**ENERGY SERVICES AGREEMENT** 



# **TOWN OF BERLIN**

**BERLIN, CONNECTICUT** 

Guaranteed Savings Reconciliation Report Year Two

May 31, 2020

Submitted by:



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# **ENERGY SERVICES AGREEMENT**

# **TOWN OF BERLIN**BERLIN, CONNECTICUT

# GUARANTEED SAVINGS RECONCILIATION REPORT YEAR TWO

May 31, 2020



# TABLE OF CONTENTS

# SECTION II: GUARANTEED SAVINGS RECONCILIATION REPORT SECTION III: ATTACHMENTS

#### OVERALL PROJECT SUMMARY

Attachment OA: Final ECM Acceptance

Attachment OB: Year Two O&M Inspection Report

#### ► ECM-1: LIGHTING IMPROVEMENT AND CONTROLS

Attachment 1A: Hours Group Summary

Attachment 1B: Lighting Savings Summary and Building Summary

#### ECM-2: DIRECT DIGITAL CONTROL ENERGY MANAGEMENT SYSTEM

Attachment 2A: New DDC EMS Savings Calculations

#### ECM-3: VARIABLE FREQUENCY DRIVES AND PREMIUM EFFICIENCY MOTORS

Attachment 3A: PE Motor & VFDs Savings Calculations

#### ▶ ECM-4: COOLER CONTROLS

Attachment 4A: Walk-In Cooler Upgrades Savings Calculations

#### ECM-7: BUILDING WEATHERIZATION

Attachment 7A: Weatherization Savings Calculations

#### ► ECM-8: HIGH-EFFICIENCY CONDENSING BOILERS

Attachment 8A: New Boilers Savings Calculations

#### ► ECM-9: NEW FAN COIL AND AIR HANDLING UNITS

Attachment 9A: New HVAC Savings Calculations

#### ECM-10: SOLAR PHOTOVOLTAICS

Attachment 10A: PV Savings Calculations



# **SECTION I:** GUARANTEED SAVINGS RECONCILIATION REPORT



# TOWN OF BERLIN BERLIN, CONNECTICUT

# GUARANTEED SAVINGS RECONCILIATION REPORT YEAR TWO

Performance Period Dates Covered: March 1, 2019 to February 29, 2020

# O. EXECUTIVE SUMMARY

#### 0.1 Project Background

NORESCO is pleased to submit the Guaranteed Savings Reconciliation Report (GSRR) for Year Two 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-1: Lighting Improvements & Controls
- ▶ ECM-2: Direct Digital Control Energy Management System
- ▶ ECM-3: Variable Frequency Drives (VFDs) and Premium Efficiency Motors
- ► ECM-4: Cooler Controls
- ► ECM-7: Building Weatherization
- ► ECM-8: High Efficiency Condensing Boilers
- ► ECM-9: 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 OA: 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 Year Two Guarantee Period covers the period from March 1, 2019 through February 29, 2020.

This Report summarizes the M&V activities and results that occurred during the Year Two Guarantee 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 Second Guaranty Period as a result of as-built conditions and post-installation M&V activities.



# 0.1 Year Two 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 Two energy rates as determined per ESA *Schedule F-2: Baseline Energy Rates* and escalated by *Schedule 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 TWO SAVINGS BASED ON ESA, DATED NOVEMBER 30, 2015

ECM No.	ECM Name	Electricity (kWh)	Natural Gas (CCF)	Proposed Savings (\$)	Guaranteed Savings (\$)
-1	Lighting Improvements & Controls	644,509	(746)	\$125,725	\$125,725
-2	Direct Digital Control Energy Management System	6,698	3,435	\$3,309	\$3,309
-3	Variable Frequency Drives and Premium Efficiency Motors	51,918		\$8,768	\$8,768
-4	Cooler Controls	20,816		\$3,654	\$3,654
-5	Plug Load Controls	25,840		\$5,043	\$5,043
-6	Computer Power Management	76,966		\$14,045	\$14,045
-7	Building Weatherization	7,702	3,565	\$4,189	\$4,189
-8	High Efficiency Condensing Boilers		15,428	\$10,821	\$10,821
-9	New Fan Coil and Air Handling Units	3,766	3,990	\$3,224	\$3,224
-10	Solar Photovoltaics	997,766		\$193,211	\$183,551
-11	LED Streetlights			(\$75,270)	(\$75,270)
Total		1,835,981	25,672	\$296,721	\$287,061

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 (PIR) sent May 30, 2018. The Revised Guaranteed Savings for the project is shown below:

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

ECM No.	ECM Name	Electricity (kWh)	Natural Gas (CCF)
-1	Lighting Improvements & Controls	644,509	(746)
-2	Direct Digital Control Energy Management System	6,698	3,435
-3	Variable Frequency Drives and Premium Efficiency Motors	51,918	
-4	Cooler Controls	20,816	
-5	Plug Load Controls		
-6	Computer Power Management		
-7	Building Weatherization	7,702	3,565
-8	High Efficiency Condensing Boilers		15,428
-9	New Fan Coil and Air Handling Units	3,766	3,990
-10	Solar Photovoltaics	997,766	
-11	LED Streetlights		
Total		1,738,189	25,672
Year Tw	Year Two Guaranteed Savings		\$267,971

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



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

**TABLE 0-2: VERIFIED SAVINGS - YEAR TWO** 

ECM No.	ECM Name	Electricity (kWh)	Natural Gas (CCF)	Utility Savings (\$)	Total Savings (\$)
-1	Lighting Improvements & Controls	663,312	(763)	\$129,042	\$129,042
-2	Direct Digital Control Energy Management System	6,698	3,335	\$3,243	\$3,243
-3	Variable Frequency Drives and Premium Efficiency Motors	51,919		\$8,768	\$8,768
-4	Cooler Controls	20,816		\$3,654	\$3,654
-5	Plug Load Controls			\$	\$
-6	Computer Power Management			\$	\$
-7	Building Weatherization	7,356	3,455	\$4,083	\$4,083
-8	High Efficiency Condensing Boilers		13,664	\$9,473	\$9,473
-9	New Fan Coil and Air Handling Units	3,766	3,990	\$3,224	\$3,224
-10	Solar Photovoltaics	947,805		\$183,723	\$183,723
-11	LED Streetlights			(\$75,270)	(\$75,270)
Total		1,701,672	23,682	\$269,766	\$269,939

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 Year Two Guarantee Period is \$269,939. This exceeds the Revised Guaranteed Savings of \$267,971 by \$1,969.



# **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 Two escalated energy rates are shown in *Table 0-5* and were calculated by escalating the baseline rates for two years.

