: New DDC EMS Savings Calculations

Project: Berlin, CT
Facility: Town Hall Complex
NORESCO New EMS Savings Summary

ECM Name	Month Demand (kW)	Yearly Demand (kW)	Electricity (kWh)	Heating Fuel (MMBtu)
Controls - CHW Reset	0	0	6,698	0
Controls - HW Reset	0	0	0	333

NORESCO

PROJECT: Berlin CT
SUBJECT: Chilled Water Reset
FACILITY: Town Hall Complex

PROJECT No: 142312-86
DATE: 11/9/2015

	Month Demand kW	Electricity kWh
Chilled Water Reset		**3,645**

Facility Name:	Town Hall Complex	
Present Full Load (tons):	120	AA
Chiller Efficiency (kW/ton):	0.54	BB

Resetting chilled water temperature based on outside air conditions can reduce chiller electrical consumption by approximately 2% for every degree that the chilled water temperature is increased.

Conduction Losses/Gains	
1,440,000 Btuh design heat gain	EE
91 Outdoor design temp	FF
60 Outdoor balance point	GG
46,452 Btuh/F heat gain	HH

Typical Occupancy Schedule 7am to 5pm6 days/week			
12am-8am	8am-4pm	4pm-12am	Days/Week
1.0	8.0	1.0	6.0
JJ	KK	LL	MM

Outdoor Air Bin Temp F	Annual Bin Hours 12am-8am	Annual Bin Hours 8am-4pm	Annual Bin Hours 4pm-12am	Operating Bin Hours 12am-8am	Operating Bin Hours 8am-4pm	Operating Bin Hours 4pm-12am	Total Operating Bin Hours	Cooling Load (%)	Existing CHW Temp (F)	Cooling Load (tons)	Existing Electric Use kWh	Proposed CHW Temp (F)	Proposed Electric Use kWh	**Total Saved kWh**
A	B	C	D	E = BxJJxMM / 8 7	F = CxKKxMM / 8 7	G = DxLLxMM / 8 7	H = E+F+G	J = (A - GG) / (FF - GG)	K constant	L = AA x J	N = H x L x BB	P = 55 - 10xJ	Q = Nx[1 - 0.02x(P - K)]	**R = N - Q**
Hartford Int'l Airport														
107	0	0	0	0	0	0	0	152%	44	182	0	40	0	**0**
102	0	0	0	0	0	0	0	135%	44	163	0	41	0	**0**
97	0	4	0	0	3	0	3	119%	44	143	266	43	271	**-5**
92	0	34	9	0	29	1	30	103%	44	124	2,018	45	1,990	**27**
87	0	105	22	0	90	2	92	87%	44	105	5,222	46	4,983	**239**
82	4	247	105	0	212	11	223	71%	44	85	10,292	48	9,489	**803**
77	55	243	158	6	208	17	231	55%	44	66	8,228	50	7,320	**908**
72	137	208	183	15	178	20	213	39%	44	46	5,342	51	4,580	**762**
67	199	231	248	21	198	27	246	23%	44	27	3,605	53	2,974	**630**
62	306	300	310	33	257	33	323	6%	44	8	1,353	54	1,073	**280**
57	270	226	289	29	194	31	254	0%	0	0	0	0	0	**0**
52	291	186	261	31	159	28	219	0%	0	0	0	0	0	**0**
47	210	129	187	23	111	20	153	0%	0	0	0	0	0	**0**
42	282	188	155	30	161	17	208	0%	0	0	0	0	0	**0**
37	288	296	306	31	254	33	317	0%	0	0	0	0	0	**0**
32	252	222	251	27	190	27	244	0%	0	0	0	0	0	**0**
27	182	160	177	20	137	19	176	0%	0	0	0	0	0	**0**
22	231	89	177	25	76	19	120	0%	0	0	0	0	0	**0**
17	135	42	57	14	36	6	57	0%	0	0	0	0	0	**0**
12	44	7	24	5	6	3	13	0%	0	0	0	0	0	**0**
7	23	3	1	2	3	0	5	0%	0	0	0	0	0	**0**
2	11	0	0	1	0	0	1	0%	0	0	0	0	0	**0**
-3	0	0	0	0	0	0	0	0%	0	0	0	0	0	**0**
-8	0	0	0	0	0	0	0	0%	0	0	0	0	0	**0**
-13	0	0	0	0	0	0	0	0%	0	0	0	0	0	**0**
-18	0	0	0	0	0	0	0	0%	0	0	0	0	0	**0**
	2,920	2,920	2,920	313	2,503	313	3,129			948	36,325		32,681	**3,645**

NORESCO

PROJECT: Berlin CT
SUBJECT: Chilled Water Reset (Part 2)
FACILITY: Town Hall Complex

PROJECT No: 142312-86
DATE: 11/9/2015

	Month Demand kW	Electricity kWh
Chilled Water Reset (Part 2)		3,053

Facility Name:	Town Hall Complex	
Current Cooling Setpoint	74	AA
Proposed Cooling Setpoint	74	BB
Current Setforward Temp	74	CC
Proposed Setforward Temp	80	DD
Percent of Building Affected:	100%	
Envelope Losses (Btu/hr/F)	46,826	EE
Ventilation Losses (Btu/hr/F)	4,218	FF
Internal Gains (MBtu/hr)	229	GG
Cooling Efficiency (kW/ton):	0.54	HH

Resetting chilled water temperature based on outside air conditions can reduce chiller electrical consumption by approximately 2% for every degree that the chilled water temperature is increased.

Typical Occupancy Schedule 7am to 5pm6 days/week			
12am-8am	8am-4pm	4pm-12am	Days/Week
1.0	8.0	1.0	6.0
JJ	KK	LL	MM

Proposed Operating Schedule - Heating 6am to 5pm7 days/week			
12am-8am	8am-4pm	4pm-12am	Days/Week
1.0	8.0	1.0	7.0
NN	PP	QQ	RR

Outdoor Air Bin Temp F	Annual Bin Hours 12am-8am	Annual Bin Hours 8am-4pm	Annual Bin Hours 4pm-12am	Total Annual Bin Hours	Occupied Bin Hours 12am-8am	Occupied Bin Hours 8am-4pm	Occupied Bin Hours 4pm-12am	Current Occupied Bin Hours	Operating Bin Hours 12am-8am	Operating Bin Hours 8am-4pm	Operating Bin Hours 4pm-12am	Proposed Operating Bin Hours	Operating Heat Gains MBtu/hr	Setforward Heat Gains MBtu/hr	Existing Electric Use kWh/yr	Existing CHW Temp (F)	Proposed CHW Temp (F)	Proposed Electric Use kWh	Saved Electric kWh/yr
A	B	C	D	E = B+C+D	F = BxJJxMM / 8 7	G = CxKKxMM / 8 7	H = DxLLxMM / 8 7	J = F+G+H	K = BxNNxRR / 8 7	L = CxPPxRR / 8 7	M = DxQQxRR / 8 7	N = K+L+M	P = (A-BB)x(EE+FF) / 1000	Q = (A-DD)xEE / 1000	R = Jx(P+GG) + (N-J)xP + (E-N)xQ / 12/HH	S	T	U = Rx[1 - 0.02x(T - S)]	V = R - U
Hartford Int'l Airport																			
107	0	0	0	0	0	0	0	0	0	0	0	0	1,684	1,264	0	44	44	0	0
102	0	0	0	0	0	0	0	0	0	0	0	0	1,429	1,030	0	44	45	0	0
97	0	4	0	4	0	3	0	3	0	4	0	4	1,174	796	247	44	47	232	15
92	0	34	9	43	0	29	1	30	0	34	1	35	919	562	1,966	44	48	1,790	175
87	0	105	22	127	0	90	2	92	0	105	3	108	664	328	4,463	44	50	3,932	531
82	4	247	105	356	0	212	11	223	1	247	13	261	408	94	7,511	44	51	6,394	1,116
77	55	243	158	456	6	208	17	231	7	243	20	270	153	0	4,251	44	53	3,493	758
72	137	208	183	528	15	178	20	213	17	208	23	248	0	0	2,198	44	54	1,741	457
67	199	231	248	678	21	198	27	246	25	231	31	287	0	0	0	0	0	0	0
62	306	300	310	916	33	257	33	323	38	300	39	377	0	0	0	0	0	0	0
57	270	226	289	785	29	194	31	254	34	226	36	296	0	0	0	0	0	0	0
52	291	186	261	738	31	159	28	219	36	186	33	255	0	0	0	0	0	0	0
47	210	129	187	526	23	111	20	153	26	129	23	179	0	0	0	0	0	0	0
42	282	188	155	625	30	161	17	208	35	188	19	243	0	0	0	0	0	0	0
37	288	296	306	890	31	254	33	317	36	296	38	370	0	0	0	0	0	0	0
32	252	222	251	725	27	190	27	244	32	222	31	285	0	0	0	0	0	0	0
27	182	160	177	519	20	137	19	176	23	160	22	205	0	0	0	0	0	0	0
22	231	89	177	497	25	76	19	120	29	89	22	140	0	0	0	0	0	0	0
17	135	42	57	234	14	36	6	57	17	42	7	66	0	0	0	0	0	0	0
12	44	7	24	75	5	6	3	13	6	7	3	16	0	0	0	0	0	0	0
7	23	3	1	27	2	3	0	5	3	3	0	6	0	0	0	0	0	0	0
2	11	0	0	11	1	0	0	1	1	0	0	1	0	0	0	0	0	0	0
-3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2,920	2,920	2,920	8,760	313	2,503	313	3,129	365	2,920	365	3,650			20,636			17,583	3,053

Notes:
1) Manufacturers' technical literature shows a saving of approximately two percent of input energy per degree Fahrenheit (or about four percent per degree Celsius) that the chilled water temperature is raised.

NORESCO

PROJECT: Berlin CT
SUBJECT: Reset Hot Water Temp
FACILITY: Town Hall Complex

PROJECT No: 142312-86
DATE: 11/9/2015

	Month Demand kW	Electricity kWh	Heating Fuel MMBtu
Reset Hot Water Temp			**333**

Facility Name:	Town Hall Complex	
Current Heating Water Temp:	180 F	(AA)
Min. required Water Temp.	120 F	
Est. Max. Temp Loss in Piping:	2.0 F	(BB)
Est. Min. Temp Loss in Piping:	1.5	
Heating System Efficiency:	85%	(CC)

Unit Designation	Quantity	Unit Pump HP	Pump Head	Pump GPM	
Hot Water Pumps	1	5	48.6	201	
TOTAL				201	(NN)

Pump Operating Schedule continuous			
12am-8am	8am-4pm	4pm-12am	Days/Week
8.0	8.0	8.0	7.0
JJ	KK	LL	MM

Outdoor Air Bin Temp F	Annual Bin Hours 12am-8am	Annual Bin Hours 8am-4pm	Annual Bin Hours 4pm-12am	Operating Bin Hours 12am-8am	Operating Bin Hours 8am-4pm	Operating Bin Hours 4pm-12am	Total Operating Bin Hours	Existing Heat Loss MBH	Required HW Temp F	Est. Temp Loss in Circuit	Proposed Heat Loss MBH	Saved Heat Loss MBH	**Fuel Savings ccf**
A	B	C	D	E = BxJJxMM / 8 7	F = CxKKxMM / 8 7	G = DxLLxMM / 8 7	H = E+F+G	K = 500xNNxBB / 1000	L	M	N = 500xNNxM / 1000	P = K - N	**Q = P x H / 103 x CC**
Hartford Int'l Airport									*Note 1*	*Note 2*		*Note 3*	
107	0	0	0	0	0	0	0	0	0.0	0.00	0	0	**0**
102	0	0	0	0	0	0	0	0	0.0	0.00	0	0	**0**
97	0	4	0	0	4	0	4	0	0.0	0.00	0	0	**0**
92	0	34	9	0	34	9	43	0	0.0	0.00	0	0	**0**
87	0	105	22	0	105	22	127	0	0.0	0.00	0	0	**0**
82	4	247	105	4	247	105	356	0	0.0	0.00	0	0	**0**
77	55	243	158	55	243	158	456	0	0.0	0.00	0	0	**0**
72	137	208	183	137	208	183	528	0	0.0	0.00	0	0	**0**
67	199	231	248	199	231	248	678	0	0.0	0.00	0	0	**0**
62	306	300	310	306	300	310	916	0	0.0	0.00	0	0	**0**
57	270	226	289	270	226	289	785	201	120.0	1.50	151	50	**464**
52	291	186	261	291	186	261	738	201	125.5	1.50	151	50	**436**
47	210	129	187	210	129	187	526	201	130.9	1.50	151	50	**311**
42	282	188	155	282	188	155	625	201	136.4	1.50	151	50	**369**
37	288	296	306	288	296	306	890	201	141.8	1.50	151	50	**526**
32	252	222	251	252	222	251	725	201	147.3	1.50	151	50	**429**
27	182	160	177	182	160	177	519	201	152.7	1.50	151	50	**307**
22	231	89	177	231	89	177	497	201	158.2	1.50	151	50	**294**
17	135	42	57	135	42	57	234	201	163.6	1.50	151	50	**138**
12	44	7	24	44	7	24	75	201	169.1	1.50	151	50	**44**
7	23	3	1	23	3	1	27	201	174.5	1.50	151	50	**16**
2	11	0	0	11	0	0	11	201	180.0	2.00	201	0	**0**
-3	0	0	0	0	0	0	0	201	180.0	1.50	151	50	**0**
-8	0	0	0	0	0	0	0	201	180.0	1.50	151	50	**0**
-13	0	0	0	0	0	0	0	201	180.0	1.50	151	50	**0**
-18	0	0	0	0	0	0	0	201	180.0	1.50	151	50	**0**
	2,920	2,920	2,920	2,920	2,920	2,920	8,760						**3,335**

Notes:

1) Estimated hot water reset schedule: 120F water at 57F outdoor, 180F water at 2F outdoor.
2) Estimate 2-degree loss at 180F water temperature, 1.5-degree loss at 120F water temperature.

ECM-3: VARIABLE FREQUENCY DRIVES AND PREMIUM EFFICIENCY MOTORS

ECM-3: VARIABLE FREQUENCY DRIVES AND PREMIUM EFFICIENCY MOTORS

Attachment 3A: PE Motor & VFDs Savings Calculations

NORESCO

PROJECT: Berlin CT
SUBJECT: High Efficiency Motors
FACILITY: Various

PROJECT No: 142312-86
DATE: 11/9/2015

	Month Demand kW	Electricity kWh	Heating Fuel MMBtu
High Efficiency Motors	**4.393**	**13,790**	

Building/Motor Designation		Motor Description (HP/Encl/RPM)	Total Operating Hours/yr	Motor Load %	Existing Motor HP	Proposed Motor HP	Proposed Load %	Existing Efficiency %	Premium Efficiency %	Existing Full-Load RPM	Hi Eff. Full-Load RPM
			A	B	D	E	F = BxD/E	G	H	J	K
			Note 1	*Note 2*				*Note 3*	*Note 4*	*Note 3*	*Note 4*
Town Hall	HWP-1	2/ODP/1800	2,826	**70%**	2.0	2.0	70%	78.5%	86.6%	1,730	1,747
Town Hall	HWP-2	2/ODP/1800	2,826	**70%**	2.0	2.0	70%	78.5%	86.6%	1,730	1,747
Town Hall	HWP-3	5/ODP/1800	4,380	**70%**	5.0	5.0	70%	87.5%	90.2%	1,730	1,730
Town Hall	HWP-4	5/ODP/1800	4,380	**70%**	5.0	5.0	70%	87.5%	90.2%	1,730	1,730
Library	AHU-1 SAF	7.5/ODP/1800	3,387	**70%**	7.5	7.5	70%	78.5%	92.2%	1,755	1,755
Library	AHU-1 RAF	3/ODP/1800	3,387	**70%**	3.0	3.0	70%	82.5%	90.2%	1,730	1,730
Library	AHU-2 SAF	7.5/ODP/1800	3,387	**70%**	7.5	7.5	70%	78.5%	92.2%	1,755	1,755
Library	AHU-2 RAF	3/ODP/1800	3,387	**70%**	3.0	3.0	70%	78.5%	90.2%	1,730	1,730
Library	HWP-1	2/ODP/1800	2,434	**70%**	2.0	2.0	70%	82.5%	86.6%	1,730	1,747
Library	HWP-2	2/ODP/1800	2,434	**70%**	2.0	2.0	70%	82.5%	86.6%	1,730	1,747

Building/Motor Designation		% Load Increase from RPM	Existing Motor kW	Existing Motor kWh	Proposed Demand kW/mo	Proposed Motor kWh	Saved Demand kW/mo	Saved Usage kWh/yr
		M = $(K/J)^3$-1 *Note 5*	N = 0.746xDxB/G	P = NxA	Q = $\frac{0.746xExFx(1+M)}{H}$	R = QxA	S = N - Q	T = SxA
Town Hall	HWP-1	3.0%	1.33	3,760	1.24	3,510	0.09	250
Town Hall	HWP-2	3.0%	1.33	3,760	1.24	3,510	0.09	250
Town Hall	HWP-3	0.0%	2.98	13,070	2.89	12,679	0.09	391
Town Hall	HWP-4	0.0%	2.98	13,070	2.89	12,679	0.09	391
Library	AHU-1 SAF	0.0%	4.99	16,898	4.25	14,387	0.74	2,511
Library	AHU-1 RAF	0.0%	1.90	6,432	1.74	5,883	0.16	549
Library	AHU-2 SAF	0.0%	4.99	16,898	4.25	14,387	0.74	2,511
Library	AHU-2 RAF	0.0%	2.00	6,759	1.74	5,883	0.26	877
Library	HWP-1	3.0%	1.27	3,081	1.24	3,022	0.02	58
Library	HWP-2	3.0%	1.27	3,081	1.24	3,022	0.02	58

Notes:

1) Hours based on EMS sequences of operation or discussions with facilities personnel
2) Unless measured in the field, motor load factors are estimated at 70%. Motors are typically sized for 70-80% of full load.
3) Existing efficiency and RPM is often listed on the motor nameplate. Efficiency can also be calculated based on rated voltage, amperes and PF and metered kW. If nameplate values are unavailable, efficiencies and speeds are estimated based on previous observations and industry standards. Estimated values are dislayed in boldface.
4) Premium efficiency and RPM are based on Baldor Super-E. http://www.baldor.com/support/Literature/Load.ashx/BR457?LitNumber=BR457
5) Premium efficiency motors typically run slightly faster than standard motors.