**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 TWO ENERGY RATES**

Facility	Electricity Blended Rate (\$/kWh)	Natural Gas (\$/CCF)
Griswold Elementary School	\$0.1989	\$ 0.9494
High School	\$0.1688	\$0.9494
Hubbard Elementary School	\$0.1824	\$1.0770
McGee Middle School	\$0.2012	\$0.7085
Willard Elementary School	\$0.1891	\$0.8619
Art League	\$0.1751	\$
Timberlin Golf Course	\$0.2174	\$1.1943
Highway, Facilities, Parks, Water, Departments	\$0.1850	\$1.2782
Library	\$0.1847	\$0.9416
Sage Park	\$0.5160	\$
Senior Center	\$0.1890	\$1.7958
Town Hall & Police Department	\$0.1544	\$0.6621
South Kensington Fire Department	\$0.1882	\$1.1626



# 1. ECM-1: 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:

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

Where:

 $ES_{LTG}$  = Annual Energy Savings (kWh)

 $P_{BASE}$  = Baseline Electrical Power (kW/fixture)

NBASE = Baseline Fixture Quantity

P<sub>POST</sub> = 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:

$$\textit{ES}_{\textit{CONTROLS}} \ = \{ \! \left( P_{\textit{post}} \, * \, H_{\textit{base}} \, \right) \! - \left( P_{\textit{post}} \, * \, H_{\textit{post}} \, \right) \! \right\} \! * \, N_{\textit{post}}$$

Where:

**ES**<sub>controls</sub> = Energy savings, in kWh, for the on/off controls.

= Electrical power, in kW, per fixture for appropriate post-installation LBC group. Ppost

= Baseline annual operating hours defined by fixture's pre-hours group.  $H_{base}$ 

 $H_{post}$ = Post-Installation annual operating hours defined by fixture's post hours group.

= Number of fixtures in representative post-installation LBC group.  $N_{post}$ 

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)

= Annual Interactive Heating Penalty РнтG

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) = Weeks of Cooling per year WC

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**<sub>HTG</sub> = 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 PIR 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 John Feeney from NORESCO O&M, met with Town of Berlin to conduct the annual inspection of ECM-1 on March 24 - 25, 2020. NORESCO noted some sensors in the Gym were disconnected. For detailed information on the inspection, please see **Attachment OB: Year Two O&M Inspection Report.** 



# 2. ECM-2: 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:

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

Where:

q = AHU Heating Load (Btu/hr)

1.08 = Conversion Constant (Btu/CFM\*hr\*°F)
CFM = AHU Air Flow (Cubic Feet per Minute)

∏T = Temperature Differential (°F)

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

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)

∏h = 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 ( $\boxtimes$  (OAT-Occupied Setpoint) x Occupied Hours +  $\boxtimes$  (OAT-Unoccupied Setpoint) x Unoccupied Hours))/10<sup>6</sup>

Infiltration Load MMBtu =  $(1.08 \times 10^{-5} \times 10^{-5})$  (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)  $\times$  10^6/12000  $\times$  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 Calculations** 

#### **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 John Feeney, from NORESCO O&M, met with Town of Berlin to conduct the annual inspection of ECM-2 on March 25, 2020. NORESCO noted some schedule and temperature changes in the controls settings and suggests reverting back to the proposed settings to ensure that overall energy savings are met. For detailed information on the inspection, please see **Attachment OB: Year Two O&M Inspection Report.** 



# 3. ECM-3: 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:

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

Proposed Usage (kWh) = (((Motor HP × 0.746) × (proposed rpm %) $^3$ ) + VFD kW) × operating bin hours

Motor Energy Savings = Current Usage (kWh) - Proposed Usage (kWh)

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

#### **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 John Feeney, from NORESCO O&M, met with Town of Berlin to conduct the annual inspection of ECM-3 on March 25, 2020. No issues were noted during this inspection. For detailed information on the inspection, please see **Attachment OB: Year Two O&M Inspection Report.** 



# 4. ECM-4: 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:

Existing  $kWh = [(Existing Fan HP \times 0.746 \times Load Factor) \times Existing Fan Run Hours] + (Door Heater <math>kW \times Existing Heater Run Hours)$ 

Proposed  $kWh = [(Proposed Fan HP \times 0.746 \times Load Factor) \times Proposed Fan Run Hours] + (Door Heater <math>kW \times Proposed Heater Run Hours)$ 

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

#### **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 John Feeney, from NORESCO O&M, met with Town of Berlin to conduct the annual inspection of ECM-4 on March 24, 2020. NORESCO noted the Walk-in Freezer in McGee Middle School was stuck in defrost mode at the time of the inspection. Issue was resolved. For detailed information on the inspection, please see **Attachment OB: Year Two O&M Inspection Report.** 



# 5. ECM-5: 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-6: 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-7: 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:

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

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

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

#### 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 John Feeney, from NORESCO O&M, met with Town of Berlin to conduct the annual inspection of ECM-7 on March 25, 2020. No issues were noted during this inspection. For detailed information on the inspection, please see **Attachment OB: Year Two O&M Inspection Report.** 



# 8. ECM-8: 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 Calculations**.

#### **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-2.

#### 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-2.

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 John Feeney, from NORESCO O&M, met with Town of Berlin to conduct the annual inspection of ECM-8 on March 25, 2020. NORESCO noted Condensing Boiler 1 in the Town Hall was down for repairs at the time of the inspection. For detailed information on the inspection, please see *Attachment OB: Year Two O&M Inspection Report.* 



#### FCM-9: NEW FAN COIL AND AIR HANDLING UNITS 9.

#### Overview of M&V Plan 9.1

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:

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

Where:

= AHU/FCU Heating Load (Btu/hr) 1.08 = Conversion Constant (Btu/CFM\*hr\*°F) CFM = AHU/FCU Air Flow (Cubic Feet per Minute) XT

= Temperature Differential (°F)

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

Where:

= 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)

Πh = Enthalpy Differential (Btu/pound)

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

Where:

kW = Motor Power (kW) Hр = Motor Hp (HP)

0.746 = Conversion Constant (kW/HP)

LF = Motor Load Factor = Motor Efficiency (%) Eff VFD = % Motor Speed

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



Envelope Load MMBtu = (UA  $x \otimes (OAT\text{-}Occupied Setpoint) \times Occupied Hours + <math>\otimes (OAT\text{-}Unoccupied Setpoint) \times Unoccupied Hours))/10^6$ 

Infiltration Load MMBtu =  $(1.08 \times 10^{-5} \times 10^{-5}) \times 10^{-5}$  (OAT-Occupied Setpoint) x Occupied Hours +  $1.08 \times 10^{-5}$  (OAT-Unoccupied Setpoint) x Unoccupied Hours))/10<sup>6</sup>

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)  $\times$  10^6/12000  $\times$  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 Calculations**.