NORESCO

PROJECT: Berlin CT
SUBJECT: Fan VFD
FACILITY: Peck Library

PROJECT NO: 142312-86
DATE: 11/9/2015

	Month Demand kW	Electricity kWh
Fan VFD		18,192

Unit	Quantity	Motor HP	Load Factor	Efficiency	Total kW
AHU-1 SAF	1	7 1/2	0.6	92.2%	3.6
AHU-1 RAF	1	3	0.6	90.2%	1.5
AHU-2 SAF	1	7 1/2	0.6	92.2%	3.6
AHU-2 RAF	1	3	0.6	90.2%	1.5
Totals	4	21			10.3

AA

Minimum Fan System Flow: 70%

F (CC)

	Cooling (F)	Heating (F)
Outdoor Temp	91	2
Balance Point	60	60
Deadband	5	5

Use HVAC operating Bins? Y/N Y

Outside Air Bin Temp (F)	Annual Bin Hours (hr/yr)	Annual Operating Hours (hr/yr)	Percent HVAC Load (%)	Required Fan Load (%)	Existing Fan Energy (kWh)	Proposed Fan Energy (kWh)	Fan Energy Savings (kWh)
A	B	C	D = Heating load + Cooling load	E =	F = AAxC	G = AAxCxE^3/0.98	H = F - G
See Note 1	See Note 1						
102	4	0	100%	100%	0	0	0
97	43	2	100%	100%	16	16	0
92	127	16	100%	100%	168	173	-5
87	356	48	87%	87%	495	371	124
82	456	135	71%	71%	1,388	650	738
77	528	173	55%	70%	1,778	807	971
72	678	201	39%	70%	2,058	934	1,124
67	916	258	70%	70%	2,643	1,200	1,443
62	785	348	70%	70%	3,571	1,621	1,950
57	738	298	70%	70%	3,060	1,389	1,671
52	526	280	70%	70%	2,877	1,306	1,571
47	625	200	70%	70%	2,051	931	1,120
42	890	238	70%	70%	2,437	1,106	1,331
37	725	338	70%	70%	3,470	1,575	1,895
32	519	276	70%	70%	2,826	1,283	1,544
27	497	197	70%	70%	2,023	918	1,105
22	234	189	70%	70%	1,938	879	1,058
17	75	89	74%	74%	912	473	440
12	27	29	83%	83%	292	195	97
7	11	10	91%	91%	105	88	17
2	0	4	100%	100%	43	44	-1
-3	0	0	100%	100%	0	0	0
-8	0	0	100%	100%	0	0	0
-13	0	0	100%	100%	0	0	0
	8,760	3,329			34,151	15,960	18,192

Notes:

1) Weather Data from NOAA for Hartford Int'l Airport

NORESCO

PROJECT: BERLIN CT
SUBJECT: CDWP VFD SAVINGS ANALYSIS
FACILITY: TOWN HALL COMPLEX

PROJECT No: 142312-86
DATE: 11/9/2015

VSD Calculator for Pumps

Inputs

Nameplate Horsepower	7.5 hp	Annual Operating Hours	3893	
Nameplate Efficiency	91 %	Type of Flow Control	Throttling Valve	
Motor Load at Pump Design GPM	90 %	Cost of Electricity		$/kWh

Duty Cycle: High Pump Loading

Percent of Capacity (gpm)	Percent of Time at this Capacity
10 %	0 %
20 %	0 %
30 %	0 %
40 %	0 %
50 %	20 %
60 %	0 %
75 %	60 %
80 %	0 %
90 %	20 %
100 %	0 %

Outputs

Energy and Cost savings

Current Annual Energy use	19,662	kWh/yr
VSD Annual Energy Use	10,910	kWh/yr
Annual Energy Savings	8,752	kWh/yr
Annual Cost Savings	0	$/yr

References and Equations

References:

- For the energy savings analysis, this tool used power curves developed from data obtained by measuring the operating characteristics of various pumps and from information provided in "Flow Control", a Westinghouse publication, Bulliten B-851, F/86/Rev-CMS 8121. The curves are representative, not precise. Final economic analysis should be based on actual power (kW) measurements of the pumping system.

Constants:

Conversion Constant (kW/hp) = 0.746
Polynomial Coefficients A1, A2, A3 and A4:

Type of Flow Contorl	A1	A2	A3	A4
1	55.21240	0.63700	-0.00190	0.00000
2	16.39683	-0.05647	0.01237	-0.00003
3	13.51137	0.34467	0.01269	-0.00007
4	102.00000	0.00000	0.00000	0.00000
VSD	27.44751	-1.00853	0.01762	0.00000

Equations:

Power at Design GPM = Nameplate Horsepower × Conversion Constant (kW/hp) × Motor Load at Design GPM / Nameplate Efficiency

Computed for each capacity level:
Percent of Design kW = A1 + (A2 × Capacity) + (A3 × (Capacity^2)) + (A4 × (Capacity^3))
Percent of Design kW for VSD = A1 + (A2 × Capacity) + (A3 × (Capacity^2)) + (A4 × (Capacity^3))

Current Power (kW) = Percent of Design kW × (Power at Design CFM / 100)
VSD Power (kW) = Percent of Design kW for VSD × (Power at Design CFM / 100)

Current Energy (kWh) = Current Power (kW) × (Percent of time at this Capacity / 100) × Operating Hours
VSD Energy (kWh) = VSD Power (kW) × (Percent of time at this Capacity / 100) × Operating Hours

Current Annual Energy Use = sum of all Current Energy (kWh)
VSD Annual Energy Use = sum of all VSD Energy (kWh)
Annual Energy Savings = Current Annual Energy Use - VSD Annual Energy Use
Annual Cost Savings = Annual Energy Savings × Cost of Electricity

NORESCO

PROJECT: BERLIN CT
SUBJECT: CHWP VFD SAVINGS ANALYSIS
FACILITY: TOWN HALL COMPLEX

PROJECT No: 142312-86
DATE: 11/9/2015

VSD Calculator for Pumps

Inputs

Nameplate Horsepower	15	hp	Annual Operating Hours	3893	
Nameplate Efficiency	93	%	Type of Flow Control	Throttling Valve	
Motor Load at Pump Design GPM	90	%	Cost of Electricity		$/kWh

Duty Cycle: High Pump Loading

Percent of Capacity (gpm)		Percent of Time at this Capacity	
10	%	0	%
20	%	0	%
30	%	0	%
40	%	0	%
50	%	20	%
60	%	0	%
75	%	60	%
80	%	0	%

Outputs

Energy and Cost savings

Current Annual Energy use	38,478	kWh/yr
VSD Annual Energy Use	21,351	kWh/yr
Annual Energy Savings	17,127	kWh/yr
Annual Cost Savings	0	$/yr

References and Equations

References:

- For the energy savings analysis, this tool used power curves developed from data obtained by measuring the operating characteristics of various pumps and from information provided in "Flow Control", a Westinghouse publication, Bulliten B-851, F/86/Rev-CMS 8121. The curves are representative, not precise. Final economic analysis should be based on actual power (kW) measurements of the pumping system.

Constants:

Conversion Constant (kW/hp) = 0.746
Polynomial Coefficients A1, A2, A3 and A4:

Type of Flow Contorl	A1	A2	A3	A4
1	55.21240	0.63700	-0.00190	0.00000
2	16.39683	-0.05647	0.01237	-0.00003
3	13.51137	0.34467	0.01269	-0.00007
4	102.00000	0.00000	0.00000	0.00000
VSD	27.44751	-1.00853	0.01762	0.00000

Equations:

Power at Design GPM = Nameplate Horsepower × Conversion Constant (kW/hp) × Motor Load at Design GPM / Nameplate Efficiency

Computed for each capacity level:
Percent of Design kW = A1 + (A2 × Capacity) + (A3 × (Capacity^2)) + (A4 × (Capacity^3))
Percent of Design kW for VSD = A1 + (A2 × Capacity) + (A3 × (Capacity^2)) + (A4 × (Capacity^3))

Current Power (kW) = Percent of Design kW × (Power at Design CFM / 100)
VSD Power (kW) = Percent of Design kW for VSD × (Power at Design CFM / 100)

Current Energy (kWh) = Current Power (kW) × (Percent of time at this Capacity / 100) × Operating Hours
VSD Energy (kWh) = VSD Power (kW) × (Percent of time at this Capacity / 100) × Operating Hours

Current Annual Energy Use = sum of all Current Energy (kWh)
VSD Annual Energy Use = sum of all VSD Energy (kWh)
Annual Energy Savings = Current Annual Energy Use – VSD Annual Energy Use
Annual Cost Savings = Annual Energy Savings × Cost of Electricity

Acknowledgements
This tool was created by the Bonneville Power Administration (BPA). For more information on BPA, visit their website at http://www.bpa.gov/energy/n/industrial/audit/.

ECM-4: COOLER CONTROLS

ECM-4: COOLER CONTROLS

Attachment 4A: Walk-In Cooler Upgrades Savings Calculations

NORESCO

PROJECT: **Town of Berlin, CT** PROJECT No: 142312

SUBJECT: **McGee MS Walk-in Cooler Controls & PE Motors** DATE: 11/9/2015

Evaporator Fan ECM Motor Upgrade

Cooler ID	Number of Evaporator Fan Motors	Amps	Volts	Phase	Power Factor	Total Power (W)
	A	B	C	D	E	F= AxBxCxE
Food Cooler	1	2.7	115	1	0.65	202
Food Freezer	2	1.1	230	1	0.65	329
					Total kW demand for evaporator fan set	0.531

Savings due to ECM Motor Upgrade	Number of Evaporator Fan Motors Replaced	Existing Motor Total Power (W)	Proposed Motor Load Reduction	Existing Energy Use (kWh)	Proposed Energy Use (kWh)	Energy Savings (kWh)
		F	G *note 1*	H= Fx8760 / 1000	I= FxGx8760 / 1000	J= J - I
Food Cooler	0	202	0%	1,768	1,768	0
Food Freezer	2	329	65%	2,881	1,873	1,008
TOTALS				4,649	3,641	**1,008**

Savings Due to Reduced Heat Load from ECM Motors	Saved Energy Use (kWh)	Energy Conversion	Cooling Efficency (kW/Ton)	Energy Savings (kWh)
	J	K 3413 BTU/kW / 12000 BTU/Ton	L	M= JxKxL
Evaporator Fan Set	1,008	0.28	1.6	**452**

ECM Motor Replacement Total Savings	**1,460 kWh**

TOWN OF BERLIN - BERLIN, CONNECTICUT
ECM-4: COOLER CONTROLS
Attachment 4A: Walk-In Cooler Upgrades Savings Calculations

Project:	Town of Berlin, Connecticut
Job Number:	142312
ECM Description:	High School Walk-In Cooler Controls & PE Motors

ENERGY SAVINGS ANALYSIS

Savings Links	Existing	Proposed	Savings
Fan Energy (kWh/yr)	11,787	4,558	7,228
Cooling Energy (kWh/yr)	0	0	1,848
Door Heaters Energy (kWh/yr)	10,092	2,657	7,435
			16,511

TOWN OF BERLIN - BERLIN, CONNECTICUT
ECM-4: COOLER CONTROLS
Attachment 4A: Walk-In Cooler Upgrades Savings Calculations

Project:	Town of Berlin, Connecticut
Job Number:	142312
ECM Description:	McGee MS Walk-IN Cooler Controls & PE Motors

ENERGY SAVINGS ANALYSIS

Savings Links	Existing	Proposed	Savings
Fan Energy (kWh/yr)	4,649	2,166	2,483
Cooling Energy (kWh/yr)	0	0	452
Door Heaters Energy (kWh/yr)	2,102	732	1,370
			4,305

NORESCO

PROJECT: **Town of Berlin, CT** PROJECT No: 142312

SUBJECT: **McGee MS Walk-in Cooler Controls & PE Motors** DATE: 11/9/2015

Evaporator Fan Cycling

Analysis of Cycling Evaporator Fan Sets	Hours
Compressor Avg. Run Time:	46%
Compressor Run Hours:	4,030
Temp & Time Delay Hours:	1,007
Defrost Run Hours:	175
Total Evap Fan Cycle Run Time:	5,212

Savings Due to Cycling Evaporator Fans	ECM Motor Total Power (W)	Existing Run Hours	Proposed Run Hours	Existing Energy Use (kWh)	Proposed Energy Use (kWh)	Energy Savings (kWh)
	A *Note 1*	B	C	D = AxB / 1000	E = AxC / 1000	F = D - E
Food Cooler	202	8,760	5,212	1,768	1,052	716
Food Freezer	214	8,760	5,212	1,873	1,114	759
TOTALS				3,641	2,166	**1,475**

Evaporator Fan Cycling Total Savings	**1,475 kWh**

Notes:

1) ECM Motor Total Power taken from proposed energy demand on Evaporator Fan Motor Upgrade

NORESCO

PROJECT: **Town of Berlin, CT** PROJECT No: 142312

SUBJECT: **McGee MS Walk-in Cooler Controls & PE Motors** DATE: 11/9/2015

Door Heater Humidistat Controls

Savings Due to Installation of Door Heater Controls	Volts	Amps	Existing Total Watts (W)	Existing Energy Use (kWh)	Estimated Proposed Run Hours	Estimated Average Heater Power %	Proposed Energy Use (kWh)	Energy Savings kWh
	A	B	C = AxB	D = Cx8760 / 1000	E *Note 1*	F *Note 2*	G = CxExF / 1000	H= D-G
Food Cooler	120	2.0	240	2,102	4,694	65%	732	1,370
				2,102			**732**	**1,370**

Notes:

1) Estimated run hours of door heaters by operating heaters to maintain 5ºF above dew point.
2) Estimated average power level of door heaters when operating to maintain 5^0F above dew point.
   Based on Select Energy Services, Inc. "Analysis of Cooler Control Energy Conservation Measures" dated March 2004.

NORESCO

PROJECT: **Town of Berlin, CT** PROJECT No: 142312

SUBJECT: **High School Walk-in Cooler Controls & PE Motors** DATE: 11/9/2015

Evaporator Fan ECM Motor Upgrade

Cooler ID	Number of Evaporator Fan Motors	Amps	Volts	Phase	Power Factor	Total Power (W)
	A	B	C	D	E	F= AxBxCxE
Food Cooler A	2	0.9	115	1	0.65	135
Food Freezer B	3	0.9	230	1	0.65	404
Food Freezer C	6	0.9	230	1	0.65	807
					Total kW demand for evaporator fan set	1.346

Savings due to ECM Motor Upgrade	Number of Evaporator Fan Motors Replaced	Existing Motor Total Power (W)	Proposed Motor Load Reduction	Existing Energy Use (kWh)	Proposed Energy Use (kWh)	Energy Savings (kWh)
		F	G *note 1*	H= Fx8760 / 1000	I= FxGx8760 / 1000	J= J - I
Food Cooler A	2	135	65%	1,179	766	413
Food Freezer B	3	404	65%	3,536	2,298	1,238
Food Freezer C	6	807	65%	7,072	4,597	2,475
TOTALS				11,787	7,661	4,125

Savings Due to Reduced Heat Load from ECM Motors	Saved Energy Use (kWh)	Energy Conversion	Cooling Efficency (kW/Ton)	Energy Savings (kWh)
	J	K 3413 BTU/kW / 12000 BTU/Ton	L	M= JxKxL
Evaporator Fan Set	4,125	0.28	1.6	1,848

ECM Motor Replacement Total Savings	**5,973 kWh**

NORESCO

PROJECT: **Town of Berlin, CT** PROJECT No: 142312

SUBJECT: **High School Walk-in Cooler Controls & PE Motors** DATE: 11/9/2015

Evaporator Fan Cycling

Analysis of Cycling Evaporator Fan Sets	Hours
Compressor Avg. Run Time:	46%
Compressor Run Hours:	4,030
Temp & Time Delay Hours:	1,007
Defrost Run Hours:	175
Total Evap Fan Cycle Run Time:	5,212

Savings Due to Cycling Evaporator Fans	ECM Motor Total Power (W)	Existing Run Hours	Proposed Run Hours	Existing Energy Use (kWh)	Proposed Energy Use (kWh)	Energy Savings (kWh)
	A *Note 1*	B	C	D = AxB / 1000	E = AxC / 1000	F = D - E
Food Cooler A	87	8,760	5,212	766	456	310
Food Freezer B	262	8,760	5,212	2,298	1,367	931
Food Freezer C	525	8,760	5,212	4,597	2,735	1,862
TOTALS				7,661	4,558	**3,103**

Evaporator Fan Cycling Total Savings	**3,103 kWh**

Notes:

1) ECM Motor Total Power taken from proposed energy demand on Evaporator Fan Motor Upgrade

NORESCO

PROJECT: **Town of Berlin, CT** PROJECT No: 142312

SUBJECT: **High School Walk-in Cooler Controls & PE Motors** DATE: 11/9/2015

Door Heater Humidistat Controls

Savings Due to Installation of Door Heater Controls	Volts	Amps	Existing Total Watts (W)	Existing Energy Use (kWh)	Estimated Proposed Run Hours	Estimated Average Heater Power %	Proposed Energy Use (kWh)	Energy Savings kWh
	A	B	C = AxB	D = Cx8760 / 1000	E *Note 1*	F *Note 2*	G = CxExF / 1000	H= D-G
Food Cooler A	120	3.2	384	3,364	1,256	65%	313	3,050
Food Freezer B	120	3.2	384	3,364	4,694	65%	1,172	2,192
Food Freezer C	120	3.2	384	3,364	4,694	65%	1,172	2,192
				10,092			**2,657**	**7,435**

Notes:

1) Estimated run hours of door heaters by operating heaters to maintain 5ºF above dew point.
2) Estimated average power level of door heaters when operating to maintain 5^0F above dew point.
   Based on Select Energy Services, Inc. "Analysis of Cooler Control Energy Conservation Measures" dated March 2004.