#### **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-2 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-2.

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 John Feeney, from NORESCO O&M, met with Town of Berlin to conduct the annual inspection of ECM-9 on March 25, 2020. No issues were noted during this inspection. For detailed information on the inspection, please see **Attachment OB: Year Two 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 Calculations*.

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<sup>®</sup>.

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:
                   = Net electric power produced (W-AC)
       EAC
       Ht
                   = Solar irradiance in the plane of the PV array (W/m2)
       ΑP
                   = Area of the PV array (m2)
       hΡ
                   = Average efficiency of PV array (%)
       LP
                   = Miscellaneous PV array losses (%)
       LC
                   = Other power conditioning losses (%)
       hinv
                   = 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-2.

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/m² 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:

PACSTC = Power output at STC (W-AC)
PAC = Power output measured (W-AC)
IrrsTC = 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  $800 \text{ W/m}^2$  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<sub>ACSTC</sub> 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 Two verified cost savings are equal to the proposed savings.

#### **Performance Period M&V Activities**

Jeffery Lyskawa and John Feeney, from NORESCO O&M, met with Town of Berlin to conduct the annual inspection of ECM-10 on March 24, 2020. No issues were noted during this inspection. For detailed information on the inspection, please see **Attachment OB: Year Two O&M Inspection Report.** 



# 11. FCM-11: LFD STRFFTLIGHTS

#### 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 John Feeney, from NORESCO O&M, met with Town of Berlin to conduct the annual inspection of ECM-11 on March 25, 2020. No issues were noted during this inspection. For detailed information on the inspection, please see **Attachment OB: Year Two 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.







## **OVERALL PROJECT SUMMARY**

Attachment OA: Final ECM Acceptance

## **ATTACHMENT H**

## **CHANGE ORDER 4**

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Price Ye	ear 1 Guaranteed Savings
(\$10,596.80)	N/A
(\$7,444.00)	N/A
(\$5,767.06)	N/A
	(\$10,596.80) (\$7,444.00)

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  $\underline{0}$  calendar days to Final Completion and Substantial Completion Dates is requested.

## 3. Summary of Changes:

	Contract Price	<u>Year 1</u> <u>Guaranteed</u> <u>Savings</u>
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 By:	Charles E. Puckhaber J	Digitally signed by: Charles E. Puckhaber Jr.  phy: CN = Charles E. Puckhaber Jr.  emial = cpuckhaber@noresco.com C =  "US O = NORESCO OU = Construction Date: 2017.11.13 14:34:55-05'00'
Title:		
Date:	ν	<del>-</del>
Customer	Pools	
Title: Achi Date: 3	15/18	nager

## **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:

Accepted for:

Customer

Accepted by:

Name: Jack Healer

Title: Acting Town Manager

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



## **OVERALL PROJECT SUMMARY**

Attachment OB: Year Two O&M Inspection Report



NORESCO Project: Town of Berlin, Connecticut ECM No. & Name: -1: Lighting Improvements & Controls NORESCO WO NO.: 142261
Inspected By: Jeffery Lyskawa
Completion Date: 3/25/2020

Inspections: Annually inspect a sample of light fixtures, and a sample of reserve stock to ensure replacements match design equivalent.

Location	Bldg. Names	Quantity Installed	Quantity Inspected	Date Inspected	Inspected By	Notes
Town of Berlin	Griswold ES	818	60	3/24/2020	J. Lyskawa	Verified fixtures in Cafeteria, Gym w/stage, room K-2 and W-2. The Gym w/stage sensors were disconnected due to issues with the lights turning off unexpectedly while occupied
Town of Berlin	Hubbard ES	618	68	3/24/2020	J. Lyskawa	Verified fixtures in the cafeteria, Gym, Work rooms, and Library and W-6
Town of Berlin	McGee MS	1,722	131	3/24/2020	J. Lyskawa	Verified fixtures in the Hall, Loading dock, Kitchen, Gym
Town of Berlin	Willard ES	990	56	3/24/2020	J. Lyskawa	Verified fixtures in the Art room, Cafeteria, Boys room,
Town of Berlin	Art League	29	9	3/25/2020	J. Lyskawa	Verified fixtures on the first and second floor
Town of Berlin	Timberlin Golf Course	157	44	3/25/2020	J. Lyskawa	Verified fixtures in the maintenance garage and golf club lounge
Town of Berlin	Highway, Facilities, Parks	308	37	3/25/2020	J. Lyskawa	Verified fixtures in the Highway dept garage and Maintenance dept garage.
Town of Berlin	Library	646	46	3/25/2020	J. Lyskawa	Verified fixtures in the basement hall, storage area, and mechanical rooms
Town of Berlin	Sage Park	83	25	3/25/2020	J. Lyskawa	Verified exterior lights
Town of Berlin	South Kensington Fire Dept.	68	11	3/25/2020	J. Lyskawa	Verified exterior lights
Town of Berlin	Senior Center	176	52	3/25/2020	J. Lyskawa	Verified fixtures in the multipurpose room and hallway
Town of Berlin	Town Hall & Police Department	842	68	3/25/2020	J. Lyskawa	Verified fixtures in the hallway, 3rd floor hallway, stairwell, and basement

Total	6,457

NORESCO Page 1 of 10



NORESCO Project: Town of Berlin, Connecticut ECM No. & Name: -1: Lighting Improvements

NORESCO WO NO.: 142261
Inspected By: Jeffery Lyskawa
Completion Date: 3/25/2020

Inspections: Annually inspect a sample of light fixtures, and a sample of reserve stock to ensure replacements match design equivalent.

		Quantity Installed Quantity Date		Quantity Installed		Date		
Location	Bldg. Name	Wall Switch	Wall Mount	Ceiling Mount	Inspected	Inspected	Inspected By	Notes
Town of Berlin	Griswold ES	0	0	4	1	3/24/2020	J. Lyskawa	Verified sensor in custodial office
Town of Berlin	Hubbard ES	2	0	2	2	3/24/2020	J. Lyskawa	Verified 2 sensors in the library
Town of Berlin	McGee MS	0	2	1	24	3/24/2020	J. Lyskawa	Verified 24 fixture mounted sensor in gym
Town of Berlin	Willard ES	7	1	14	11	3/24/2020	J. Lyskawa	Verified sensors in E9,10, 11 and Cafeteria
Town of Berlin	Timberlin Golf Course	0	0	2	-	-	-	Not checked this inspection
Town of Berlin	Highway, Facilities, Parks	2	0	3	20	3/25/2020	J. Lyskawa	Verified garage fixture mounted sensors
Town of Berlin	Library	9	1	5	2	3/25/2020	J. Lyskawa	Verified basement hall sensors
Total		20	4	31	104			
lotai		20	4	31	104			

NORESCO Page 2 of 10



NORESCO Project: Town of Berlin, Connecticut ECM No. & Name: -2: Direct Digital Control Energy Management System