ECM-7: BUILDING WEATHERIZATION

ECM-7: BUILDING WEATHERIZATION

Attachment 7A: Weatherization Savings Calculations

NORESCO

PROJECT: Town of Berlin, CT
SUBJECT: Building Weatherization
FACILITY: Willard Elementary School

PROJECT NO: 142312
DATE: 10/5/2015

Savings	Electricity kWh	Heating Fuel MMBtu
Building Weatherization	2,167	96.8

FACILITY INFORMATION

LOCATION: Bradley Int'l Airport (Weather data from NOAA for Bradley Int'l Airport)

Design Data	Heating	Cooling	
Maintained Indoor Temp (F):	72	72	
Outdoor Balance Temp (F):	55	60	
Annual Degree-Hrs (F-hr/yr):	92,171	33,451	
HVAC System Efficiency:	70%	1.33	kW/ton

Building Coefficients		
Building Type	k	n
1	110.0	0.60
2	80.0	0.65
3	60.0	0.70
4	23.0	0.65

Building Type
4

WEATHERIZATION SAVINGS - INFILTRATION

				HEATING				COOLING - only sensible				
Description	Total Crack Length (ft)	Average Crack Width (in)	Total Crack Area (SF)	Average Wind Speed (MPH)	Wind Pressure Differential (Pa)	Infiltration Flow (CFM)	Fuel Heating Savings (MBtu/yr)	Average Wind Speed (MPH)	Wind Pressure Differential (Pa)	Infiltration Flow (CFM)	Cooling Savings (MBtu/yr)	Cooling Savings (kWh/yr)
Buck Frame Sealing	C = AxB/12	D	E = CxD/12	F *Note 1*	G = (1.6*F)^2x.0464 / 2	H = kxExG^n *Note 3*	J = 1.1*H*HDH/Eff *Note 3*	L = *Note 2*	M = (1.6*L)^2xp / 2	O = kxExM^n *Note 3*	P = 1.1*O*CDH *Note 3*	Q = P*Eff/12
Seal	2,421	1/20	10.088	9.2	5.09	668	96,775	7.7	3.57	530	19,507	2,167
TOTALS							96,775					2,167

Notes:

1) Average heating season wind speed is taken from NOAA weather data for Bradley Int'l Airport and is based on November through April.
2) Average cooling season wind speed is taken from NOAA weather data for Bradley Int'l Airport and is based on May through October.
3) Formula and building types from Energy Canada Study 128 (EC128) (Divided by 1000 to convert Btus to MBtus)

Outside Air Minimum Temperature	Outdoor Air Maximum Temperature	Outdoor Air Average Temperature	Annual Bin Hours for Bradley Int'l Airport				Annual Heating Degree-hrs	Annual Cooling Degree-hrs
			12am-8am	8am-4pm	4pm-12am	TOTAL		
105	109	107	0	0	0	0	0	0
100	104	102	0	0	0	0	0	0
95	99	97	0	4	0	4	0	148
90	94	92	0	34	9	43	0	1,376
85	89	87	0	105	22	127	0	3,429
80	84	82	4	247	105	356	0	7,832
75	79	77	55	243	158	456	0	7,752
70	74	72	137	208	183	528	0	6,336
65	69	67	199	231	248	678	0	4,746
60	64	62	306	300	310	916	0	1,832
55	59	57	270	226	289	785	0	0
50	54	52	291	186	261	738	2,214	0
45	49	47	210	129	187	526	4,208	0
40	44	42	282	188	155	625	8,125	0
35	39	37	288	296	306	890	16,020	0
30	34	32	252	222	251	725	16,675	0
25	29	27	182	160	177	519	14,532	0
20	24	22	231	89	177	497	16,401	0
15	19	17	135	42	57	234	8,892	0
10	14	12	44	7	24	75	3,225	0
5	9	7	23	3	1	27	1,296	0
0	4	2	11	0	0	11	583	0
-5	-1	-3	0	0	0	0	0	0
-10	-6	-8	0	0	0	0	0	0
-15	-11	-13	0	0	0	0	0	0
-20	-16	-18	0	0	0	0	0	0
-25	-21	-23	0	0	0	0	0	0
-30	-26					0	0	0
			2,920	2,920	2,920	8,760	92,171	33,451

NORESCO

PROJECT: Town of Berlin, CT
SUBJECT: Building Weatherization
FACILITY: Peck Memorial Library

PROJECT NO: 142312
DATE: 10/5/2015

Savings	Electricity kWh	Heating Fuel MMBtu
Building Weatherization	953	77

FACILITY INFORMATION

LOCATION: Bradley Int'l Airport (Weather data from NOAA for Bradley Int'l Airport)

Design Data	Heating	Cooling	
Maintained Indoor Temp (F):	72	72	
Outdoor Balance Temp (F):	52	65	
Annual Degree-Hrs (F-hr/yr):	77,570	20,659	
HVAC System Efficiency:	70%	1.00	kW/ton

Building Coefficients		
Building Type	k	n
1	110.0	0.60
2	80.0	0.65
3	60.0	0.70
4	23.0	0.65

Building Type
4

WEATHERIZATION SAVINGS - INFILTRATION

				HEATING				COOLING - only sensible				
Description	Total Crack Length (ft)	Average Crack Width (in)	Total Crack Area (SF)	Average Wind Speed (MPH)	Wind Pressure Differential (Pa)	Infiltration Flow (CFM)	Fuel Heating Savings (MBtu/yr)	Average Wind Speed (MPH)	Wind Pressure Differential (Pa)	Infiltration Flow (CFM)	Cooling Savings (MBtu/yr)	Cooling Savings (kWh/yr)
	C = AxB/12	D	E = CxD/12	F *Note 1*	G = (1.6*F)^2x.0464 / 2	H = kxExG^n *Note 3*	J = 1.1*H*HDH/Eff *Note 3*	L = *Note 2*	M = (1.6*L)^2xp / 2	O = kxExM^n *Note 3*	P = 1.1*O*CDH *Note 3*	Q = P*Eff/12
Attic Bypass Sealing	365	1/5	6.083	9.2	5.09	403	49,116	7.7	3.57	320	7,265	605
Attic Bypass Sealing	293	1/7	3.488	9.2	5.09	231	28,162	7.7	3.57	183	4,166	347

Notes:

1) Average heating season wind speed is taken from NOAA weather data for Bradley Int'l Airport and is based on November through April.
2) Average cooling season wind speed is taken from NOAA weather data for Bradley Int'l Airport and is based on May through October.
3) Formula and building types from Energy Canada Study 128 (EC128) (Divided by 1000 to convert Btus to MBtus)

Outside Air Minimum Temperature	Outdoor Air Maximum Temperature	Outdoor Air Average Temperature	Annual Bin Hours for Bradley Int'l Airport				Annual Heating Degree-hrs	Annual Cooling Degree-hrs
			12am-8am	8am-4pm	4pm-12am	TOTAL		
105	109	107	0	0	0	0	0	0
100	104	102	0	0	0	0	0	0
95	99	97	0	4	0	4	0	128
90	94	92	0	34	9	43	0	1,161
85	89	87	0	105	22	127	0	2,794
80	84	82	4	247	105	356	0	6,052
75	79	77	55	243	158	456	0	5,472
70	74	72	137	208	183	528	0	3,696
65	69	67	199	231	248	678	0	1,356
60	64	62	306	300	310	916	0	0
55	59	57	270	226	289	785	0	0
50	54	52	291	186	261	738	0	0
45	49	47	210	129	187	526	2,630	0
40	44	42	282	188	155	625	6,250	0
35	39	37	288	296	306	890	13,350	0
30	34	32	252	222	251	725	14,500	0
25	29	27	182	160	177	519	12,975	0
20	24	22	231	89	177	497	14,910	0
15	19	17	135	42	57	234	8,190	0
10	14	12	44	7	24	75	3,000	0
5	9	7	23	3	1	27	1,215	0
0	4	2	11	0	0	11	550	0
-5	-1	-3	0	0	0	0	0	0
-10	-6	-8	0	0	0	0	0	0
-15	-11	-13	0	0	0	0	0	0
-20	-16	-18	0	0	0	0	0	0
-25	-21	-23	0	0	0	0	0	0
-30	-26					0	0	0
			2,920	2,920	2,920	8,760	77,570	20,659

NORESCO

PROJECT: Town of Berlin, CT
SUBJECT: Building Weatherization
FACILITY: Peck Memorial Library

PROJECT NO: 142312
DATE: 10/5/2015

Savings	Electricity kWh	Heating Fuel MMBtu
Building Weatherization	281	23

FACILITY INFORMATION

LOCATION: Bradley Int'l Airport (Weather data from NOAA for Bradley Int'l Airport)

Design Data	Heating	Cooling	
Maintained Indoor Temp (F):	72	72	
Outdoor Balance Temp (F):	52	65	
Annual Degree-Hrs (F-hr/yr):	77,570	20,659	
HVAC System Efficiency:	70%	1.00	kW/ton

Building Coefficients		
Building Type	k	n
1	110.0	0.60
2	80.0	0.65
3	60.0	0.70
4	23.0	0.65

Building Type
4

WEATHERIZATION SAVINGS - INFILTRATION

Description	Total Crack Length (ft)	Average Crack Width (in)	Total Crack Area (SF)	HEATING: Average Wind Speed (MPH)	HEATING: Wind Pressure Differential (Pa)	HEATING: Infiltration Flow (CFM)	HEATING: Fuel Heating Savings (MBtu/yr)	COOLING - only sensible: Average Wind Speed (MPH)	COOLING: Wind Pressure Differential (Pa)	COOLING: Infiltration Flow (CFM)	COOLING: Cooling Savings (MBtu/yr)	COOLING: Cooling Savings (kWh/yr)
	C = AxB/12	D	E = CxD/12	F *Note 1*	G = (1.6*F)^2x.0464 / 2	H = kxExG^n *Note 3*	J = 1.1*H*HDH/Eff *Note 3*	L = *Note 2*	M = (1.6*L)^2xp / 2	O = kxExM^n *Note 3*	P = 1.1*O*CDH *Note 3*	Q = P*Eff/12
Window Casing Sealing	3,387	1/100	2.823	9.2	5.09	187	22,788	7.7	3.57	148	3,371	281
TOTALS							22,788					281

1) Average heating season wind speed is taken from NOAA weather data for Bradley Int'l Airport and is based on November through April.
2) Average cooling season wind speed is taken from NOAA weather data for Bradley Int'l Airport and is based on May through October.
3) Formula and building types from Energy Canada Study 128 (EC128) (Divided by 1000 to convert Btus to MBtus)

Outside Air Minimum Temperature	Outdoor Air Maximum Temperature	Outdoor Air Average Temperature	Annual Bin Hours for Bradley Int'l Airport: 12am-8am	8am-4pm	4pm-12am	TOTAL	Annual Heating Degree-hrs	Annual Cooling Degree-hrs
105	109	107	0	0	0	0	0	0
100	104	102	0	0	0	0	0	0
95	99	97	0	4	0	4	0	128
90	94	92	0	34	9	43	0	1,161
85	89	87	0	105	22	127	0	2,794
80	84	82	4	247	105	356	0	6,052
75	79	77	55	243	158	456	0	5,472
70	74	72	137	208	183	528	0	3,696
65	69	67	199	231	248	678	0	1,356
60	64	62	306	300	310	916	0	0
55	59	57	270	226	289	785	0	0
50	54	52	291	186	261	738	0	0
45	49	47	210	129	187	526	2,630	0
40	44	42	282	188	155	625	6,250	0
35	39	37	288	296	306	890	13,350	0
30	34	32	252	222	251	725	14,500	0
25	29	27	182	160	177	519	12,975	0
20	24	22	231	89	177	497	14,910	0
15	19	17	135	42	57	234	8,190	0
10	14	12	44	7	24	75	3,000	0
5	9	7	23	3	1	27	1,215	0
0	4	2	11	0	0	11	550	0
-5	-1	-3	0	0	0	0	0	0
-10	-6	-8	0	0	0	0	0	0
-15	-11	-13	0	0	0	0	0	0
-20	-16	-18	0	0	0	0	0	0
-25	-21	-23	0	0	0	0	0	0
-30	-26					0	0	0
			2,920	2,920	2,920	8,760	77,570	20,659

NORESCO

PROJECT: Town of Berlin, CT
SUBJECT: Building Weatherization
FACILITY: Timberlin Golf Course

PROJECT NO: 142312
DATE: 10/5/2015

Savings	Electricity kWh	Heating Fuel MMBtu
Building Weatherization	264	17.9

FACILITY INFORMATION

LOCATION: Bradley Int'l Airport (Weather data from NOAA for Bradley Int'l Airport)

Design Data	Heating	Cooling	
Maintained Indoor Temp (F):	74	72	
Outdoor Balance Temp (F):	52	65	
Annual Degree-Hrs (F-hr/yr):	77,570	20,659	
HVAC System Efficiency:	70%	1.20	kW/ton

Building Coefficients		
Building Type	k	n
1	110.0	0.60
2	80.0	0.65
3	60.0	0.70
4	23.0	0.65

Building Type
4

WEATHERIZATION SAVINGS - INFILTRATION

				HEATING				COOLING - only sensible				
Description	Total Crack Length (ft)	Average Crack Width (in)	Total Crack Area (SF)	Average Wind Speed (MPH)	Wind Pressure Differential (Pa)	Infiltration Flow (CFM)	Fuel Heating Savings (MBtu/yr)	Average Wind Speed (MPH)	Wind Pressure Differential (Pa)	Infiltration Flow (CFM)	Cooling Savings (MBtu/yr)	Cooling Savings (kWh/yr)
Attic Bypass Air Sealing	C = AxB/12	D	E = CxD/12	F *Note 1*	G = (1.6*F)^2x.0464 / 2	H = kxExG^n *Note 3*	J = 1.1*H*HDH/Eff *Note 3*	L = *Note 2*	M = (1.6*L)^2xp / 2	O = kxExM^n *Note 3*	P = 1.1*O*CDH *Note 3*	Q = P*Eff/12
Seal Attic Air Barrier	3,400	1/128	2.214	9.2	5.09	147	17,872	7.7	3.57	116	2,644	264
TOTALS							17,872					264

Notes:

1) Average heating season wind speed is taken from NOAA weather data for Bradley Int'l Airport and is based on November through April.
2) Average cooling season wind speed is taken from NOAA weather data for Bradley Int'l Airport and is based on May through October.
3) Formula and building types from Energy Canada Study 128 (EC128) (Divided by 1000 to convert Btus to MBtus)

Outside Air Minimum Temperature	Outdoor Air Maximum Temperature	Outdoor Air Average Temperature	Annual Bin Hours for Bradley Int'l Airport				Annual Heating Degree-hrs	Annual Cooling Degree-hrs
			12am-8am	8am-4pm	4pm-12am	TOTAL		
105	109	107	0	0	0	0	0	0
100	104	102	0	0	0	0	0	0
95	99	97	0	4	0	4	0	128
90	94	92	0	34	9	43	0	1,161
85	89	87	0	105	22	127	0	2,794
80	84	82	4	247	105	356	0	6,052
75	79	77	55	243	158	456	0	5,472
70	74	72	137	208	183	528	0	3,696
65	69	67	199	231	248	678	0	1,356
60	64	62	306	300	310	916	0	0
55	59	57	270	226	289	785	0	0
50	54	52	291	186	261	738	0	0
45	49	47	210	129	187	526	2,630	0
40	44	42	282	188	155	625	6,250	0
35	39	37	288	296	306	890	13,350	0
30	34	32	252	222	251	725	14,500	0
25	29	27	182	160	177	519	12,975	0
20	24	22	231	89	177	497	14,910	0
15	19	17	135	42	57	234	8,190	0
10	14	12	44	7	24	75	3,000	0
5	9	7	23	3	1	27	1,215	0
0	4	2	11	0	0	11	550	0
-5	-1	-3	0	0	0	0	0	0
-10	-6	-8	0	0	0	0	0	0
-15	-11	-13	0	0	0	0	0	0
-20	-16	-18	0	0	0	0	0	0
-25	-21	-23	0	0	0	0	0	0
-30	-26					0	0	0
			2,920	2,920	2,920	8,760	77,570	20,659

NORESCO

PROJECT: Town of Berlin, CT
SUBJECT: Building Weatherization
FACILITY: Town Hall Complex

PROJECT NO: 142312
DATE: 10/5/2015

Savings	Electricity kWh	Heating Fuel MMBtu
Building Weatherization	4,317	154.2

FACILITY INFORMATION

LOCATION: Bradley Int'l Airport (Weather data from NOAA for Bradley Int'l Airport)

Design Data	Heating	Cooling	
Maintained Indoor Temp (F):	72	72	
Outdoor Balance Temp (F):	57	60	
Annual Degree-Hrs (F-hr/yr):	101,905	33,451	
HVAC System Efficiency:	86%	1.50	kW/ton

Building Coefficients		
Building Type	k	n
1	110.0	0.60
2	80.0	0.65
3	60.0	0.70
4	23.0	0.65

Building Type
4

WEATHERIZATION SAVINGS - INFILTRATION

				HEATING				COOLING - only sensible				
Description	Total Crack Length (ft)	Average Crack Width (in)	Total Crack Area (SF)	Average Wind Speed (MPH)	Wind Pressure Differential (Pa)	Infiltration Flow (CFM)	Fuel Heating Savings (MBtu/yr)	Average Wind Speed (MPH)	Wind Pressure Differential (Pa)	Infiltration Flow (CFM)	Cooling Savings (MBtu/yr)	Cooling Savings (kWh/yr)
	C = AxB/12	D	E = CxD/12	F	G = (1.6*F)^2x.0464 / 2	H = kxExG^n	J = 1.1*H*HDH/Eff	L =	M = (1.6*L)^2xp / 2	O = kxExM^n	P = 1.1*O*CDH	Q = P*Eff/12
				Note 1		*Note 3*	*Note 3*	*Note 2*		*Note 3*	*Note 3*	
Block Seal	81	1/5	1.350	9.2	5.09	89	11,655	7.7	3.57	71	2,611	326
Seal	1,585	1/8	16.510	9.2	5.09	1,094	142,541	7.7	3.57	868	31,928	3,991
TOTALS							154,196					4,317

Notes:

1) Average heating season wind speed is taken from NOAA weather data for Bradley Int'l Airport and is based on November through April.
2) Average cooling season wind speed is taken from NOAA weather data for Bradley Int'l Airport and is based on May through October.
3) Formula and building types from Energy Canada Study 128 (EC128) (Divided by 1000 to convert Btus to MBtus)

Outside Air Minimum Temperature	Outdoor Air Maximum Temperature	Outdoor Air Average Temperature	Annual Bin Hours for Bradley Int'l Airport				Annual Heating Degree-hrs	Annual Cooling Degree-hrs
			12am-8am	8am-4pm	4pm-12am	TOTAL		
105	109	107	0	0	0	0	0	0
100	104	102	0	0	0	0	0	0
95	99	97	0	4	0	4	0	148
90	94	92	0	34	9	43	0	1,376
85	89	87	0	105	22	127	0	3,429
80	84	82	4	247	105	356	0	7,832
75	79	77	55	243	158	456	0	7,752
70	74	72	137	208	183	528	0	6,336
65	69	67	199	231	248	678	0	4,746
60	64	62	306	300	310	916	0	1,832
55	59	57	270	226	289	785	0	0
50	54	52	291	186	261	738	3,690	0
45	49	47	210	129	187	526	5,260	0
40	44	42	282	188	155	625	9,375	0
35	39	37	288	296	306	890	17,800	0
30	34	32	252	222	251	725	18,125	0
25	29	27	182	160	177	519	15,570	0
20	24	22	231	89	177	497	17,395	0
15	19	17	135	42	57	234	9,360	0
10	14	12	44	7	24	75	3,375	0
5	9	7	23	3	1	27	1,350	0
0	4	2	11	0	0	11	605	0
-5	-1	-3	0	0	0	0	0	0
-10	-6	-8	0	0	0	0	0	0
-15	-11	-13	0	0	0	0	0	0
-20	-16	-18	0	0	0	0	0	0
-25	-21	-23	0	0	0	0	0	0
-30	-26					0	0	0
			2,920	2,920	2,920	8,760	101,905	33,451

ECM-8: HIGH-EFFICIENCY CONDENSING BOILERS

ECM-8: HIGH-EFFICIENCY CONDENSING BOILERS

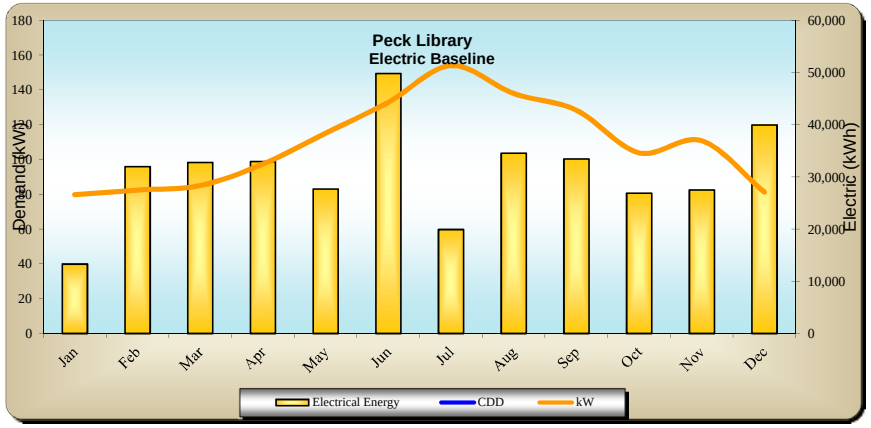
Attachment 8A: New Boilers Savings Calculations

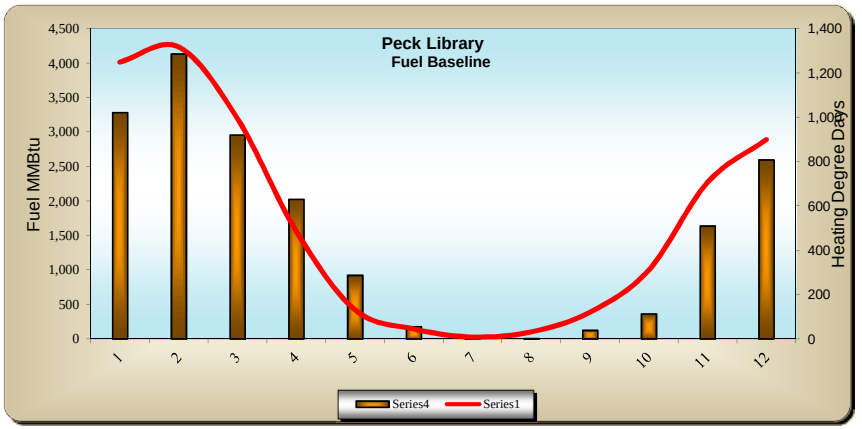
Peck Library

43,712 ft²

NORESCO

FROM:	May-2014	TO:	Apr-2015							
Month	HDD	CDD	Billed Demand kW	Electrical Energy kWh	Total Electric Cost $	Blended Unit Cost $/kWh	Natural Gas CCF	Natural Gas Cost $	Natural Gas $/CCF	Total Utility Cost $
Jan	1,249		79.8	13,317		$0.0000	3,283		$0.00	$0
Feb	1,317		82.4	32,000		$0.0000	4,134		$0.00	$0
Mar	994		85.0	32,800		$0.0000	2,958		$0.00	$0
Apr	486		97.3	32,960		$0.0000	2,024		$0.00	$0
May	131		115.0	27,680		$0.0000	923		$0.00	$0
Jun	44		132.8	49,825		$0.0000	179		$0.00	$0
Jul	8		153.9	19,935		$0.0000	8		$0.00	$0
Aug	31		137.9	34,560		$0.0000	7		$0.00	$0
Sep	120		128.3	33,440		$0.0000	124		$0.00	$0
Oct	310		103.8	26,880		$0.0000	362		$0.00	$0
Nov	706		110.7	27,520		$0.0000	1,638		$0.00	$0
Dec	899		81.2	39,963		$0.0000	2,597		$0.00	$0
TOTALS	**6,295**	**0**	**1,308.1**	**370,880**	**$0**	**$0.0000**	**18,237**	**$0**	**$0.00**	**$0**
				8.5					**42.8**	**$0.00**
				kWh/Sqft					Mbtu/Sqft	$/Sqft
				29.0					**6.8**	**71.8**
				Mbtu/Sqft					Btu/Sqft/HDD	Mbtu/Sqft





NORESCO

PROJECT: Berlin CT
SUBJECT: Facility Information
FACILITY: Peck Library

PROJECT No: 142312-86
DATE: 11/9/2015

Facility Name:	Peck Library	
Facility Square Footage	43,712	sq ft
Weather Data	*Hartford Int'l Airport*	
HEATING EQUIPMENT		
	Existing Efficiency	Proposed Efficiency
Boiler Burner Efficiency	85%	90%
Boiler Losses	-1%	0%
Distribution Losses	-5%	-5%
Heating System Efficiency	79.0%	85%
% of Square Footage Heated	100.0%	100.0%
COOLING EQUIPMENT	Existing Efficiency	Proposed Efficiency
Cooling System Efficiency	0.54	0.54
% of Square Footage Cooled	100.0%	

SPACE TEMPERATURES		
Heating Design Temperature	2	F
Cooling Design Temperature	91	F
Outdoor Balance Point	60	F
Current Heating Setpoint	72	F
Proposed Heating Setpoint	72	F
Current Setback Temp	73	F
Proposed Setback Temp	67	F
Current Cooling Setpoint	74	F
Proposed Cooling Setpoint	74	F
Current Setforward Temp	74	F
Proposed Setforward Temp	80	F
Does setback occur at the end of the Occupied Time?		
(Normally the answer is No)	y or n	Y

Typical Occupancy Schedule
7am to 5pm6 days/week

12am-8am	8am-4pm	4pm-12am	Days/Week
1.0	8.0	1.0	6.0
7.0		5.0 pm	1.0

Current Operating Schedule - Heating
6am to 6pm6 days/week*

12am-8am	8am-4pm	4pm-12am	Days/Week
2.0	8.0	2.0	6.0
6.0		6.0 pm	1.0

Current Operating Schedule - Cooling
6am to 6pm6 days/week*

12am-8am	8am-4pm	4pm-12am	Days/Week
2.0	8.0	2.0	6.0
6.0		6.0 pm	1.0

Proposed Operating Schedule - Heating
6am to 6pm6 days/week

12am-8am	8am-4pm	4pm-12am	Days/Week
2.0	8.0	2.0	6.0
6.0		6.0 pm	1.0

Proposed Operating Schedule - Cooling
6am to 6pm6 days/week

12am-8am	8am-4pm	4pm-12am	Days/Week
2.0	8.0	2.0	6.0
6.0		6.0 pm	1.0

SEER/COP/KW/Ton Quick Calculator

	INPUT Value	OUTPUT Conversion SEER/EER	KW/TON	COP
SEER/EER	*14.00*	14.00	0.86	4.10
KW/TON	*1.06*	11.32	1.06	3.32
COP	*3.60*	12.29	0.98	3.60

2 Natural Gas (ccf)

	Heating Fuel	Description	Unit	Abbrev Ui	Btu/unit
	SELECT HEATING FUEL...				
1	Natural Gas (tl	Natural Gas	therms	therm	100,000
2	Natural Gas (c	Natural Gas	ccf	ccf	102,700
3	Natural Gas (M	Natural Gas	MMBtu	MMBtu	1,000,000
4	Propane	Propane	gallons	gal	91,600
5	Fuel Oil #2	Fuel Oil #2	gallons	gal	139,000
6	Fuel Oil #4	Fuel Oil #4	gallons	gal	144,000
7	Fuel Oil #6	Fuel Oil #6	gallons	gal	152,000
8	Anthracite Coa	Anthracite Coa	tons	ton	25,400,000
9	Steam	Steam	lbs	lb	970
10	Electricity	Electric Heat	kWh	kWh	3,413

NORESCO

PROJECT: Berlin CT
SUBJECT: Load Calculations
FACILITY: Peck Library

PROJECT No: 142312-86
DATE: 11/9/2015

Facility Name: Peck Library
Floor Area: 43,712 ft^2
Ceiling Height: 12 ft
Total Volume: 524,544 ft^3

HEATING LOADS

Design Conditions

Item	Temperature DB (F)
Occupied Heating Setpoint	72
Outdoor Design Condition	2
Design Difference	70

Building Envelope Losses

Item	Total Wall Area (ft^2)	Net Wall Area (ft^2)	Temperature Difference (F)	U-Factor Btu/(hr-F-ft^2)	Heat Transfer (BtuH)	UA
	A	B	C	D	E = BxCxD	F = BxD
North Wall	3,548	3,016	70	0.20	42,222	603
East Wall	3,548	3,016	70	0.20	42,222	603
South Wall	3,548	3,016	70	0.20	42,222	603
West Wall	3,548	3,016	70	0.20	42,222	603
Roof	---	21,856	70	0.10	152,992	2,186
Glass Area	---	3,548	70	0.70	173,857	2,484

Infiltration Losses - Sensible

Item	Wall Area (ft^2)	Infiltration Rate (CFM/ft^2)	Infiltration Rate (CFM)	Temperature Difference (F)	Heat Transfer (BtuH)	UA
	A	B	C = AxB	D	E = 1.08xCxD	F
Infiltration	12,064	0.15	1,810	70	136,801	---

Infiltration Losses - Latent

Item	Wall Area (ft^2)	Infiltration Rate (CFM/ft^2)	Infiltration Rate (CFM)	Humidity Ratio Difference (gr/lb)	Heat Transfer (BtuH)	UA
	A	B	C = AxB	D	E = 4840xCxD/7000	F
Infiltration	12,064	0.15	1,810	0	0	---

TOTAL ENVELOPE LOSSES: **632,540 BTUH**
9,036 Btu/hr/F

NORESCO

PROJECT: Berlin CT
SUBJECT: Load Calculations
FACILITY: Peck Library

PROJECT No: 142312-86
DATE: 11/9/2015

Facility Name: Peck Library
Floor Area: 43,712 ft^2
Ceiling Height: 12 ft
Total Volume: 524,544 ft^3

HEATING LOADS

Ventilation Losses - Sensible

Item	Number of Occupants	Ventilation Rate (CFM/person)	Ventilation Rate (CFM)	Temperature Difference (F)	Heat Transfer (BtuH)	UA
	A	B	C = AxB	D	E = 1.08xCxD	F
Ventilation	150	20	3,000	70	226,800	---

Ventilation Losses - Latent

Item	Number of Occupants	Ventilation Rate (CFM/person)	Ventilation Rate (CFM)	Humidity Ratio Difference (gr/lb)	Heat Transfer (BtuH)	UA
	A	B	C = AxB	D	E = 4840xCxD/7000	F
Ventilation	150	20	3,000	0	0	---

TOTAL VENTILATION LOSSES: 226,800 BTUH
3,240 Btu/hr/F

Internal Loads

Load	Factor 1	Factor 2	Heat Transfer (BtuH)	UA
	A	B	C = AxB	D
People	150 People	250 BtuH/Person	37,500	---
Equipment	43,712 ft^2	1.71 Btu/ft^2	74,595	---
Lighting	43,712 ft^2	2.56 Btu/ft^2	111,892	---

TOTAL TEMP-INDEPENDENT GAINS: 223,986 BTUH

Notes:

1) Btu/hr/person figure is based on the assumption that the sensible heat gain for an office worker is 250 Btu/hr. (From ASHRAE Fundamentals Handbook, 30.4)
2) Equipment heat gain is based on 0.5 watts per squre foot (from ASHRAE Fundamentals Handbook, 30.12)
3) Lighting heat gain is based on 1.0 watts per square foot, with a 75% usage factor.

NORESCO

PROJECT: Berlin CT
SUBJECT: Load Calculations
FACILITY: Peck Library

PROJECT No: 142312-86
DATE: 11/9/2015

Facility Name: Peck Library
Floor Area: 43,712 ft^2
Ceiling Height: 12 ft
Total Volume: 524,544 ft^3

COOLING LOADS

Design Conditions

Item	Temperature DB (F)	Humidity Ratio (gr/lb)	Estimate of Window Solar Gain Assumptions		
			Affected Glass	35%	Percent
Occupied Cooling Setpoint	74	58	Solar Ht Gain[1]	280	Btu/(Hr.-sq. ft.)
Outdoor Design Condition	91	124	SHGF.	0.70	
Design Difference	17	66	SC	0.88	
			1. ASHRAE 1989 Ch 27 Tb 3-11; 40 NL August 21, noon		

Building Envelope Gains

Item	Total Wall Area (ft^2)	Net Wall Area (ft^2)	Temperature Difference (F)	U-Factor Btu/(hr-F-ft^2)	Heat Transfer (BtuH)	UA
	A	B	C	D	E = BxCxD	F = BxD
North Wall	3,548	3,016	17	0.20	10,254	603
East Wall	3,548	3,016	17	0.20	10,254	603
South Wall	3,548	3,016	17	0.20	10,254	603
West Wall	3,548	3,016	17	0.20	10,254	603
Roof	---	21,856	17	0.10	37,155	2,186
Glass Area	---	3,548	17	0.70	42,222	2,484
Glass - Solar		3,548			215,416	

Infiltration Gains - Sensible

Item	Wall Area (ft^2)	Infiltration Rate (CFM/ft^2)	Infiltration Rate (CFM)	Temperature Difference (F)	Heat Transfer (BtuH)	UA
	A	B	C = AxB	D	E = 1.08xCxD	F
Infiltration	12,064	0.15	1,810	17	33,223	---

Infiltration Gains - Latent

Item	Wall Area (ft^2)	Infiltration Rate (CFM/ft^2)	Infiltration Rate (CFM)	Humidity Ratio Difference (gr/lb)	Heat Transfer (BtuH)	UA
	A	B	C = AxB	D	E = 4840xCxD/7000	F
Infiltration	12,064	0.15	1,810	66	82,114	---

TOTAL ENVELOPE GAINS: **451,147 BTUH**
26,538 Btu/hr/F

NORESCO

PROJECT: Berlin CT
SUBJECT: Load Calculations
FACILITY: Peck Library

PROJECT No: 142312-86
DATE: 11/9/2015

Facility Name:	Peck Library
Floor Area:	43,712 ft^2
Ceiling Height:	12 ft
Total Volume:	524,544 ft^3

COOLING LOADS

Ventilation Gains - Sensible

Item	Number of Occupants	Ventilation Rate (CFM/person)	Ventilation Rate (CFM)	Temperature Difference (F)	Heat Transfer (BtuH)	UA
	A	B	C = AxB	D	E = 1.08xCxD	F
Ventilation	150	20	3,000	17	55,080	---

Ventilation Gains - Latent

Item	Number of Occupants	Ventilation Rate (CFM/person)	Ventilation Rate (CFM)	Humidity Ratio Difference (gr/lb)	Heat Transfer (BtuH)	UA
	A	B	C = AxB	D	E = 4840xCxD/7000	F
Ventilation	150	20	3,000	66	136,136	---

TOTAL VENTILATION GAINS: 191,216 BTUH
11,248 Btu/hr/F

Internal Loads

Load	Factor 1	Factor 2	Heat Transfer (BtuH)	UA
	A	B	C = AxB	D
People	150 People	450 BtuH/Person	67,500	---
Equipment	43,712 ft^2	1.71 Btu/ft^2	74,595	---
Lighting	43,712 ft^2	2.56 Btu/ft^2	111,892	---

TOTAL TEMP-INDEPENDENT GAINS: 253,986 BTUH

Notes:

1) Btu/hr/person figure is based on the assumption that the total heat gain for an office worker is 450 Btu/hr. (From ASHRAE Fundamentals Handbook, 30.4)
2) Equipment heat gain is based on 0.5 watts per squre foot (from ASHRAE Fundamentals Handbook, 30.12)
3) Lighting heat gain is based on 1.0 watts per square foot, with a 75% usage factor.
4) Design humidity ratio based on 72F dry bulb with 50% relative humidity.

NORESCO

NORESCO

PROJECT: Berlin CT
SUBJECT: Boiler Replacement
FACILITY: Peck Library

PROJECT NO: 142312-86
DATE: 11/9/2015

	Month Demand kW	Electricity kWh	Heating Fuel MMBtu
Boiler Replacement			**171**

	Existing	Proposed
Design Combustion Efficiency	85%	90%
Radiant Jacket Losses	1%	0%
Cycling Losses (Low Load)	3%	1%
Cycling Losses (Full Load)	3%	1%
Distribution Losses	4%	2%
Total Efficiency	80%	88%

Boiler Output

Design Heating Load (kBh)	635	635
Heating Balance Temp (F)	60	60
Design Heating Temp (F)	2	2

Outside Air Bin Temp (F)	Annual Bin Hours	Existing Number of Boilers	Proposed Number of Boilers	Heating Load (%)	Existing Heating Load (kBh)	Proposed Heating Load (kBh)	Existing Heating Efficiency	Proposed Heating Efficiency	Existing Standby Losses	Propoosed Standby Losses	Existing Cycling Losses	Propoosed Cycling Losses	Existing NG Use (ccf)	Proposed NG Use (ccf)	Saved Energy Use (ccf)
	See Note 1														
112	0	0	0	0%	0	0	80%	88%	0	0	0	0	0	0	0
107	0	0	0	0%	0	0	80%	88%	0	0	0	0	0	0	0
102	0	0	0	0%	0	0	80%	88%	0	0	0	0	0	0	0
97	4	0	0	0%	0	0	80%	88%	0	0	0	0	0	0	0
92	43	0	0	0%	0	0	80%	88%	0	0	0	0	0	0	0
87	127	0	0	0%	0	0	80%	88%	0	0	0	0	0	0	0
82	356	0	0	0%	0	0	80%	88%	0	0	0	0	0	0	0
77	456	0	0	0%	0	0	80%	88%	0	0	0	0	0	0	0
72	528	0	0	0%	0	0	80%	88%	0	0	0	0	0	0	0
67	678	0	0	0%	0	0	80%	88%	0	0	0	0	0	0	0
62	916	0	0	0%	0	0	80%	88%	0	0	0	0	0	0	0
57	785	4	4	5%	33	33	80%	88%	258	0	645	129	324	288	36
52	738	4	4	14%	88	88	80%	88%	647	0	1617	647	812	724	88
47	526	4	4	22%	142	142	80%	88%	749	0	1873	749	940	839	101
42	625	4	4	31%	197	197	80%	88%	1232	0	3081	1232	1,546	1,380	167
37	890	4	4	40%	252	252	80%	88%	2242	0	5606	2242	2,814	2,510	304
32	725	4	4	48%	307	307	80%	88%	2224	0	5559	2224	2,791	2,489	301
27	519	4	4	57%	361	361	80%	88%	1876	0	4690	1876	2,354	2,100	254
22	497	4	4	66%	416	416	80%	88%	2069	0	5172	2069	2,596	2,316	280
17	234	4	4	74%	471	471	80%	88%	1102	0	2756	1102	1,383	1,234	149
12	75	4	4	83%	526	526	80%	88%	394	0	986	394	495	441	53
7	27	4	4	91%	581	581	80%	88%	157	0	392	157	197	175	21
2	11	4	4	100%	635	635	80%	88%	70	0	175	70	88	78	9
-3	0	4	4	100%	635	635	80%	88%	0	0	0	0	0	0	0
-8	0	4	4	100%	635	635	80%	88%	0	0	0	0	0	0	0
-13	0	4	4	100%	635	635	80%	88%	0	0	0	0	0	0	0
-18	0	4	4	100%	635	635	80%	88%	0	0	0	0	0	0	0
-23	0	4	4	100%	635	635	80%	88%	0	0	0	0	0	0	0
	8760												16,339	14,575	1,764