<u>Inspections:</u> Inspect the EMS controls and write down schedules and set points for controlled units

NORESCO WO NO.: Inspected By: Completion Date: 142261 Jeffery Lyskawa 3/25/2020

			Observed	Observed Heating Occupied/	Observed Cooling			
Location	Bldg. Name	Unit No.	Operating Schedule	Unoccupied	Occupied/ Unoccupied	Date Inspected	Inspected By	Notes
Basment M.E.R (Boiler Room)	Library	AHU-1	6-8pm (M-F), 8-4 (Sat)	85/60	70/85	3/25/2020	J. Lyskawa	Off on Sunday
Basment M.E.R	Library	AHU-2	6-8pm (M-F), 8-4 (Sat)	72/55	77/70	3/25/2020	J. Lyskawa	Off on Sunday
Basment M.E.R (Boiler Room)	Library	HW Reset	HW reset 9/180deg, 60/110deg	Ok	N/A	3/25/2020	J. Lyskawa	
Basement Storage	Town Hall	AHU-1	5:30-11pm (M-F only)	68/60	70/80	3/25/2020	J. Lyskawa	
Basement Storage	Town Hall	AHU-3	24/7	70/60	72/80	3/25/2020	J. Lyskawa	Serves Police department area
Basement Storage	Town Hall	AHU-4	5:30-1lpm (M-F only)	68/55	N/A	3/25/2020	J. Lyskawa	Heating only unit
Located above the ceiling in Town Clerk RM# 19	Town Hall	AHU-5	24/7	70/60	72/80	3/25/2020	J. Lyskawa	Serves Police department area
Located above the ceiling in Town Clerk Tax	Town Hall	AHU-6	5:45-10pm(M-TH), 5:30-4PM (F), weekend unocc.	75/60	76/75	3/25/2020	J. Lyskawa	
3rd Floor Mech RM	Town Hall	AHU-7	5:45-10pm(M-TH), 5:30-4PM (F), weekend unocc.	70/55	72/95	3/25/2020	J. Lyskawa	
Various locations	Town Hall	FCUs	5:45-10pm (M-F), weekend unocc, 24/7 for police dept	74/60	65/80	3/25/2020	J. Lyskawa	
Boiler RM in basement	Town Hall	HW Reset	Enable below 90deg/daily,below 50 deg/nightly	Ok	N/A	3/25/2020	J. Lyskawa	Lochinvar boilers maintain HW reset, Current HW setpoint at 142deg with OA at 45deg
Boiler RM in basement	Town Hall	Chiller	Enable at 60 deg	N/A	Off	3/25/2020	J. Lyskawa	Carrier CW reset through chiller
Boiler RM on 1st Floor	McGEE MS	HW Reset	Enabled below 99 deg	Ok	N/A	3/25/2020	J. Lyskawa	Lochinvar boilers maintain HW reset Current HW setpoint of 130deg with OA at44deg

NORESCO Page 3 of 10



NORESCO Project: Town of Berlin, Connecticut
ECM No. & Name: -3: Variable Frequency Drives and Premium Efficiency Motors

<u>Inspections:</u> Inspect drives and motors for any maintenance issues and VFD drives for setting

NORESCO WO NO.: Inspected By: Completion Date:

142261 Jeffery Lyskawa 3/25/2020

Unit Location	Bldg. Name	Unit No.	Manufacturer	Equipment Description	Model / Cat No.	Date Inspected	Inspected By	Notes
Basment M.E.R (Boiler Room)	Peck Library	AHU-1 Supply	Trane Fan/Baldor Motor	7.5hp	213TC	3/25/2020	J. Lyskawa	Ok, unit not running, put in night setback
Basment M.E.R (Boiler Room)	Peck Library	AHU-1 Return	Trane Fan/Baldor Motor	3 HP	182T	3/25/2020	J. Lyskawa	Ok, unit not running, put in night setback
Basment M.E.R	Peck Library	AHU-2 Supply	Trane Fan/Baldor Motor	7.5hp	213TC	3/25/2020	J. Lyskawa	Ok, Running
Basment M.E.R	Peck Library	AHU-2 Return	Trane Fan/Baldor Motor	3 HP	182T	3/25/2020	J. Lyskawa	Ok, Running
Basment M.E.R (Boiler Room)	Peck Library	Hot Water Pump 1	Taco/ Balodor Motor	2 HP	B5B2CL0	3/25/2020	J. Lyskawa	Ok, Off
Basment M.E.R (Boiler Room)	Peck Library	Hot Water Pump 2	Taco/ US Electric Motor	2 HP	B5B2CL0	3/25/2020	J. Lyskawa	Ok, running
Basment M.E.R (Boiler Room)	Town Library	AHU-1 Supply Fan	ABB Drive	7.5 HP	ACH550-VCR-024A-S+F267	3/25/2020	J. Lyskawa	Ok, fan not enabled
Basment M.E.R (Boiler Room)	Town Library	AHU-1 Return Fan	ABB Drive	3 HP	ACH550-VCR-012A-2+F267	3/25/2020	J. Lyskawa	Ok, fan not enabled
Basment M.E.R	Town Library	AHU-2 Supply Fan	ABB Drive	7.5 HP	ACH550-VCR-024A-S+F267	3/25/2020	J. Lyskawa	Running at 18.5Hz
Basment M.E.R	Town Library	AHU-2 Return Fan	ABB Drive	3 HP	ACH550-VCR-012A-2+F267	3/25/2020	J. Lyskawa	Running at 15.4Hz
Penthouse #401	Town Hall	AHU-7 Supply Fan	ABB Drive	7.5 HP	ACH550-VCR-024A-S+F267	3/25/2020	J. Lyskawa	Ok

NORESCO Page 4 of 10



NORESCO Project: Town of Berlin, Connecticut ECM No. & Name: -4: Walk-In Cooler Upgrades

Inspections: Inspect Cooler/Freezer controls for operation

NORESCO WO NO.: Inspected By: Completion Date: 142261 Jeffery Lyskawa 3/25/2020

Unit Location	Bldg. Name	Unit No.	Manufacturer	Model / Cat No.	Date Inspected	Inspected By	Notes
Controller Outside of cooler by Entry doors	McGee MS	Walk in Freezer	458	GEX 21794	3/24/2020	J. Lyskawa	Setpoint -3deg / Controller was stuck in est. defrost. Was able to get it out of this mode
Controller Outside of cooler by Entry doors	McGee MS	Walk inCooler	485	GEX 21795	3/24/2020	J. Lyskawa	Setpoint 38deg
Controller to the left of Cooler door on 2ndFloor	Berlin HS	Walk in Cooler	NRM-Cooltrol CCS2	RBA 41629, 41792	3/24/2020	J. Lyskawa	Not inspected
Controller to the left of Freezer door on 2nd FL	Berlin HS	Walk in Freezer	NRM-Cooltrol CCS2	RBA 40352, 51691, 44276	3/24/2020	J. Lyskawa	Not inspected
Controller to the right of freezer doors on 1st FL	Berlin HS	Walk in Big Freezer	NRM-Cooltrol CCS2	RBA 44217, 77219, 44362	3/24/2020	J. Lyskawa	Not inspected
Controller to the right of freezer doors on 1st FL	Berlin HS	Walk in Big Freezer	NRM-Cooltrol CCS2	RBA 51239, 50172, 50170	3/24/2020	J. Lyskawa	Not inspected
Additional Notes:							Manufacturer/National Resource Management