Notes:

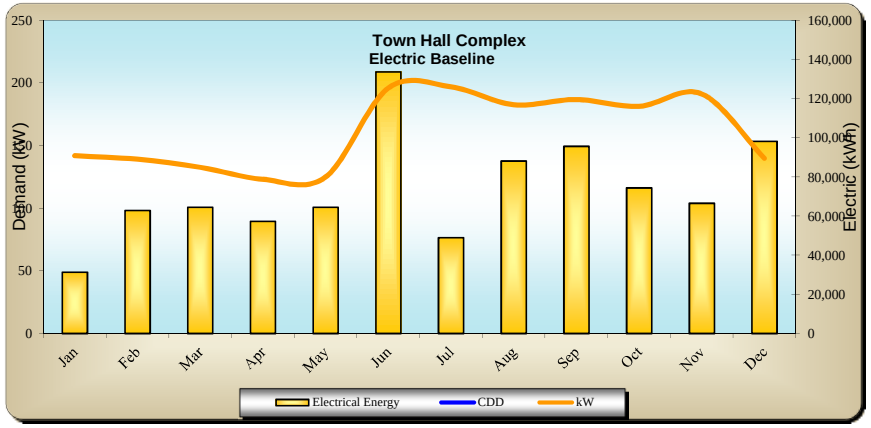
1) Weather from USAF for Hartford Int'l Airport

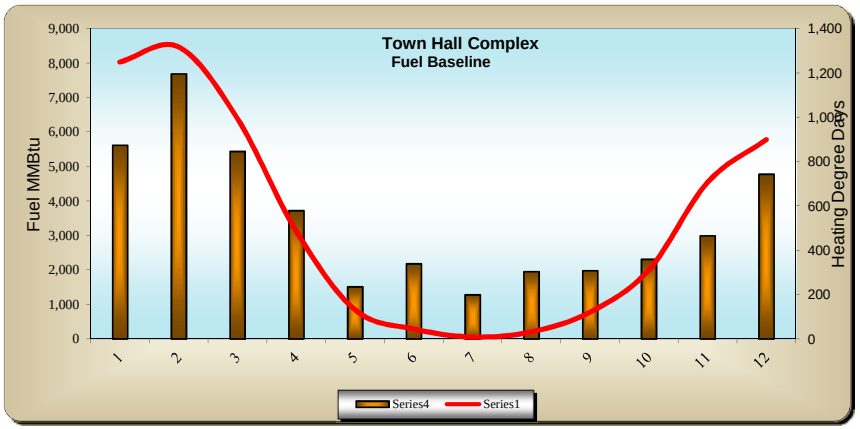
Town Hall Complex

49,018 ft²

NORESCO

FROM:	May-2014	TO:	Apr-2015							
Month	HDD	CDD	Billed Demand kW	Electrical Energy kWh	Total Electric Cost $	Blended Unit Cost $/kWh	Natural Gas CCF	Natural Gas Cost $	Natural Gas $/CCF	Total Utility Cost $
Jan	1,249		141.8	31,357		$0.0000	5,620		$0.00	$0
Feb	1,317		139.0	62,880		$0.0000	7,690		$0.00	$0
Mar	994		132.6	64,480		$0.0000	5,440		$0.00	$0
Apr	486		123.0	57,280		$0.0000	3,720		$0.00	$0
May	131		124.8	64,480		$0.0000	1,510		$0.00	$0
Jun	44		195.8	133,744		$0.0000	2,180		$0.00	$0
Jul	8		196.8	48,946		$0.0000	1,280		$0.00	$0
Aug	31		182.6	88,160		$0.0000	1,950		$0.00	$0
Sep	120		186.7	95,680		$0.0000	1,980		$0.00	$0
Oct	310		181.3	74,400		$0.0000	2,310		$0.00	$0
Nov	706		191.2	66,560		$0.0000	2,990		$0.00	$0
Dec	899		139.9	98,243		$0.0000	4,780		$0.00	$0
TOTALS	**6,295**	**0**	**1,935.5**	**886,210**	**$0**	**$0.0000**	**41,450**	**$0**	**$0.00**	**$0**
				18.1					**86.8**	**$0.00**
				kWh/Sqft					Mbtu/Sqft	$/Sqft
				61.7					**13.8**	**148.5**
				Mbtu/Sqft					Btu/Sqft/HDD	Mbtu/Sqft





NORESCO

PROJECT: Berlin CT
SUBJECT: Facility Information
FACILITY: Town Hall Complex

PROJECT No: 142312-86
DATE: 11/9/2015

Facility Name:	Town Hall Complex	
Facility Square Footage	49,018	sq ft
Weather Data	*Hartford Int'l Airport*	
HEATING EQUIPMENT		
	Existing Efficiency	Proposed Efficiency
Boiler Burner Efficiency	85%	90%
Boiler Losses	-1%	0%
Distribution Losses	-5%	-5%
Heating System Efficiency	79.0%	85%
% of Square Footage Heated	100.0%	100.0%
COOLING EQUIPMENT	Existing Efficiency	Proposed Efficiency
Cooling System Efficiency	0.54	0.54
% of Square Footage Cooled	100.0%	

SPACE TEMPERATURES		
Heating Design Temperature	2	F
Cooling Design Temperature	91	F
Outdoor Balance Point	60	F
Current Heating Setpoint	72	F
Proposed Heating Setpoint	72	F
Current Setback Temp	73	F
Proposed Setback Temp	67	F
Current Cooling Setpoint	74	F
Proposed Cooling Setpoint	74	F
Current Setforward Temp	74	F
Proposed Setforward Temp	80	F
Does setback occur at the end of the Occupied Time?		
(Normally the answer is No)	y or n	**n**
Setback starts at the end of the equipment operating hours.		

Typical Occupancy Schedule
7am to 5pm6 days/week

12am-8am	8am-4pm	4pm-12am	Days/Week
1.0	8.0	1.0	6.0
7.0		5.0	1.0
		pm	

Current Operating Schedule - Heating
continuous

12am-8am	8am-4pm	4pm-12am	Days/Week
8.0	8.0	8.0	7.0
0.0		12.0	0.0
		am	

Current Operating Schedule - Cooling
6am to 4pm7 days/week*

12am-8am	8am-4pm	4pm-12am	Days/Week
2.0	8.0	0.0	7.0
6.0		4.0	0.0
		pm	

Proposed Operating Schedule - Heating
6am to 5pm7 days/week

12am-8am	8am-4pm	4pm-12am	Days/Week
2.0	8.0	1.0	7.0
6.0		5.0	0.0
		pm	

Proposed Operating Schedule - Cooling
6am to 5pm6 days/week

12am-8am	8am-4pm	4pm-12am	Days/Week
2.0	8.0	1.0	6.0
6.0		5.0	1.0
		pm	

SEER/COP/KW/Ton Quick Calculator

	INPUT Value	OUTPUT Conversion SEER/EER	KW/TON	COP
SEER/EER	*14.00*	14.00	0.86	4.10
KW/TON	*1.06*	11.32	1.06	3.32
COP	*3.60*	12.29	0.98	3.60

2 Natural Gas (ccf)

	Heating Fuel	Description	Unit	Abbrev Ui	Btu/unit
	SELECT HEATING FUEL...				
1	Natural Gas (tl	Natural Gas	therms	therm	100,000
2	Natural Gas (c	Natural Gas	ccf	ccf	102,700
3	Natural Gas (M	Natural Gas	MMBtu	MMBtu	1,000,000
4	Propane	Propane	gallons	gal	91,600
5	Fuel Oil #2	Fuel Oil #2	gallons	gal	139,000
6	Fuel Oil #4	Fuel Oil #4	gallons	gal	144,000
7	Fuel Oil #6	Fuel Oil #6	gallons	gal	152,000
8	Anthracite Coa	Anthracite Coa	tons	ton	25,400,000
9	Steam	Steam	lbs	lb	970
10	Electricity	Electric Heat	kWh	kWh	3,413

NORESCO

PROJECT: Berlin CT
SUBJECT: Load Calculations
FACILITY: Town Hall Complex

PROJECT No: 142312-86
DATE: 11/9/2015

Facility Name:	Town Hall Complex
Floor Area:	49,018 ft^2
Ceiling Height:	12 ft
Total Volume:	588,216 ft^3

HEATING LOADS

Design Conditions

Item	Temperature DB (F)
Occupied Heating Setpoint	72
Outdoor Design Condition	2
Design Difference	70

Building Envelope Losses

Item	Total Wall Area (ft^2)	Net Wall Area (ft^2)	Temperature Difference (F)	U-Factor Btu/(hr-F-ft^2)	Heat Transfer (BtuH)	UA
	A	B	C	D	E = BxCxD	F = BxD
North Wall	5,314	4,517	70	0.20	63,232	903
East Wall	2,657	2,258	70	0.20	31,616	452
South Wall	5,314	4,517	70	0.20	63,232	903
West Wall	2,657	2,258	70	0.20	31,616	452
Roof	---	24,509	70	0.10	171,563	2,451
Glass Area	---	7,970	70	0.70	390,550	5,579

Infiltration Losses - Sensible

Item	Wall Area (ft^2)	Infiltration Rate (CFM/ft^2)	Infiltration Rate (CFM)	Temperature Difference (F)	Heat Transfer (BtuH)	UA
	A	B	C = AxB	D	E = 1.08xCxD	F
Infiltration	13,550	0.15	2,032	70	153,653	---

Infiltration Losses - Latent

Item	Wall Area (ft^2)	Infiltration Rate (CFM/ft^2)	Infiltration Rate (CFM)	Humidity Ratio Difference (gr/lb)	Heat Transfer (BtuH)	UA
	A	B	C = AxB	D	E = 4840xCxD/7000	F
Infiltration	13,550	0.15	2,032	0	0	---

TOTAL ENVELOPE LOSSES: **905,462 BTUH**
12,935 Btu/hr/F

NORESCO

PROJECT: Berlin CT
SUBJECT: Load Calculations
FACILITY: Town Hall Complex

PROJECT No: 142312-86
DATE: 11/9/2015

Facility Name:	Town Hall Complex	
Floor Area:	49,018	ft^2
Ceiling Height:	12	ft
Total Volume:	588,216	ft^3

HEATING LOADS

Ventilation Losses - Sensible

Item	Number of Occupants	Ventilation Rate (CFM/person)	Ventilation Rate (CFM)	Temperature Difference (F)	Heat Transfer (BtuH)	UA
	A	B	C = AxB	D	E = 1.08xCxD	F
Ventilation	45	25	1,125	70	85,050	---

Ventilation Losses - Latent

Item	Number of Occupants	Ventilation Rate (CFM/person)	Ventilation Rate (CFM)	Humidity Ratio Difference (gr/lb)	Heat Transfer (BtuH)	UA
	A	B	C = AxB	D	E = 4840xCxD/7000	F
Ventilation	45	25	1,125	0	0	---

TOTAL VENTILATION LOSSES: **85,050 BTUH**
1,215 Btu/hr/F

Internal Loads

Load	Factor 1		Factor 2		Heat Transfer (BtuH)	UA
	A		B		C = AxB	D
People	45	People	250	BtuH/Person	11,250	---
Equipment	49,018	ft^2	1.71	Btu/ft^2	83,649	---
Lighting	49,018	ft^2	2.56	Btu/ft^2	125,474	---

TOTAL TEMP-INDEPENDENT GAINS: **220,373 BTUH**

Notes:

1) Btu/hr/person figure is based on the assumption that the sensible heat gain for an office worker is 250 Btu/hr. (From ASHRAE Fundamentals Handbook, 30.4)
2) Equipment heat gain is based on 0.5 watts per squre foot (from ASHRAE Fundamentals Handbook, 30.12)
3) Lighting heat gain is based on 1.0 watts per square foot, with a 75% usage factor.

NORESCO

PROJECT: Berlin CT
SUBJECT: Load Calculations
FACILITY: Town Hall Complex

PROJECT No: 142312-86
DATE: 11/9/2015

Facility Name:	Town Hall Complex
Floor Area:	49,018 ft^2
Ceiling Height:	12 ft
Total Volume:	588,216 ft^3

COOLING LOADS

Design Conditions

Item	Temperature DB (F)	Humidity Ratio (gr/lb)
Occupied Cooling Setpoint	74	58
Outdoor Design Condition	91	124
Design Difference	17	66

Estimate of Window Solar Gain Assumptions		
Affected Glass	35%	Percent
Solar Ht Gain[1]	280	Btu/(Hr.-sq. ft.)
SHGF.	0.70	
SC	0.88	

1. ASHRAE 1989 Ch 27 Tb 3-11; 40 NL August 21, noon

Building Envelope Gains

Item	Total Wall Area (ft^2)	Net Wall Area (ft^2)	Temperature Difference (F)	U-Factor Btu/(hr-F-ft^2)	Heat Transfer (BtuH)	UA
	A	B	C	D	E = BxCxD	F = BxD
North Wall	5,314	4,517	17	0.20	15,356	903
East Wall	2,657	2,258	17	0.20	7,678	452
South Wall	5,314	4,517	17	0.20	15,356	903
West Wall	2,657	2,258	17	0.20	7,678	452
Roof	---	24,509	17	0.10	41,665	2,451
Glass Area	---	7,970	17	0.70	94,848	5,579
Glass - Solar		7,970			483,907	

Infiltration Gains - Sensible

Item	Wall Area (ft^2)	Infiltration Rate (CFM/ft^2)	Infiltration Rate (CFM)	Temperature Difference (F)	Heat Transfer (BtuH)	UA
	A	B	C = AxB	D	E = 1.08xCxD	F
Infiltration	13,550	0.15	2,032	17	37,316	---

Infiltration Gains - Latent

Item	Wall Area (ft^2)	Infiltration Rate (CFM/ft^2)	Infiltration Rate (CFM)	Humidity Ratio Difference (gr/lb)	Heat Transfer (BtuH)	UA
	A	B	C = AxB	D	E = 4840xCxD/7000	F
Infiltration	13,550	0.15	2,032	66	92,230	---

TOTAL ENVELOPE GAINS: **796,034 BTUH**
46,826 Btu/hr/F

NORESCO

PROJECT: Berlin CT
SUBJECT: Load Calculations
FACILITY: Town Hall Complex

PROJECT No: 142312-86
DATE: 11/9/2015

Facility Name:	Town Hall Complex
Floor Area:	49,018 ft^2
Ceiling Height:	12 ft
Total Volume:	588,216 ft^3

COOLING LOADS

Ventilation Gains - Sensible

Item	Number of Occupants	Ventilation Rate (CFM/person)	Ventilation Rate (CFM)	Temperature Difference (F)	Heat Transfer (BtuH)	UA
	A	B	C = AxB	D	E = 1.08xCxD	F
Ventilation	45	25	1,125	17	20,655	---

Ventilation Gains - Latent

Item	Number of Occupants	Ventilation Rate (CFM/person)	Ventilation Rate (CFM)	Humidity Ratio Difference (gr/lb)	Heat Transfer (BtuH)	UA
	A	B	C = AxB	D	E = 4840xCxD/7000	F
Ventilation	45	25	1,125	66	51,051	---

TOTAL VENTILATION GAINS: 71,706 BTUH
4,218 Btu/hr/F

Internal Loads

Load	Factor 1	Factor 2	Heat Transfer (BtuH)	UA
	A	B	C = AxB	D
People	45 People	450 BtuH/Person	20,250	---
Equipment	49,018 ft^2	1.71 Btu/ft^2	83,649	---
Lighting	49,018 ft^2	2.56 Btu/ft^2	125,474	---

TOTAL TEMP-INDEPENDENT GAINS: 229,373 BTUH

Notes:

1) Btu/hr/person figure is based on the assumption that the total heat gain for an office worker is 450 Btu/hr. (From ASHRAE Fundamentals Handbook, 30.4)
2) Equipment heat gain is based on 0.5 watts per squre foot (from ASHRAE Fundamentals Handbook, 30.12)
3) Lighting heat gain is based on 1.0 watts per square foot, with a 75% usage factor.
4) Design humidity ratio based on 72F dry bulb with 50% relative humidity.

NORESCO

PROJECT: Berlin CT
SUBJECT: Boiler Replacement
FACILITY: Town Hall Complex

PROJECT NO: 142312-86
DATE: 11/9/2015

	Month Demand kW	Electricity kWh	Heating Fuel MMBtu
Boiler Replacement			**436**

	Existing	Proposed
Design Combustion Efficiency	85%	90%
Radiant Jacket Losses	1%	0%
Cycling Losses (Low Load)	3%	1%
Cycling Losses (Full Load)	3%	1%
Distribution Losses	4%	2%
Total Efficiency	80%	88%

Boiler Output

Design Heating Load (kBh)	770	770
Heating Balance Temp (F)	97	97
Design Heating Temp (F)	2	2

Outside Air Bin Temp (F)	Annual Bin Hours	Existing Number of Boilers	Proposed Number of Boilers	Heating Load (%)	Existing Heating Load (kBh)	Proposed Heating Load (kBh)	Existing Heating Efficiency	Proposed Heating Efficiency	Existing Standby Losses	Propoosed Standby Losses	Existing Cycling Losses	Propoosed Cycling Losses	Existing NG Use (ccf)	Proposed NG Use (ccf)	Saved Energy Use (ccf)
	See Note 1														
112	0	0	0	0%	0	0	80%	88%	0	0	0	0	0	0	0
107	0	0	0	0%	0	0	80%	88%	0	0	0	0	0	0	0
102	0	0	0	0%	0	0	80%	88%	0	0	0	0	0	0	0
97	4	0	0	0%	0	0	80%	88%	0	0	0	0	0	0	0
92	43	4	4	5%	41	41	80%	88%	17	0	44	9	22	19	2
87	127	4	4	11%	81	81	80%	88%	103	0	257	103	129	115	14
82	356	4	4	16%	122	122	80%	88%	433	0	1082	433	543	485	59
77	456	4	4	21%	162	162	80%	88%	739	0	1848	739	928	828	100
72	528	4	4	26%	203	203	80%	88%	1070	0	2675	1070	1,343	1,198	145
67	678	4	4	32%	243	243	80%	88%	1649	0	4122	1649	2,069	1,846	223
62	916	4	4	37%	284	284	80%	88%	2599	0	6498	2599	3,261	2,910	352
57	785	4	4	42%	324	324	80%	88%	2546	0	6364	2546	3,194	2,850	345
52	738	4	4	47%	365	365	80%	88%	2692	0	6731	2692	3,378	3,014	364
47	526	4	4	53%	405	405	80%	88%	2132	0	5330	2132	2,675	2,387	289
42	625	4	4	58%	446	446	80%	88%	2787	0	6967	2787	3,497	3,120	377
37	890	4	4	63%	486	486	80%	88%	4329	0	10822	4329	5,432	4,846	586
32	725	4	4	68%	527	527	80%	88%	3820	0	9551	3820	4,794	4,277	517
27	519	4	4	74%	567	567	80%	88%	2945	0	7363	2945	3,696	3,297	399
22	497	4	4	79%	608	608	80%	88%	3022	0	7554	3022	3,792	3,383	409
17	234	4	4	84%	649	649	80%	88%	1518	0	3794	1518	1,904	1,699	205
12	75	4	4	89%	689	689	80%	88%	517	0	1292	517	649	579	70
7	27	4	4	95%	730	730	80%	88%	197	0	492	197	247	221	27
2	11	4	4	100%	770	770	80%	88%	85	0	212	85	106	95	11
-3	0	4	4	100%	770	770	80%	88%	0	0	0	0	0	0	0
-8	0	4	4	100%	770	770	80%	88%	0	0	0	0	0	0	0
-13	0	4	4	100%	770	770	80%	88%	0	0	0	0	0	0	0
-18	0	4	4	100%	770	770	80%	88%	0	0	0	0	0	0	0
-23	0	4	4	100%	770	770	80%	88%	0	0	0	0	0	0	0
	8760												41,661	37,167	4,495

Notes:

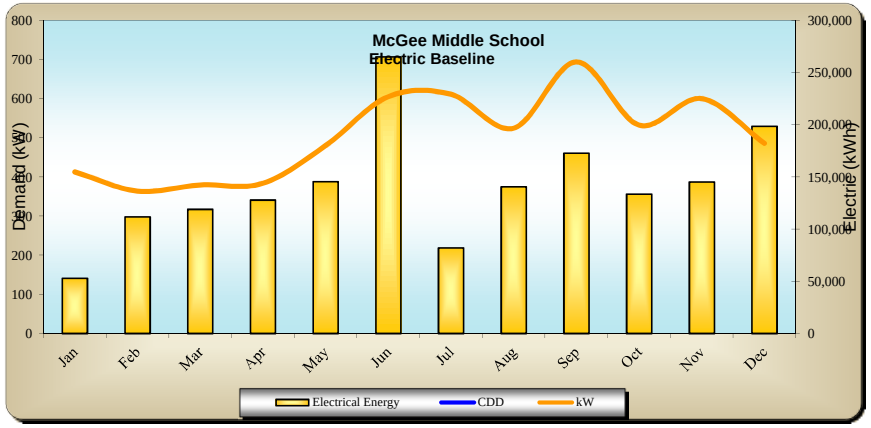
1) Weather from USAF for Hartford Int'l Airport

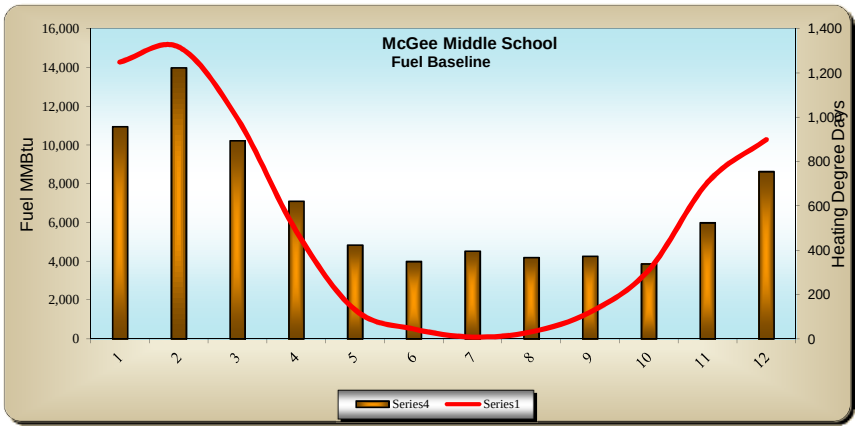
McGee Middle School

142,500 ft²

NORESCO

FROM:	May-2014	TO:	Apr-2015							
Month	HDD	CDD	Billed Demand kW	Electrical Energy kWh	Total Electric Cost $	Blended Unit Cost $/kWh	Natural Gas CCF	Natural Gas Cost $	Natural Gas $/CCF	Total Utility Cost $
Jan	1,249		412.4	52,940		$0.0000	10,945		$0.00	$0
Feb	1,317		363.6	111,744		$0.0000	13,986		$0.00	$0
Mar	994		379.0	119,040		$0.0000	10,225		$0.00	$0
Apr	486		383.2	127,872		$0.0000	7,107		$0.00	$0
May	131		479.6	145,536		$0.0000	4,841		$0.00	$0
Jun	44		604.8	265,108		$0.0000	3,993		$0.00	$0
Jul	8		610.9	82,028		$0.0000	4,524		$0.00	$0
Aug	31		524.2	140,544		$0.0000	4,195		$0.00	$0
Sep	120		693.5	172,800		$0.0000	4,258		$0.00	$0
Oct	310		532.2	133,632		$0.0000	3,870		$0.00	$0
Nov	706		599.8	145,152		$0.0000	5,991		$0.00	$0
Dec	899		485.6	198,580		$0.0000	8,628		$0.00	$0
TOTALS	**6,295**	**0**	**6,068.8**	**1,694,976**	**$0**	**$0.0000**	**82,563**	**$0**	**$0.00**	**$0**
				11.9					**59.5**	**$0.00**
				kWh/Sqft					Mbtu/Sqft	$/Sqft
				40.6					**9.5**	**100.1**
				Mbtu/Sqft					Btu/Sqft/HDD	Mbtu/Sqft





NORESCO

PROJECT: Berlin CT
SUBJECT: Facility Information
FACILITY: McGee Middle School

PROJECT No: 142312-86
DATE: 11/9/2015

Facility Name:	McGee Middle School	
Facility Square Footage	142,500	sq ft
Weather Data	*Hartford Int'l Airport*	
HEATING EQUIPMENT		
	Existing Efficiency	Proposed Efficiency
Boiler Burner Efficiency	85%	90%
Boiler Losses	-1%	0%
Distribution Losses	-5%	-5%
Heating System Efficiency	79.0%	85%
% of Square Footage Heated	100.0%	100.0%
COOLING EQUIPMENT	Existing Efficiency	Proposed Efficiency
Cooling System Efficiency	0.54	0.54
% of Square Footage Cooled	100.0%	

SPACE TEMPERATURES		
Heating Design Temperature	2	F
Cooling Design Temperature	91	F
Outdoor Balance Point	60	F
Current Heating Setpoint	72	F
Proposed Heating Setpoint	72	F
Current Setback Temp	73	F
Proposed Setback Temp	67	F
Current Cooling Setpoint	74	F
Proposed Cooling Setpoint	74	F
Current Setforward Temp	74	F
Proposed Setforward Temp	80	F
Does setback occur at the end of the Occupied Time?		
(Normally the answer is No)	y or n	**n**
Setback starts at the end of the equipment operating hours.		

Typical Occupancy Schedule
7am to 5pm6 days/week

12am-8am	8am-4pm	4pm-12am	Days/Week
1.0	8.0	1.0	6.0
7.0		5.0	1.0
		pm	

Current Operating Schedule - Heating
continuous

12am-8am	8am-4pm	4pm-12am	Days/Week
8.0	8.0	8.0	7.0
0.0		12.0	0.0
		am	

Current Operating Schedule - Cooling
6am to 4pm7 days/week*

12am-8am	8am-4pm	4pm-12am	Days/Week
2.0	8.0	0.0	7.0
6.0		4.0	0.0
		pm	

Proposed Operating Schedule - Heating
continuous

12am-8am	8am-4pm	4pm-12am	Days/Week
8.0	8.0	8.0	7.0
0.0		12.0	0.0
		am	

Proposed Operating Schedule - Cooling
6am to 5pm6 days/week

12am-8am	8am-4pm	4pm-12am	Days/Week
2.0	8.0	1.0	6.0
6.0		5.0	1.0
		pm	

SEER/COP/KW/Ton Quick Calculator

	INPUT Value	OUTPUT Conversion SEER/EER	KW/TON	COP
SEER/EER	*14.00*	14.00	0.86	4.10
KW/TON	*1.06*	11.32	1.06	3.32
COP	*3.60*	12.29	0.98	3.60

2 Natural Gas (ccf)

	Heating Fuel	Description	Unit	Abbrev Ui	Btu/unit
	SELECT HEATING FUEL...				
1	Natural Gas (tl	Natural Gas	therms	therm	100,000
2	Natural Gas (c	Natural Gas	ccf	ccf	102,700
3	Natural Gas (M	Natural Gas	MMBtu	MMBtu	1,000,000
4	Propane	Propane	gallons	gal	91,600
5	Fuel Oil #2	Fuel Oil #2	gallons	gal	139,000
6	Fuel Oil #4	Fuel Oil #4	gallons	gal	144,000
7	Fuel Oil #6	Fuel Oil #6	gallons	gal	152,000
8	Anthracite Coa	Anthracite Coa	tons	ton	25,400,000
9	Steam	Steam	lbs	lb	970
10	Electricity	Electric Heat	kWh	kWh	3,413

NORESCO

PROJECT: Berlin CT
SUBJECT: Load Calculations
FACILITY: McGee Middle School

PROJECT No: 142312-86
DATE: 11/9/2015

Facility Name: McGee Middle School
Floor Area: 142,500 ft^2
Ceiling Height: 12 ft
Total Volume: 1,710,000 ft^3

HEATING LOADS

Design Conditions

Item	Temperature DB (F)
Occupied Heating Setpoint	72
Outdoor Design Condition	2
Design Difference	70

Building Envelope Losses

Item	Total Wall Area (ft^2)	Net Wall Area (ft^2)	Temperature Difference (F)	U-Factor Btu/(hr-F-ft^2)	Heat Transfer (BtuH)	UA
	A	B	C	D	E = BxCxD	F = BxD
North Wall	4,530	3,850	70	0.30	80,859	1,155
East Wall	9,060	7,701	70	0.30	161,717	2,310
South Wall	4,530	3,850	70	0.30	80,859	1,155
West Wall	9,060	7,701	70	0.30	161,717	2,310
Roof	---	71,250	70	0.20	997,500	14,250
Glass Area	---	13,590	70	1.00	951,279	13,590

Infiltration Losses - Sensible

Item	Wall Area (ft^2)	Infiltration Rate (CFM/ft^2)	Infiltration Rate (CFM)	Temperature Difference (F)	Heat Transfer (BtuH)	UA
	A	B	C = AxB	D	E = 1.08xCxD	F
Infiltration	23,102	0.35	8,086	70	611,292	---

Infiltration Losses - Latent

Item	Wall Area (ft^2)	Infiltration Rate (CFM/ft^2)	Infiltration Rate (CFM)	Humidity Ratio Difference (gr/lb)	Heat Transfer (BtuH)	UA
	A	B	C = AxB	D	E = 4840xCxD/7000	F
Infiltration	23,102	0.35	8,086	0	0	---

TOTAL ENVELOPE LOSSES: 3,045,223 BTUH
43,503 Btu/hr/F

NORESCO

PROJECT: Berlin CT
SUBJECT: Load Calculations
FACILITY: McGee Middle School

PROJECT No: 142312-86
DATE: 11/9/2015

Facility Name:	McGee Middle School
Floor Area:	142,500 ft^2
Ceiling Height:	12 ft
Total Volume:	1,710,000 ft^3

HEATING LOADS

Ventilation Losses - Sensible

Item	Number of Occupants	Ventilation Rate (CFM/person)	Ventilation Rate (CFM)	Temperature Difference (F)	Heat Transfer (BtuH)	UA
	A	B	C = AxB	D	E = 1.08xCxD	F
Ventilation	780	30	23,400	70	1,769,040	---

Ventilation Losses - Latent

Item	Number of Occupants	Ventilation Rate (CFM/person)	Ventilation Rate (CFM)	Humidity Ratio Difference (gr/lb)	Heat Transfer (BtuH)	UA
	A	B	C = AxB	D	E = 4840xCxD/7000	F
Ventilation	780	30	23,400	0	0	---

TOTAL VENTILATION LOSSES: **1,769,040 BTUH**
25,272 Btu/hr/F

Internal Loads

Load	Factor 1	Factor 2	Heat Transfer (BtuH)	UA
	A	B	C = AxB	D
People	780 People	450 BtuH/Person	351,000	---
Equipment	142,500 ft^2	1.71 Btu/ft^2	243,176	---
Lighting	142,500 ft^2	2.56 Btu/ft^2	364,764	---

TOTAL TEMP-INDEPENDENT GAINS: **958,941 BTUH**

Notes:

1) Btu/hr/person figure is based on the assumption that the sensible heat gain for an office worker is 250 Btu/hr. (From ASHRAE Fundamentals Handbook, 30.4)
2) Equipment heat gain is based on 0.5 watts per squre foot (from ASHRAE Fundamentals Handbook, 30.12)
3) Lighting heat gain is based on 1.0 watts per square foot, with a 75% usage factor.

NORESCO

PROJECT: Berlin CT
SUBJECT: Load Calculations
FACILITY: McGee Middle School

PROJECT No: 142312-86
DATE: 11/9/2015

Facility Name:	McGee Middle School
Floor Area:	142,500 ft^2
Ceiling Height:	12 ft
Total Volume:	1,710,000 ft^3

COOLING LOADS

Design Conditions

Item	Temperature DB (F)	Humidity Ratio (gr/lb)
Occupied Cooling Setpoint	74	58
Outdoor Design Condition	91	124
Design Difference	17	66

Estimate of Window Solar Gain Assumptions		
Affected Glass	35%	Percent
Solar Ht Gain[1]	280	Btu/(Hr.-sq. ft.)
SHGF.	0.70	
SC	0.88	

1. ASHRAE 1989 Ch 27 Tb 3-11; 40 NL August 21, noon

Building Envelope Gains

Item	Total Wall Area (ft^2)	Net Wall Area (ft^2)	Temperature Difference (F)	U-Factor Btu/(hr-F-ft^2)	Heat Transfer (BtuH)	UA
	A	B	C	D	E = BxCxD	F = BxD
North Wall	4,530	3,850	17	0.30	19,637	1,155
East Wall	9,060	7,701	17	0.30	39,274	2,310
South Wall	4,530	3,850	17	0.30	19,637	1,155
West Wall	9,060	7,701	17	0.30	39,274	2,310
Roof	---	71,250	17	0.20	242,250	14,250
Glass Area	---	13,590	17	1.00	231,025	13,590
Glass - Solar		13,590			825,071	

Infiltration Gains - Sensible

Item	Wall Area (ft^2)	Infiltration Rate (CFM/ft^2)	Infiltration Rate (CFM)	Temperature Difference (F)	Heat Transfer (BtuH)	UA
	A	B	C = AxB	D	E = 1.08xCxD	F
Infiltration	23,102	0.35	8,086	17	148,457	---

Infiltration Gains - Latent

Item	Wall Area (ft^2)	Infiltration Rate (CFM/ft^2)	Infiltration Rate (CFM)	Humidity Ratio Difference (gr/lb)	Heat Transfer (BtuH)	UA
	A	B	C = AxB	D	E = 4840xCxD/7000	F
Infiltration	23,102	0.35	8,086	66	366,925	---

TOTAL ENVELOPE GAINS: **1,931,551 BTUH**
113,621 Btu/hr/F

NORESCO

PROJECT: Berlin CT
SUBJECT: Load Calculations
FACILITY: McGee Middle School

PROJECT No: 142312-86
DATE: 11/9/2015

Facility Name:	McGee Middle School
Floor Area:	142,500 ft^2
Ceiling Height:	12 ft
Total Volume:	1,710,000 ft^3

COOLING LOADS

Ventilation Gains - Sensible

Item	Number of Occupants	Ventilation Rate (CFM/person)	Ventilation Rate (CFM)	Temperature Difference (F)	Heat Transfer (BtuH)	UA
	A	B	C = AxB	D	E = 1.08xCxD	F
Ventilation	780	30	23,400	17	429,624	---

Ventilation Gains - Latent

Item	Number of Occupants	Ventilation Rate (CFM/person)	Ventilation Rate (CFM)	Humidity Ratio Difference (gr/lb)	Heat Transfer (BtuH)	UA
	A	B	C = AxB	D	E = 4840xCxD/7000	F
Ventilation	780	30	23,400	66	1,061,858	---

TOTAL VENTILATION GAINS: 1,491,482 BTUH
87,734 Btu/hr/F

Internal Loads

Load	Factor 1	Factor 2	Heat Transfer (BtuH)	UA
	A	B	C = AxB	D
People	780 People	450 BtuH/Person	351,000	---
Equipment	142,500 ft^2	1.71 Btu/ft^2	243,176	---
Lighting	142,500 ft^2	2.56 Btu/ft^2	364,764	---

TOTAL TEMP-INDEPENDENT GAINS: 958,941 BTUH

Notes:

1) Btu/hr/person figure is based on the assumption that the total heat gain for an office worker is 450 Btu/hr. (From ASHRAE Fundamentals Handbook, 30.4)
2) Equipment heat gain is based on 0.5 watts per squre foot (from ASHRAE Fundamentals Handbook, 30.12)
3) Lighting heat gain is based on 1.0 watts per square foot, with a 75% usage factor.
4) Design humidity ratio based on 72F dry bulb with 50% relative humidity.