NORESCO Page 5 of 10



NORESCO Project: Town of Berlin, Connecticut

ECM No. & Name: -7: Weatherization

Inspections: Inspect weatherization for condition

NORESCO WO NO.: 142261
Inspected By: Jeffery Lyskawa
Completion Date: 3/25/2020

Unit Location	Bldg. Name	Units	Date Inspected	Inspected By	Notes
Attic Bypass Air sealing	Peck Memorial Library	411 SF	3/25/2020	J. Lyskawa	Not verified this inspection
Seal from Below	Peck Memorial Library	563 SF	3/25/2020	J. Lyskawa	Not verified this inspection
Window Casing Sealing	Peck Memorial Library	3,786	3/25/2020	J. Lyskawa	Not verified this inspection
Roof-Wall Intersection Air Sealing/ Block seal	Berlin Town Hall	81 SF	3/25/2020	J. Lyskawa	Not verified this inspection
Roof-Wall Intersection Air Sealing/ Seal	Berlin Town Hall	1,585 SF	3/25/2020	J. Lyskawa	Not verified this inspection
Attic Bypass Air sealing, Above dropped ceiling on 2nd floor	Timberlin Golf Course	3,400 SF	3/25/2020	J. Lyskawa	Verified section above drop ceiling in lounge area
Window Casing Sealing	Willard Elementary	6,211 SF	3/25/2020	J. Lyskawa	Verified 36 window and 4 exterior door sealing

NORESCO Page 6 of 10



NORESCO Project: Town of Berlin, Connecticut ECM No. & Name: -8: High Effciency Condensing Boilers

Inspections: Inspect boilers for operation

NORESCO WO NO.: 142261
Inspected By: Jeffery Lyskawa
Completion Date: 3/25/2020

Unit Location	Bldg. Name	Unit	Model	Date Inspected	Inspected By	Notes
Boiler RM on 1st Floor	McGee Middle School	5,000 MB Condensing Boiler 1	FBN5000 B1 LEADER	3/25/2020	J. Lyskawa	No issues noted with operation
Boiler RM on 1st Floor	McGee Middle School	5,000 MB Condensing Boiler 2	FBN5000 B2 member	3/25/2020	J. Lyskawa	No issues noted with operation
Boiler RM on 1st Floor	McGee Middle School	Condensing Hot Water Heater	BTH-500A300	3/25/2020	J. Lyskawa	No issues noted with operation
Boiler RM in basement	Town Hall	3,000 MPH Condensing Boiler 1	FBN3000 B1	3/25/2020	J. Lyskawa	Down for repairs
Boiler RM in basement	Town Hall	3,000 MPH Condensing Boiler 2	FBN3000 B2	3/25/2020	J. Lyskawa	No issues noted with operation
Additional Notes:						Lochinvar boilers-Customer not happy with very high maintenance costs (around \$6000 per boiler) Would not suggest these boilers used in future projects

NORESCO Page 7 of 10



NORESCO Project: Town of Berlin, Connecticut ECM No. & Name: -9: New Air-Handling Units and Fan Coil Units

 $\underline{\textit{Inspections:}} \ \textit{Inspect units for operation}$ 

NORESCO WO NO.: 142261
Inspected By: Jeffery Lyskawa
Completion Date: 3/25/2020

Unit Location	Bldg. Name	Unit	Model	Date Inspected	Inspected By	Notes
Basement Storage	Town Hall	AHU 1	Daikin LAH007A 3HP	3/25/2020	J. Lyskawa	Ok
Basement Storage	Town Hall	AHU 3	Daikin LAH005AEH 3 HP	3/25/2020	J. Lyskawa	Ok
Basement Storage	Town Hall	AHU 4	Daikin LAH005A 3 HP	3/25/2020	J. Lyskawa	Ok
Located above the ceiling in Town Clerk RM# 19	Town Hall	AHU 5	Daikin CAH003GHAC 3 HP	3/25/2020	J. Lyskawa	Not checked during this inspection
Located above the ceiling in Town Clerk Tax	Town Hall	AHU 6	Daikin CAH003GdAC 3 HP	3/25/2020	J. Lyskawa	Not checked during this inspection
Various Locations	Town Hall	FCU 1-91	Daikin	3/25/2020	J. Lyskawa	Checked FCU 90 & 91- No issues

NORESCO Page 8 of 10



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

Inspections: Inspect units for operation and proper maintenance

NORESCO WO NO.: 142261
Inspected By: Jeffery Lyskawa
Completion Date: 3/25/2020

Unit Location	Bldg. Name	Unit	Date Inspected	Inspected By	Notes
Controller located outside next to boiler room	McGee MS	PV Array	3/24/2020	Llyckawa	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	3/24/2020	Llyckawa	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	3/24/2020	J. Lyskawa	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	3/24/2020		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 Page 9 of 10



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

NORESCO WO NO.: Inspected By: Completion Date: 142261 Jeffery Lyskawa 3/25/2020

Inspections: Check Lighting stock

Unit Location	Bldg. Name	Unit	Date Inspected	Inspected By	Notes
Town Street Lights	Town Wide	LED Street Lights	3/25/2020	J. Lyskawa	Verified approximately 250 street lights

NORESCO Page 10 of 10



## **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**

			% Contribution to	Hours		
Hours Type	Hours / Day	Days / Year	Demand Charge	Pre	Controls	Notes
Α	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		

NORESCO Page 1 of 2

## TOWN OF BERLIN - BERLIN, CONNECTICUT ECM-1: LIGHTING IMPROVEMENTS AND CONTROLS

## **Attachment 1A: Hours Group Summary**

		D (V	% Contribution to	Hours	6	
Hours Type	Hours / Day	Days / Year	Demand Charge	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		

NORESCO Page 2 of 2



## **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	Lighting Controls	Cooling	Total	
	Energy Savings	Energy Savings	Energy Savings	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

NORESCO Page 1 of 2

# 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.

NORESCO Page 2 of 2



# 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 Page 1 of 4

## **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 Co	omplex
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.