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PROJECT: Berlin CT
SUBJECT: Boiler Replacement
FACILITY: McGee Middle School

PROJECT NO: 142312-86
DATE: 11/9/2015

	Month Demand kW	Electricity kWh	Heating Fuel MMBtu
Boiler Replacement			**847**

	Existing	Proposed
Design Combustion Efficiency	85%	90%
Radiant Jacket Losses	1%	0%
Cycling Losses (Low Load)	2%	1%
Cycling Losses (Full Load)	2%	1%
Distribution Losses	4%	2%
Total Efficiency	80%	88%

Boiler Output

Design Heating Load (kBh)	3855	3855
Heating Balance Temp (F)	55	55
Design Heating Temp (F)	2	2

Outside Air Bin Temp (F)	Annual Operating Bin Hours	Existing Number of Boilers	Proposed Number of Boilers	Heating Load (%)	Existing Heating Load (kBh)	Proposed Heating Load (kBh)	Existing Heating Efficiency	Proposed Heating Efficiency	Existing Standby Losses	Propoosed Standby Losses	Existing Cycling Losses	Propoosed Cycling Losses	Existing NG Use (ccf)	Proposed NG Use (ccf)	Saved Energy Use (ccf)
	See Note 1														
112	0	0	0	0%	0	0	80%	88%	0	0	0	0	0	0	0
107	0	0	0	0%	0	0	80%	88%	0	0	0	0	0	0	0
102	0	0	0	0%	0	0	80%	88%	0	0	0	0	0	0	0
97	0	0	0	0%	0	0	80%	88%	0	0	0	0	0	0	0
92	0	0	0	0%	0	0	80%	88%	0	0	0	0	0	0	0
87	0	0	0	0%	0	0	80%	88%	0	0	0	0	0	0	0
82	5	0	0	0%	0	0	80%	88%	0	0	0	0	0	0	0
77	6	0	0	0%	0	0	80%	88%	0	0	0	0	0	0	0
72	16	0	0	0%	0	0	80%	88%	0	0	0	0	0	0	0
67	44	0	0	0%	0	0	80%	88%	0	0	0	0	0	0	0
62	135	0	0	0%	0	0	80%	88%	0	0	0	0	0	0	0
57	334	0	0	0%	0	0	80%	88%	0	0	0	0	0	0	0
52	477	4	4	6%	218	218	80%	88%	1041	0	2550	1041	1,306	1,165	140
47	401	4	4	15%	582	582	80%	88%	2334	0	5717	2334	2,927	2,612	315
42	552	4	4	25%	946	946	80%	88%	5220	0	12789	5220	6,548	5,844	704
37	874	4	4	34%	1,309	1,309	80%	88%	11444	0	28037	11444	14,355	12,811	1,544
32	716	4	4	43%	1,673	1,673	80%	88%	11979	0	29349	11979	15,027	13,411	1,616
27	519	4	4	53%	2,037	2,037	80%	88%	10571	0	25899	10571	13,260	11,834	1,426
22	497	4	4	62%	2,400	2,400	80%	88%	11930	0	29229	11930	14,965	13,356	1,609
17	234	4	4	72%	2,764	2,764	80%	88%	6468	0	15847	6468	8,114	7,241	873
12	75	4	4	81%	3,128	3,128	80%	88%	2346	0	5748	2346	2,943	2,626	316
7	27	4	4	91%	3,492	3,492	80%	88%	943	0	2310	943	1,183	1,055	127
2	11	4	4	100%	3,855	3,855	80%	88%	424	0	1039	424	532	475	57
-3	0	4	4	100%	3,855	3,855	80%	88%	0	0	0	0	0	0	0
-8	0	4	4	100%	3,855	3,855	80%	88%	0	0	0	0	0	0	0
-13	0	4	4	100%	3,855	3,855	80%	88%	0	0	0	0	0	0	0
-18	0	4	4	100%	3,855	3,855	80%	88%	0	0	0	0	0	0	0
-23	0	4	4	100%	3,855	3,855	80%	88%	0	0	0	0	0	0	0
	4922.5												81,159	72,431	8,728

Notes:

1) Weather from USAF for Hartford Int'l Airport

ECM-9: NEW FAN COIL AND AIR HANDLING UNITS

ECM-9: NEW FAN COIL AND AIR HANDLING UNITS

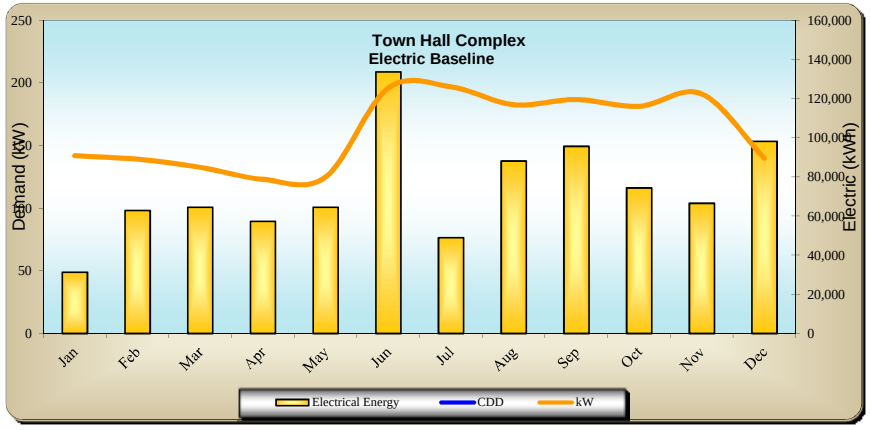
Attachment 9A: New HVAC Savings Calculations

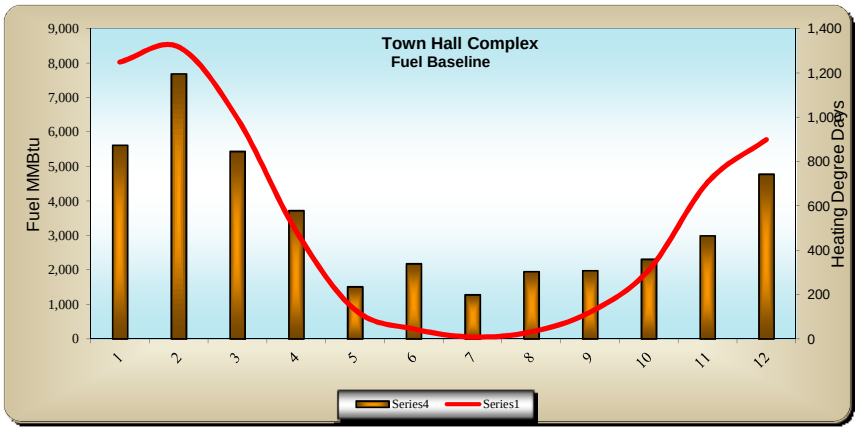
Town Hall Complex

49,018 ft²

NORESCO

FROM:	May-2014	TO:	Apr-2015							
Month	HDD	CDD	Billed Demand kW	Electrical Energy kWh	Total Electric Cost $	Blended Unit Cost $/kWh	Natural Gas CCF	Natural Gas Cost $	Natural Gas $/CCF	Total Utility Cost $
Jan	1,249		141.8	31,357		$0.0000	5,620		$0.00	$0
Feb	1,317		139.0	62,880		$0.0000	7,690		$0.00	$0
Mar	994		132.6	64,480		$0.0000	5,440		$0.00	$0
Apr	486		123.0	57,280		$0.0000	3,720		$0.00	$0
May	131		124.8	64,480		$0.0000	1,510		$0.00	$0
Jun	44		195.8	133,744		$0.0000	2,180		$0.00	$0
Jul	8		196.8	48,946		$0.0000	1,280		$0.00	$0
Aug	31		182.6	88,160		$0.0000	1,950		$0.00	$0
Sep	120		186.7	95,680		$0.0000	1,980		$0.00	$0
Oct	310		181.3	74,400		$0.0000	2,310		$0.00	$0
Nov	706		191.2	66,560		$0.0000	2,990		$0.00	$0
Dec	899		139.9	98,243		$0.0000	4,780		$0.00	$0
TOTALS	**6,295**	**0**	**1,935.5**	**886,210**	**$0**	**$0.0000**	**41,450**	**$0**	**$0.00**	**$0**
				18.1					**86.8**	**$0.00**
				kWh/Sqft					Mbtu/Sqft	$/Sqft
				61.7					**13.8**	**148.5**
				Mbtu/Sqft					Btu/Sqft/HDD	Mbtu/Sqft





NORESCO

PROJECT: Berlin CT
SUBJECT: Facility Information
FACILITY: Town Hall Complex

PROJECT No: 142312-86
DATE: 11/9/2015

Facility Name:	Town Hall Complex	
Facility Square Footage	49,018	sq ft
Weather Data	*Hartford Int'l Airport*	
HEATING EQUIPMENT		
	Existing Efficiency	Proposed Efficiency
Boiler Burner Efficiency	85%	90%
Boiler Losses	-1%	0%
Distribution Losses	-5%	-5%
Heating System Efficiency	79.0%	85%
% of Square Footage Heated	100.0%	100.0%
COOLING EQUIPMENT	Existing Efficiency	Proposed Efficiency
Cooling System Efficiency	0.54	0.54
% of Square Footage Cooled	100.0%	

SPACE TEMPERATURES		
Heating Design Temperature	2	F
Cooling Design Temperature	91	F
Outdoor Balance Point	60	F
Current Heating Setpoint	72	F
Proposed Heating Setpoint	72	F
Current Setback Temp	73	F
Proposed Setback Temp	67	F
Current Cooling Setpoint	74	F
Proposed Cooling Setpoint	74	F
Current Setforward Temp	74	F
Proposed Setforward Temp	80	F
Does setback occur at the end of the Occupied Time?		
(Normally the answer is No)	y or n	**n**
Setback starts at the end of the equipment operating hours.		

Typical Occupancy Schedule
7am to 5pm6 days/week

12am-8am	8am-4pm	4pm-12am	Days/Week
1.0	8.0	1.0	6.0
7.0		5.0	1.0
		pm	

Current Operating Schedule - Heating
continuous

12am-8am	8am-4pm	4pm-12am	Days/Week
8.0	8.0	8.0	7.0
0.0		12.0	0.0
		am	

Current Operating Schedule - Cooling
6am to 4pm7 days/week*

12am-8am	8am-4pm	4pm-12am	Days/Week
2.0	8.0	0.0	7.0
6.0		4.0	0.0
		pm	

Proposed Operating Schedule - Heating
6am to 5pm7 days/week

12am-8am	8am-4pm	4pm-12am	Days/Week
2.0	8.0	1.0	7.0
6.0		5.0	0.0
		pm	

Proposed Operating Schedule - Cooling
6am to 5pm6 days/week

12am-8am	8am-4pm	4pm-12am	Days/Week
2.0	8.0	1.0	6.0
6.0		5.0	1.0
		pm	

SEER/COP/KW/Ton Quick Calculator

	INPUT Value	OUTPUT Conversion SEER/EER	KW/TON	COP
SEER/EER	*14.00*	14.00	0.86	4.10
KW/TON	*1.06*	11.32	1.06	3.32
COP	*3.60*	12.29	0.98	3.60

2 Natural Gas (ccf)

	Heating Fuel	Description	Unit	Abbrev Ui	Btu/unit
	SELECT HEATING FUEL...				
1	Natural Gas (th	Natural Gas	therms	therm	100,000
2	Natural Gas (cc	Natural Gas	ccf	ccf	102,700
3	Natural Gas (M	Natural Gas	MMBtu	MMBtu	1,000,000
4	Propane	Propane	gallons	gal	91,600
5	Fuel Oil #2	Fuel Oil #2	gallons	gal	139,000
6	Fuel Oil #4	Fuel Oil #4	gallons	gal	144,000
7	Fuel Oil #6	Fuel Oil #6	gallons	gal	152,000
8	Anthracite Coa	Anthracite Coa	tons	ton	25,400,000
9	Steam	Steam	lbs	lb	970
10	Electricity	Electric Heat	kWh	kWh	3,413

NORESCO

PROJECT: Berlin CT
SUBJECT: Load Calculations
FACILITY: Town Hall Complex

PROJECT No: 142312-86
DATE: 11/9/2015

Facility Name: Town Hall Complex
Floor Area: 49,018 ft^2
Ceiling Height: 12 ft
Total Volume: 588,216 ft^3

HEATING LOADS

Design Conditions

Item	Temperature DB (F)
Occupied Heating Setpoint	72
Outdoor Design Condition	2
Design Difference	70

Building Envelope Losses

Item	Total Wall Area (ft^2)	Net Wall Area (ft^2)	Temperature Difference (F)	U-Factor Btu/(hr-F-ft^2)	Heat Transfer (BtuH)	UA
	A	B	C	D	E = BxCxD	F = BxD
North Wall	5,314	4,517	70	0.20	63,232	903
East Wall	2,657	2,258	70	0.20	31,616	452
South Wall	5,314	4,517	70	0.20	63,232	903
West Wall	2,657	2,258	70	0.20	31,616	452
Roof	---	24,509	70	0.10	171,563	2,451
Glass Area	---	7,970	70	0.70	390,550	5,579

Infiltration Losses - Sensible

Item	Wall Area (ft^2)	Infiltration Rate (CFM/ft^2)	Infiltration Rate (CFM)	Temperature Difference (F)	Heat Transfer (BtuH)	UA
	A	B	C = AxB	D	E = 1.08xCxD	F
Infiltration	13,550	0.15	2,032	70	153,653	---

Infiltration Losses - Latent

Item	Wall Area (ft^2)	Infiltration Rate (CFM/ft^2)	Infiltration Rate (CFM)	Humidity Ratio Difference (gr/lb)	Heat Transfer (BtuH)	UA
	A	B	C = AxB	D	E = 4840xCxD/7000	F
Infiltration	13,550	0.15	2,032	0	0	---

TOTAL ENVELOPE LOSSES: 905,462 BTUH
12,935 Btu/hr/F

NORESCO

PROJECT: Berlin CT
SUBJECT: Load Calculations
FACILITY: Town Hall Complex

PROJECT No: 142312-86
DATE: 11/9/2015

Facility Name:	Town Hall Complex	
Floor Area:	49,018	ft^2
Ceiling Height:	12	ft
Total Volume:	588,216	ft^3

HEATING LOADS

Ventilation Losses - Sensible

Item	Number of Occupants	Ventilation Rate (CFM/person)	Ventilation Rate (CFM)	Temperature Difference (F)	Heat Transfer (BtuH)	UA
	A	B	C = AxB	D	E = 1.08xCxD	F
Ventilation	45	25	1,125	70	85,050	---

Ventilation Losses - Latent

Item	Number of Occupants	Ventilation Rate (CFM/person)	Ventilation Rate (CFM)	Humidity Ratio Difference (gr/lb)	Heat Transfer (BtuH)	UA
	A	B	C = AxB	D	E = 4840xCxD/7000	F
Ventilation	45	25	1,125	0	0	---

TOTAL VENTILATION LOSSES: 85,050 BTUH
1,215 Btu/hr/F

Internal Loads

Load	Factor 1	Factor 2	Heat Transfer (BtuH)	UA
	A	B	C = AxB	D
People	45 People	250 BtuH/Person	11,250	---
Equipment	49,018 ft^2	1.71 Btu/ft^2	83,649	---
Lighting	49,018 ft^2	2.56 Btu/ft^2	125,474	---

TOTAL TEMP-INDEPENDENT GAINS: 220,373 BTUH

Notes:

1) Btu/hr/person figure is based on the assumption that the sensible heat gain for an office worker is 250 Btu/hr. (From ASHRAE Fundamentals Handbook, 30.4)
2) Equipment heat gain is based on 0.5 watts per squre foot (from ASHRAE Fundamentals Handbook, 30.12)
3) Lighting heat gain is based on 1.0 watts per square foot, with a 75% usage factor.

NORESCO

PROJECT: Berlin CT
SUBJECT: Load Calculations
FACILITY: Town Hall Complex

PROJECT No: 142312-86
DATE: 11/9/2015

Facility Name:	Town Hall Complex
Floor Area:	49,018 ft^2
Ceiling Height:	12 ft
Total Volume:	588,216 ft^3

COOLING LOADS

Design Conditions

Item	Temperature DB (F)	Humidity Ratio (gr/lb)
Occupied Cooling Setpoint	74	58
Outdoor Design Condition	91	124
Design Difference	17	66

Estimate of Window Solar Gain Assumptions

Affected Glass	35%	Percent
Solar Ht Gain[1]	280	Btu/(Hr.-sq. ft.)
SHGF.	0.70	
SC	0.88	

1. ASHRAE 1989 Ch 27 Tb 3-11; 40 NL August 21, noon

Building Envelope Gains

Item	Total Wall Area (ft^2)	Net Wall Area (ft^2)	Temperature Difference (F)	U-Factor Btu/(hr-F-ft^2)	Heat Transfer (BtuH)	UA
	A	B	C	D	E = BxCxD	F = BxD
North Wall	5,314	4,517	17	0.20	15,356	903
East Wall	2,657	2,258	17	0.20	7,678	452
South Wall	5,314	4,517	17	0.20	15,356	903
West Wall	2,657	2,258	17	0.20	7,678	452
Roof	---	24,509	17	0.10	41,665	2,451
Glass Area	---	7,970	17	0.70	94,848	5,579
Glass - Solar		7,970			483,907	

Infiltration Gains - Sensible

Item	Wall Area (ft^2)	Infiltration Rate (CFM/ft^2)	Infiltration Rate (CFM)	Temperature Difference (F)	Heat Transfer (BtuH)	UA
	A	B	C = AxB	D	E = 1.08xCxD	F
Infiltration	13,550	0.15	2,032	17	37,316	---

Infiltration Gains - Latent

Item	Wall Area (ft^2)	Infiltration Rate (CFM/ft^2)	Infiltration Rate (CFM)	Humidity Ratio Difference (gr/lb)	Heat Transfer (BtuH)	UA
	A	B	C = AxB	D	E = 4840xCxD/7000	F
Infiltration	13,550	0.15	2,032	66	92,230	---

TOTAL ENVELOPE GAINS: **796,034 BTUH**
46,826 Btu/hr/F

NORESCO

PROJECT: Berlin CT
SUBJECT: Load Calculations
FACILITY: Town Hall Complex

PROJECT No: 142312-86
DATE: 11/9/2015

Facility Name:	Town Hall Complex
Floor Area:	49,018 ft^2
Ceiling Height:	12 ft
Total Volume:	588,216 ft^3

COOLING LOADS

Ventilation Gains - Sensible

Item	Number of Occupants	Ventilation Rate (CFM/person)	Ventilation Rate (CFM)	Temperature Difference (F)	Heat Transfer (BtuH)	UA
	A	B	C = AxB	D	E = 1.08xCxD	F
Ventilation	45	25	1,125	17	20,655	---

Ventilation Gains - Latent

Item	Number of Occupants	Ventilation Rate (CFM/person)	Ventilation Rate (CFM)	Humidity Ratio Difference (gr/lb)	Heat Transfer (BtuH)	UA
	A	B	C = AxB	D	E = 4840xCxD/7000	F
Ventilation	45	25	1,125	66	51,051	---

TOTAL VENTILATION GAINS: **71,706 BTUH**
4,218 Btu/hr/F

Internal Loads

Load	Factor 1	Factor 2	Heat Transfer (BtuH)	UA
	A	B	C = AxB	D
People	45 People	450 BtuH/Person	20,250	---
Equipment	49,018 ft^2	1.71 Btu/ft^2	83,649	---
Lighting	49,018 ft^2	2.56 Btu/ft^2	125,474	---

TOTAL TEMP-INDEPENDENT GAINS: **229,373 BTUH**

Notes:

1) Btu/hr/person figure is based on the assumption that the total heat gain for an office worker is 450 Btu/hr. (From ASHRAE Fundamentals Handbook, 30.4)
2) Equipment heat gain is based on 0.5 watts per squre foot (from ASHRAE Fundamentals Handbook, 30.12)
3) Lighting heat gain is based on 1.0 watts per square foot, with a 75% usage factor.
4) Design humidity ratio based on 72F dry bulb with 50% relative humidity.