Cooling

Existing

Cooling

Existing

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

Operating

Operating

Outdoor A		Annual	Annual	Ì	Operating					
Bin Temp		Bin Hours	Bin Hours		Bin Hours					
F	12am-8am	8am-4pm	4pm-12am		12am-8am					
Α	В	С	D		E = BxJJx <u>MM</u>					
	Hartford I	Hartford Int'l Airport								
	_	_	_		_					
107	0	0	0		0					
102	0	0	0		0					
97	0	4	0		0					
92	0	34	9		0					
87	0	105	22		0					
82	4	247	105		0					
77	55	243	158		6					
72	137	208	183		15					
67	199	231	248		21					
62	306	300	310		33					
57	270	226	289		29					
52	291	186	261		31					
47	210	129	187		23					
42	282	188	155		30					
37	288	296	306		31					
32	252	222	251		27					
27	182	160	177		20					
22	231	89	177		25					
17	135	42	57		14					
12	44	7	24		5					
7	23	3	1		2					
2	11	0	0		1					
-3	0	0	0		0					
-8	0	0	0		0					
-13	0	0	0		0					
-18	0	Ö	0		Ō					
1		-								
	2,920	2,920	2,920		313					

	Bin Hours	Bin Hours	Bin Hours	Operating	
L	12am-8am	8am-4pm	4pm-12am	Bin Hours	
	E =	F =	G =	H =	
ı	Bx <u>JJ</u> x <u>MM</u>	Cx <u>KK</u> x <u>MM</u>	Dx <u>LL</u> x <u>MM</u>	E+F+G	
L	8 7	8 7	8 7		
	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	
ı	33	257	33	323	
	29	194	31	254	
	31	159	28	219	
ı	23	111	20	153	
	30	161	17	208	
	31	254	33	317	
ı	27	190	27	244	
ı	20	137	19	176	
ı	25	76	19	120	
ı	14	36	6	57	
ı	5	6	3	13	
ı	2	3	0	5	
	1	0	0	1	
1	0	0	0	0	
1	0	0	0	0	
1	0	0	0	0	
ı	0	0	0	0	
ŀ	313	2,503	313	3,129	

Load	CHW Temp	Load	Electric Use
(%)	(F)	(tons)	kWh
J =	K	L =	N =
(A - GG)	constant	AA x J	H x L x BB
(FF - GG)			
152%	44	182	0
135%	44	163	0
119%	44	143	266
103%	44	124	2,018
87%	44	105	5,222
71%	44	85	10,292
55%	44	66	8,228
39%	44	46	5,342
23%	44	27	3,605
6%	44	8	1,353
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	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
0%	0	0	0
		948	36,325

		N -
40 41 43 45 46 48 50 51 53 54 0 0 0 0 0 0	0 0 271 1,990 4,983 9,489 7,320 4,580 2,974 1,073 0 0 0 0 0 0 0 0 0	0 0 0 -5 27 23 80 90 76 63 28 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
	32,681	3,64

Total Saved kWh R = N - Q
0 0 -5 27 239 803 908 762 630 280 0 0 0 0 0 0 0
2 ( 45

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

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

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

Facility Name:	Town Hall C	omplex	
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	Т
Cooling Efficiency (kW/ton):	0.54	HH	Τ

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

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.

		Proj	pos			
12am-8am	8am-4pm 4pm-12am Days/Week				12am-8am	Г
1.0	8.0	1.0	6.0		1.0	Т
IJ	KK	LL	MM		NN	

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

Bin Hours 12am-8am	Bin Hours 8am-4pm	Bin Hours 4pm-12am	Occupied Bin Hours	Bin Hours 12am-8am	Bin Hours 8am-4pm	Bin Hours 4pm-12am	Operating Bin Hours
F = Bx <u>JJ</u> x <u>MM</u> 8 7	G = Cx <u>KK</u> x <u>MM</u> 8 7	H = Dx <u>LL</u> x <u>MM</u> 8 7	J = F+G+H	K = Bx <u>NN</u> x <u>RR</u> 8 7	L = Cx <u>PP</u> xRR 8 7	M = Dx <u>QQ</u> x <u>RR</u> 8 7	N = K+L+M
,	· ,	0 /			0 /	0 /	
0	0	0	0	0	0	0	0
ŏ	Ö	ő	Ö	ő	ő	ő	Ö
ō	3	ō	3	ō	4	ō	4
0	29	1	30	0	34	1	35
ō	90	2	92	ō	105	3	108
0	212	11	223	1	247	13	261
6	208	17	231	7	243	20	270
15	178	20	213	17	208	23	248
21	198	27	246	25	231	31	287
33	257	33	323	38	300	39	377
29	194	31	254	34	226	36	296
31	159	28	219	36	186	33	255
23	111	20	153	26	129	23	179
30	161	17	208	35	188	19	243
31	254	33	317	36	296	38	370
27	190	27	244	32	222	31	285
20	137	19	176	23	160	22	205
25	76	19	120	29	89	22	140
14	36	6	57	17	42	7	66
5	6	3	13	6	7	3	16
2	3	0	5	3	3	0	6
1	0	0	1	1	0	0	1
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	0	0
313	2 503	313	3 129	365	2 920	365	3.650

				_											
Occupied	Occupied	Occupied	Current		Operating	Operating	Operating	Proposed	ı	Operating	Setforward	Existing		Existing	Pr
Bin Hours	Bin Hours	Bin Hours	Occupied		Bin Hours	Bin Hours	Bin Hours	Operating		Heat Gains	Heat Gains	Electric Use		CHW Temp	CH
12am-8am	8am-4pm	4pm-12am	Bin Hours		12am-8am	8am-4pm	4pm-12am	Bin Hours		MBtu/hr	MBtu/hr	kWh/yr		(F)	
F =	G =	H =	J =		K =	L =	M =	N =	1	P =	Q =	R =		S	
Bx <u>JJ</u> x <u>MM</u>	CxKKxMM	DxLLxMM	F+G+H		BxNNxRR	CxPPxRR	DxQQxRR	K+L+M		(A-BB)x(EE+FF)	(A-DD)xEE	Jx(P+GG) + (N-J)xP + (E-N)xQ			
8 7	8 7	8 7			8 7	8 7	8 7			1000	1000	12/HH			
									1						
0	0	0	0		0	0	0	0		1,684	1,264	0		44	
0	0	0	0		0	0	0	0		1,429	1,030	0		44	
0	3	0	3		0	4	0	4		1,174	796	247		44	
0	29	1	30		0	34	1	35		919	562	1,966		44	
0	90	2	92		0	105	3	108		664	328	4,463		44	
0	212	11	223		1	247	13	261		408	94	7,511		44	
6	208	17	231		7	243	20	270		153	0	4,251		44	
15	178	20	213		17	208	23	248		0	0	2,198		44	
21	198	27	246		25	231	31	287		0	0	0		0	
33	257	33	323		38	300	39	377		0	0	0		0	
29	194	31	254		34	226	36	296		0	0	0		0	
31	159	28	219		36	186	33	255		0	0	o		0	
23	111	20	153		26	129	23	179		0	0	0		0	
30	161	17	208		35	188	19	243		0	0	0		0	
31	254	33	317		36	296	38	370		0	0	o		0	
27	190	27	244		32	222	31	285		0	0	0		0	
20	137	19	176		23	160	22	205		0	0	o		0	
25	76	19	120		29	89	22	140		0	0	0		0	
14	36	6	57		17	42	7	66		0	0	0		0	
5	6	3	13		6	7	3	16		0	0	0		0	
2	3	0	5		3	3	0	6	1	0	0	0		0	
1	0	0	1		1	0	0	1		0	0	0		0	
0	0	0	0		0	0	0	0	1	0	0	o		0	
0	0	0	0		0	0	0	0	1	0	0	0		0	
0	0	0	0		0	0	0	0	1	0	0	0		0	
0	0	0	0		0	0	0	0	1	0	0	0		0	
									1						
313	2,503	313	3,129		365	2,920	365	3,650	1			20,636	1		

Saved	Proposed	Proposed	Existing
Electric	Electric Use	CHW Temp	CHW Temp
kWh/yr	kWh	(F)	(F)
V =	U =	Т	S
R-U	Rx[1 - 0.02x(T - S)]		
0	0	44	44
0	0	45	44
15	232	47	44
175	1,790	48	44
531	3,932	50	44
1,116	6,394	51	44
758	3,493	53	44
457	1,741	54	44
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	o
0	0	0	0
0	0	0	0
Ö	0	0	o
0	0	0	0
0	0	0	o
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	0	0
0	0	0	0
3,053	17,583		

\normawes.noresco.com\Data\Jobs\2014\142312 - Berlin CT\1 - Project Development\Work\ECMs\EMCS\Savings\[Town Hall EMS Savings Calcs.xlsm]HW Reset

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

PROJECT No: 142312-86 SUBJECT: Reset Hot Water Temp DATE: 11/9/2015 FACILITY: Town Hall Complex

	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)

I	Pump Operating Schedule continuous							
	12am-8am	8am-4pm	4pm-12am	Days/Week				
	8.0	8.0	8.0	7.0				
•	.l.l	KK	- 11	MM				

Operating Operating Operating

Outdoor Air	Annual	Annual	Annual
Bin Temp	Bin Hours	Bin Hours	Bin Hours
F .	12am-8am	8am-4pm	4pm-12am
A	В	С	D
	Hartford Int'l	Airport	-
	_	_	_
107	0	0	0
102	0	0	0
97	0	4	0
92	0	34	9
87	0	105	22
82	4	247	105
77	55	243	158
72	137	208	183
67	199	231	248
62	306	300	310
57	270	226	289
52	291	186	261
47	210	129	187
42	282	188	155
37	288	296	306
32	252	222	251
27	182	160	177
22	231	89	177
17	135	42	57
12	44	7	24
7	23	3	1
2	11	0	0
-3	0	0	0
-8	0	0	0
-13	0	0	0
-18	0	0	0
	2,920	2,920	2,920

Bin Hours 12am-8am	Bin Hours 8am-4pm	Bin Hours 4pm-12am	Operating Bin Hours	Heat Loss MBH	HW Temp F	Loss in Circuit	Heat Loss MBH	Heat Loss MBH
E = Bx <u>JJ</u> x <u>MM</u> 8 7	F = Cx <u>KKxMM</u> 8 7	G = Dx <u>LL</u> x <u>MM</u> 8 7	H = E+F+G	K = 500xNNxBB 1000	L Note 1	M Note 2	N = <u>500xNNxM</u> 1000	P = K - N <i>Note</i> 3
0 0 0 0 0 4 555 137 199 306 270 291 210	0 0 4 34 105 247 243 208 231 300 226 186 129	0 0 0 9 22 105 158 183 248 310 289 261 187	0 0 4 43 127 356 456 528 678 916 785 738 526 625	0 0 0 0 0 0 0 0 0 0 0 0 0 0 201 201 201	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 120.0 125.5 130.9	0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.0	0 0 0 0 0 0 0 0 0 0 0 151 151 151	0 0 0 0 0 0 0 0 0 0 0 50 50 50
288 252 182 231 135 44 23 11 0 0 0	296 222 160 89 42 7 3 0 0 0	306 251 1777 177 57 24 1 0 0 0	890 725 519 497 234 75 27 11 0 0	201 201 201 201 201 201 201 201 201 201	141.8 147.3 152.7 158.2 163.6 169.1 174.5 180.0 180.0 180.0 180.0	1.50 1.50 1.50 1.50 1.50 1.50 1.50 2.00 1.50 1.50 1.50	151 151 151 151 151 151 151 151 201 151 151 151	50 50 50 50 50 50 50 50 50 50 50
2,920	2,920	2,920	8,760					

Total Existing Required Est. Temp Proposed Saved

- Notes:

  1) Estimated hot water reset schedule: 120F water at 57F outdoor, 180F water at 2F outdoor.

  1 5-degree loss at 120F water temperature. 15-degree loss at 120F water temperature.
  - 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

**Attachment 3A: PE Motor & VFDs Savings Calculations** 

#### NORESCO

SUBJECT: High Efficiency Motors

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

FACILITY: Various

	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 Note 1	B Note 2	D	E	F = BxD/E	G Note 3	H Note 4	J Note 3	K Note 4
Town Hall HWP-1 Town Hall HWP-2 Town Hall HWP-3 Town Hall HWP-4 Library AHU-1 RA Library AHU-1 RA Library AHU-2 RA Library HWP-1 Library HWP-1	3/ODP/1800 7.5/ODP/1800	2,826 2,826 4,380 4,380 3,387 3,387 3,387 2,434 2,434	70% 70% 70% 70% 70% 70% 70% 70% 70% 70%	2.0 2.0 5.0 5.0 7.5 3.0 7.5 3.0 2.0	2.0 2.0 5.0 5.0 7.5 3.0 7.5 3.0 2.0 2.0	70% 70% 70% 70% 70% 70% 70% 70% 70% 70%	78.5% 78.5% 87.5% 87.5% 78.5% 82.5% 78.5% 82.5% 82.5%	86.6% 86.6% 90.2% 90.2% 92.2% 90.2% 92.29 90.29 86.6% 86.6%	1,730 1,730 1,730 1,730 1,755 1,730 1,755 1,730 1,750 1,730	1,747 1,747 1,730 1,730 1,755 1,730 1,755 1,730 1,747 1,747