NORESCO

PROJECT: Berlin CT
SUBJECT: New HVAC (Temperature Setback Analysis - Cooling)
FACILITY: Town Hall Complex

PROJECT No: 142312-86
DATE: 11/9/2015

	Month Demand kW	Electricity kWh	Heating Fuel MMBtu
New HVAC (Temperature Setback Analysis - Cooling)		**3,766**	

Facility Name:	Town Hall Complex	
Current Cooling Setpoint	74	AA
Proposed Cooling Setpoint	74	BB
Current Setforward Temp	74	CC
Proposed Setforward Temp	80	DD
Percent of Building Affected:	100%	
Envelope Losses (Btu/hr/F)	46,826	EE
Ventilation Losses (Btu/hr/F)	4,218	FF
Internal Gains (MBtu/hr)	229	GG
Cooling Efficiency (kW/ton):	0.54	HH

Use HVAC operating Bins? Y/N Y

Typical Occupancy Schedule 7am to 5pm6 days/week				Current Operating Schedule - Cooling 6am to 4pm7 days/week*				Proposed Operating Schedule - Cooling 6am to 5pm6 days/week			
12am-8am	8am-4pm	4pm-12am	Days/Week	12am-8am	8am-4pm	4pm-12am	Days/Week	12am-8am	8am-4pm	4pm-12am	Days/Week
1.0	8.0	1.0	6.0	2.0	8.0	0.0	7.0	2.0	8.0	1.0	6.0
JJ	KK	LL	MM	NN	PP	QQ	RR	SS	TT	UU	VV

Unoccupied Hours - Fans Still Running; Occupied Hours; Unoccupied Hours - Systems Shut Down

Outdoor Air Bin Temp F	Annual Bin Hours 12am-8am	Annual Bin Hours 8am-4pm	Annual Bin Hours 4pm-12am	Total Annual Bin Hours	Occupied Bin Hours 12am-8am	Occupied Bin Hours 8am-4pm	Occupied Bin Hours 4pm-12am	Current Occupied Bin Hours	Operating Bin Hours 12am-8am	Operating Bin Hours 8am-4pm	Operating Bin Hours 4pm-12am	Current Operating Bin Hours	EXISTING Operating Heat Gains MBtu/hr	EXISTING Setforward Heat Gains MBtu/hr	EXISTING Total Electric Use kWh/yr	Operating Bin Hours 12am-8am	Operating Bin Hours 8am-4pm	Operating Bin Hours 4pm-12am	Proposed Operating Bin Hours	PROPOSED Operating Heat Gains MBtu/hr	PROPOSED Setforward Heat Gains MBtu/hr	PROPOSED Total Electric Use kWh/yr	Saved Electric kWh/yr
A	B	C	D	E = B+C+D	F = B x JJ / 8	G = C x KK / 8	H = D x LL / 8	J = F+G+H	K = B x NN / 8	L = C x PP / 8	M = D x QQ / 8	N = K+L+M	P = (A-AA) x (EE+FF) / 1000	Q = (A-CC) x EE / 1000	R = J x (P+GG) + (N-J) x P + (E-N) x Q / 12/HH	S = B x SS / 8	T = C x TT / 8	U = D x UU / 8	V = S+T+U	W = (A-BB) x (EE+FF) / 1000	X = (A-DD) x EE / 1000	Y = J x (W+GG) + (V-J) x W + (E-V) x X / 12/HH	Z = R - Y
Hartford Int'l Airport																							
107	0	0	0	0	0	0	0	0	0	0	0	0	1,684	1,545	0	0	0	0	0	1,684	1,264	0	**0**
102	0	0	0	0	0	0	0	0	0	0	0	0	1,429	1,311	0	0	0	0	0	1,429	1,030	0	**0**
97	0	4	0	4	0	3	0	3	0	4	0	4	1,174	1,077	247	0	3	0	3	1,174	796	237	**10**
92	0	34	9	43	0	29	1	30	0	34	0	34	919	843	2,062	0	29	1	30	919	562	1,885	**177**
87	0	105	22	127	0	90	2	92	0	105	0	105	664	609	4,700	0	90	2	92	664	328	4,230	**470**
82	4	247	105	356	0	212	11	223	1	247	0	248	408	375	8,700	1	212	11	224	408	94	6,989	**1,711**
77	55	243	158	456	6	208	17	231	14	243	0	257	153	140	5,424	12	208	17	237	153	0	4,026	**1,398**
72	137	208	183	528	15	178	20	213	34	208	0	242	0	0	2,198	29	178	20	227	0	0	2,198	**0**
67	199	231	248	678	21	198	27	246	50	231	0	281	0	0	2,543	43	198	27	267	0	0	2,543	**0**
62	306	300	310	916	33	257	33	323	77	300	0	377	0	0	3,342	66	257	33	356	0	0	3,342	**0**
57	270	226	289	785	29	194	31	254	68	226	0	294	0	0	0	58	194	31	283	0	0	0	**0**
52	291	186	261	738	31	159	28	219	73	186	0	259	0	0	0	62	159	28	250	0	0	0	**0**
47	210	129	187	526	23	111	20	153	53	129	0	182	0	0	0	45	111	20	176	0	0	0	**0**
42	282	188	155	625	30	161	17	208	71	188	0	259	0	0	0	60	161	17	238	0	0	0	**0**
37	288	296	306	890	31	254	33	317	72	296	0	368	0	0	0	62	254	33	348	0	0	0	**0**
32	252	222	251	725	27	190	27	244	63	222	0	285	0	0	0	54	190	27	271	0	0	0	**0**
27	182	160	177	519	20	137	19	176	46	160	0	206	0	0	0	39	137	19	195	0	0	0	**0**
22	231	89	177	497	25	76	19	120	58	89	0	147	0	0	0	50	76	19	145	0	0	0	**0**
17	135	42	57	234	14	36	6	57	34	42	0	76	0	0	0	29	36	6	71	0	0	0	**0**
12	44	7	24	75	5	6	3	13	11	7	0	18	0	0	0	9	6	3	18	0	0	0	**0**
7	23	3	1	27	2	3	0	5	6	3	0	9	0	0	0	5	3	0	8	0	0	0	**0**
2	11	0	0	11	1	0	0	1	3	0	0	3	0	0	0	2	0	0	2	0	0	0	**0**
-3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
-8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
-13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
-18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
	2,920	2,920	2,920	8,760	313	2,503	313	3,129	730	2,920	0	3,650			29,215	626	2,503	313	3,441			25,450	**3,766**

NORESCO

PROJECT: Berlin CT
SUBJECT: New HVAC (Temperature Setback - Heating)
FACILITY: Town Hall Complex

PROJECT No: 142312-86
DATE: 11/9/2015

	Month Demand kW	Electricity kWh	Heating Fuel MMBtu
New HVAC (Temperature Setback - Heating)			**387**

Facility Name:	Town Hall Complex	
Current Heating Setpoint	72	AA
Proposed Heating Setpoint	72	BB
Current Setback Temp	73	CC
Proposed Setback Temp	67	DD
Percent of Building Affected:	100%	
Envelope Losses (Btu/hr/F)	12,935	EE
Ventilation Losses (Btu/hr/F)	1,215	FF
Internal Gains (MBtu/hr)	220	GG
Heating System Efficiency:	85.0%	HH

Use HVAC operating Bins? Y/N Y

Typical Occupancy Schedule
7am to 5pm6 days/week

12am-8am	8am-4pm	4pm-12am	Days/Week
1.0	8.0	1.0	6.0
JJ	KK	LL	MM

Current Operating Schedule - Heating
continuous

12am-8am	8am-4pm	4pm-12am	Days/Week
8.0	8.0	8.0	7.0
NN	PP	QQ	RR

Proposed Operating Schedule - Heating
6am to 5pm7 days/week

12am-8am	8am-4pm	4pm-12am	Days/Week
2.0	8.0	1.0	7.0
SS	TT	UU	VV

Unoccupied Hours - Fans Still Running Setback may be on or off
Unoccupied Hours - Systems Shut Down
Occupied Hours

EXISTING

Outdoor Air Bin Temp F	Annual Bin Hours 12am-8am	Annual Bin Hours 8am-4pm	Annual Bin Hours 4pm-12am	Total Annual Bin Hours
A	B	C	D	E = B+C+D
Hartford Int'l Airport				
107	0	0	0	0
102	0	0	0	0
97	0	4	0	4
92	0	34	9	43
87	0	105	22	127
82	4	247	105	356
77	55	243	158	456
72	137	208	183	528
67	199	231	248	678
62	306	300	310	916
57	270	226	289	785
52	291	186	261	738
47	210	129	187	526
42	282	188	155	625
37	288	296	306	890
32	252	222	251	725
27	182	160	177	519
22	231	89	177	497
17	135	42	57	234
12	44	7	24	75
7	23	3	1	27
2	11	0	0	11
-3	0	0	0	0
-8	0	0	0	0
-13	0	0	0	0
-18	0	0	0	0
	2,920	2,920	2,920	8,760

Occupied Bin Hours 12am-8am	Occupied Bin Hours 8am-4pm	Occupied Bin Hours 4pm-12am	Current Occupied Bin Hours
F = BxJJxMM / 8 / 7	G = CxKKxMM / 8 / 7	H = DxLLxMM / 8 / 7	J = F+G+H
0	0	0	0
0	0	0	0
0	3	0	3
0	29	1	30
0	90	2	92
0	212	11	223
6	208	17	231
15	178	20	213
21	198	27	246
33	257	33	323
29	194	31	254
31	159	28	219
23	111	20	153
30	161	17	208
31	254	33	317
27	190	27	244
20	137	19	176
25	76	19	120
14	36	6	57
5	6	3	13
2	3	0	5
1	0	0	1
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
313	2,503	313	3,129

Operating Bin Hours 12am-8am	Operating Bin Hours 8am-4pm	Operating Bin Hours 4pm-12am	Current Operating Bin Hours
K = BxNNxRR / 8 / 7	L = CxPPxRR / 8 / 7	M = DxQQxRR / 8 / 7	N = K+L+M
0	0	0	0
0	0	0	0
0	4	0	4
0	34	9	43
0	105	22	127
4	247	105	356
55	243	158	456
137	208	183	528
199	231	248	678
306	300	310	916
270	226	289	785
291	186	261	738
210	129	187	526
282	188	155	625
288	296	306	890
252	222	251	725
182	160	177	519
231	89	177	497
135	42	57	234
44	7	24	75
23	3	1	27
11	0	0	11
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
2,920	2,920	2,920	8,760

Operating Heat Loss MBtu/hr	Setback Heat Loss MBtu/hr	Total Fuel Use ccf/yr
P = (AA-A)x(EE+FF) / 1000	Q = (CC-A)xEE / 1000	R = [a(P-GG)+(24-h)xP+c(N-h)xQ] / (E-N)xΩ / 103xHH
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
212	207	1,292
283	272	1,841
354	336	1,745
425	401	2,514
495	466	4,248
566	530	4,084
637	595	3,342
708	660	3,725
778	724	1,943
849	789	696
920	854	271
991	918	122
1,061	983	0
1,132	1,048	0
1,203	1,112	0
1,274	1,177	0
		25,825

Operating Bin Hours 12am-8am	Operating Bin Hours 8am-4pm	Operating Bin Hours 4pm-12am	Proposed Operating Bin Hours
S = BxSSxVV / 8 / 7	T = CxTTxVV / 8 / 7	U = DxUUxVV / 8 / 7	V = S+T+U
0	0	0	0
0	0	0	0
0	4	0	4
0	34	1	35
0	105	3	108
1	247	13	261
14	243	20	277
34	208	23	265
50	231	31	312
77	300	39	415
68	226	36	330
73	186	33	291
53	129	23	205
71	188	19	278
72	296	38	406
63	222	31	316
46	160	22	228
58	89	22	169
34	42	7	83
11	7	3	21
6	3	0	9
3	0	0	3
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
730	2,920	365	4,015

Unoccupied Hours - Fans Still Running Setback may be on or off
Unoccupied Hours - Systems Shut Down
Occupied Hours

PROPOSED

Occupied Heat Loss MBtu/hr	Unoccupied Heat Loss MBtu/hr	Total Fuel Use ccf/yr
W = (BB-A)x(EE+FF) / 1000	X = (DD-A)xEE / 1000	Y = [a(W-GG)+(24-h)xW+c(V-h)xX] / (E-V)xΩ / 103xHH
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
212	129	860
283	194	1,386
354	259	1,395
425	323	2,112
495	388	3,654
566	453	3,554
637	517	2,944
708	582	3,254
778	647	1,716
849	711	611
920	776	242
991	841	108
1,061	905	0
1,132	970	0
1,203	1,035	0
1,274	1,099	0
		21,835

Saved Fuel Use ccf/yr
Z = R - Y
0
0
0
0
0
0
0
0
0
0
432
455
350
402
594
530
398
471
228
85
30
14
0
0
0
0
3,990

ECM-10: SOLAR PHOTOVOLTAICS

ECM-10: SOLAR PHOTOVOLTAICS

Attachment 10A: PV Savings Calculations

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Caution: Photovoltaic system performance predictions calculated by PVWatts® include many inherent assumptions and uncertainties and do not reflect variations between PV technologies nor site-specific characteristics except as represented by PVWatts® inputs. For example, PV modules with better performance are not differentiated within PVWatts® from lesser performing modules. Both NREL and private companies provide more sophisticated PV modeling tools (such as the System Advisor Model at http://sam.nrel.gov) that allow for more precise and complex modeling of PV systems.

RESULTS

261,595 kWh per Year *

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Energy Value ($)
January	3.09	18,351	N/A
February	2.43	13,101	N/A
March	3.99	22,506	N/A
April	5.97	31,524	N/A
May	5.24	28,146	N/A
June	6.40	32,013	N/A
July	5.32	27,859	N/A
August	5.30	27,546	N/A
September	3.64	18,980	N/A
October	3.29	18,106	N/A
November	2.84	15,550	N/A
December	1.36	7,911	N/A
Annual	4.07	261,593	0

Location and Station Identification

Requested Location	133 Heather Lane, Berlin, CT	
Weather Data Source	(TMY3) HARTFORD BRAINARD FD, CT	9.6 mi
Latitude	41.73° N	
Longitude	72.65° W	

PV System Specifications *(Commercial)*

DC System Size	221.34 kW
Module Type	Standard
Array Type	Fixed (roof mount)
Array Tilt	18°
Array Azimuth	180°
System Losses	13%
Inverter Efficiency	96%
DC to AC Size Ratio	1.1

Initial Economic Comparison

Average Cost of Electricity Purchased from Utility	No utility data available
Initial Cost	No initial cost defined
Cost of Electricity Generated by System	not determined

- For economic incentives to be calculated, Average Cost of Electricity Purchased and Initial Cost must both be set on the SYSTEM INFO page.

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Caution: Photovoltaic system performance predictions calculated by PVWatts® include many inherent assumptions and uncertainties and do not reflect variations between PV technologies nor site-specific characteristics except as represented by PVWatts® inputs. For example, PV modules with better performance are not differentiated within PVWatts® from lesser performing modules. Both NREL and private companies provide more sophisticated PV modeling tools (such as the System Advisor Model at http://sam.nrel.gov) that allow for more precise and complex modeling of PV systems.

RESULTS

174,396 kWh per Year *

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Energy Value ($)
January	3.09	12,234	N/A
February	2.43	8,734	N/A
March	3.99	15,004	N/A
April	5.97	21,016	N/A
May	5.24	18,764	N/A
June	6.40	21,342	N/A
July	5.32	18,573	N/A
August	5.30	18,364	N/A
September	3.64	12,654	N/A
October	3.29	12,071	N/A
November	2.84	10,366	N/A
December	1.36	5,274	N/A
Annual	4.07	174,396	0

Location and Station Identification

Requested Location	139 Grove St, East Berlin, CT	
Weather Data Source	(TMY3) HARTFORD BRAINARD FD, CT	8.9 mi
Latitude	41.73° N	
Longitude	72.65° W	

PV System Specifications *(Commercial)*

DC System Size	147.56 kW
Module Type	Standard
Array Type	Fixed (roof mount)
Array Tilt	18°
Array Azimuth	180°
System Losses	13%
Inverter Efficiency	96%
DC to AC Size Ratio	1.1

Initial Economic Comparison

Average Cost of Electricity Purchased from Utility	No utility data available
Initial Cost	No initial cost defined
Cost of Electricity Generated by System	not determined

- For economic incentives to be calculated, Average Cost of Electricity Purchased and Initial Cost must both be set on the SYSTEM INFO page.

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Caution: Photovoltaic system performance predictions calculated by PVWatts® include many inherent assumptions and uncertainties and do not reflect variations between PV technologies nor site-specific characteristics except as represented by PVWatts® inputs. For example, PV modules with better performance are not differentiated within PVWatts® from lesser performing modules. Both NREL and private companies provide more sophisticated PV modeling tools (such as the System Advisor Model at http://sam.nrel.gov) that allow for more precise and complex modeling of PV systems.

RESULTS

261,595 kWh per Year *

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Energy Value ($)
January	3.09	18,351	N/A
February	2.43	13,101	N/A
March	3.99	22,506	N/A
April	5.97	31,524	N/A
May	5.24	28,146	N/A
June	6.40	32,013	N/A
July	5.32	27,859	N/A
August	5.30	27,546	N/A
September	3.64	18,980	N/A
October	3.29	18,106	N/A
November	2.84	15,550	N/A
December	1.36	7,911	N/A
Annual	4.07	261,593	0

Location and Station Identification

Requested Location	899 Norto Rd, Berlin, CT	
Weather Data Source	(TMY3) HARTFORD BRAINARD FD, CT	10.0 mi
Latitude	41.73° N	
Longitude	72.65° W	

PV System Specifications *(Commercial)*

DC System Size	221.34 kW
Module Type	Standard
Array Type	Fixed (roof mount)
Array Tilt	18°
Array Azimuth	180°
System Losses	13%
Inverter Efficiency	96%
DC to AC Size Ratio	1.1

Initial Economic Comparison

Average Cost of Electricity Purchased from Utility	No utility data available
Initial Cost	No initial cost defined
Cost of Electricity Generated by System	not determined

- For economic incentives to be calculated, Average Cost of Electricity Purchased and Initial Cost must both be set on the SYSTEM INFO page.

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Caution: Photovoltaic system performance predictions calculated by PVWatts® include many inherent assumptions and uncertainties and do not reflect variations between PV technologies nor site-specific characteristics except as represented by PVWatts® inputs. For example, PV modules with better performance are not differentiated within PVWatts® from lesser performing modules. Both NREL and private companies provide more sophisticated PV modeling tools (such as the System Advisor Model at http://sam.nrel.gov) that allow for more precise and complex modeling of PV systems.

RESULTS

305,194 kWh per Year *

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Energy Value ($)
January	3.09	21,410	N/A
February	2.43	15,285	N/A
March	3.99	26,257	N/A
April	5.97	36,779	N/A
May	5.24	32,837	N/A
June	6.40	37,349	N/A
July	5.32	32,503	N/A
August	5.30	32,137	N/A
September	3.64	22,144	N/A
October	3.29	21,123	N/A
November	2.84	18,141	N/A
December	1.36	9,230	N/A
Annual	4.07	305,195	0

Location and Station Identification

Requested Location	1088 Norton Rd, Berlin, CT	
Weather Data Source	(TMY3) HARTFORD BRAINARD FD, CT	9.8 mi
Latitude	41.73° N	
Longitude	72.65° W	

PV System Specifications *(Commercial)*

DC System Size	258.23 kW
Module Type	Standard
Array Type	Fixed (roof mount)
Array Tilt	18°
Array Azimuth	180°
System Losses	13%
Inverter Efficiency	96%
DC to AC Size Ratio	1.1

Initial Economic Comparison

Average Cost of Electricity Purchased from Utility	No utility data available
Initial Cost	No initial cost defined
Cost of Electricity Generated by System	not determined

- For economic incentives to be calculated, Average Cost of Electricity Purchased and Initial Cost must both be set on the SYSTEM INFO page.