Building/Motor	Designation	% Load Increase	Existing Motor	Existing Motor	Proposed Demand	Proposed Motor	Saved Demand	Saved Usage
		from RPM	kW	kWh	kW/mo	kWh	kW/mo	kWh/yr
		M =	N =	P =	Q =	R =	S =	T =
		(K/J) <sup>3</sup> -1	0.746xDxB/G	NxA	0.746xExFx(1+M)	QxA	N - Q	SxA
		Note 5			Н			
	1040	2.00/	4.00	0.740	404	2.540		250
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.
- 5) Premium efficiency motors typically run slightly faster than standard motors.

http://www.baldor.com/support/Literature/Load.ashx/BR457?LitNumber=BR457

## **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

Use	HVA	C٥	perating	Bins? Y	/N

Outside Air	Annual	Annual	Percent	Required	Existing	Proposed	Fan Energy
Bin Temp	Bin Hours	Operating Hours	HVAC Load	Fan Load	Fan Energy	Fan Energy	Savings
(F)	(hr/yr)	(hr/yr)	(%)	(%)	(kWh)	(kWh)	(kWh)
Α	В	C	D =	E =	F =	G =	H =
			Heating load +		AAxC	AAxCxE^3/0.98	F - G
			Cooling load				
See Note 1	See Note 1						
400			4000/	1 4000/			
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	Ö	Ō	100%	100%	Ō	Ö	Ō
-13	0	0	100%	100%	0	0	0
	8,760	3,329			34,151	15,960	18,192

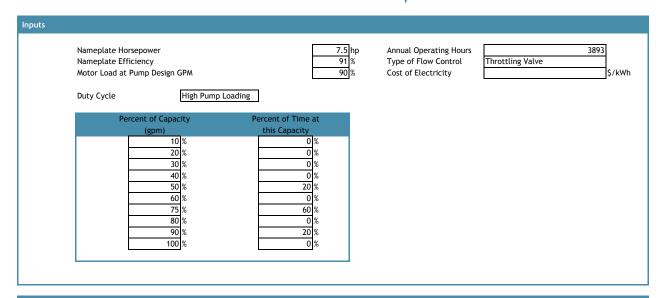
Notes:

<sup>1)</sup> Weather Data from NOAA for Hartford Int'l Airport

PROJECT: BERLIN CT PROJECT No: 142312-86 SUBJECT: CDWP VFD SAVINGS ANALYSIS DATE: 11/9/2015

FACILITY: TOWN HALL COMPLEX

## **VSD Calculator for Pumps**



puts	
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 +  $(A2 \times Capacity)$  +  $(A3 \times (Capacity^2))$  +  $(A4 \times (Capacity^3))$ 

Percent of Design kW for VSD = A1 +  $(A2 \times Capacity) + (A3 \times (Capacity^2)) + (A4 \times (Capacity^3))$ 

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)  $\times$  (Percent of time at this Capacity / 100)  $\times$  Operating Hours VSD Energy (kWh) = VSD Power (kW)  $\times$  (Percent of time at this Capacity / 100)  $\times$  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  $\times$  Cost of Electricity

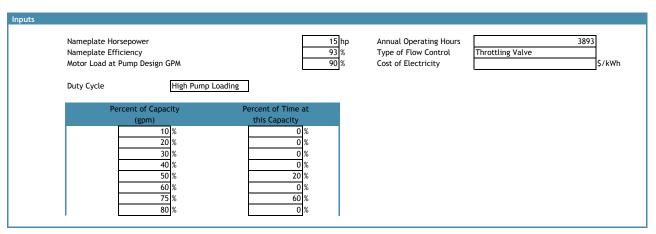
This tool was created by the Bonneville Power Administration (BPA). For more information on BPA, visit their website at http://www.bpa.gov/energy/n/industrial/audit/.

**NORESCO** 

PROJECT: BERLIN CT PROJECT No: 142312-86
SUBJECT: CHWP VFD SAVINGS ANALYSIS DATE: 1/9/2015

FACILITY: TOWN HALL COMPLEX

## **VSD Calculator for Pumps**



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<sup>2</sup>)) + (A4 × (Capacity<sup>3</sup>))

Percent of Design kW for VSD = A1 +  $(A2 \times Capacity) + (A3 \times (Capacity^2)) + (A4 \times (Capacity^3))$ 

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)  $\times$  (Percent of time at this Capacity / 100)  $\times$  Operating Hours VSD Energy (kWh) = VSD Power (kW)  $\times$  (Percent of time at this Capacity / 100)  $\times$  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**

Attachment 4A: Walk-In Cooler Upgrades Savings Calculations

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**

	Evaporator Fan Motors A	Amps B	Volts	Phase D	Power Factor E	Total Power (W) F= AxBxCxE
Food Cooler Food Freezer	1 2	2.7 1.1	115 230 tal kW demand	1	0.65 0.65	202 329 0.531

	Number	Existing	Proposed	Existing	Proposed	
	of	Motor	Motor	Energy	Energy	Energy
Savings due to ECM	Evaporator Fan	Total Power	Load	Use	Use	Savings
Motor Upgrade	Motors Replaced	(W)	Reduction	(kWh)	(kWh)	(kWh)
		F	G	H=	l=	J=
				Fx8760	FxGx8760	J - I
			note 1	1000	1000	
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		M= JxKxL
Evaporator Fan Set	1,008	0.28	1.6	452

ECM Motor Replacement Total Saving	1,460 kWh
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# 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

NORESCO Page 1 of 8

# 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 Page 2 of 8

PROJECT: Town of Berlin, CT

SUBJECT: McGee MS Walk-in Cooler Controls & PE Motors

PROJECT No: 142312

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) A	Existing Run Hours B	Proposed Run Hours C	Existing Energy Use (kWh) D = AxB 1000	Proposed Energy Use (kWh) E = AxC 1000	Energy Savings (kWh) F = D - E
Food Cooler Food Freezer	202 214	8,760 8,760	5,212 5,212	1,768 1,873	1,052 1,114	716 759
TOTALS				3,641	2,166	1,475

<sup>1)</sup> ECM Motor Total Power taken from proposed energy demand on Evaporator Fan Motor Upgrade

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 A	Amps B	Existing Total Watts (W) C = AxB	Existing Energy Use (kWh) D = Cx8760	Estimated Proposed Run Hours E	Estimated Average Heater Power % F	Proposed Energy Use (kWh) G = CXEXF	Energy Savings kWh H= D-G
Food Cooler	120	2.0	240	2,102	Note 1 4,694	Note 2 65%	732	1,370
				2,102			732	1,370

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

TOTALS

PROJECT: Town of Berlin, CT

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

PROJECT No:

142312

### **Evaporator Fan ECM Motor Upgrade**

					AxBxCxE
Food Cooler A Food Freezer B Food Freezer C	3 0	1.9 11! 1.9 230 1.9 230	1	0.65 0.65 0.65	135 404 807

	Number	Existing	Proposed	Existing	Proposed	
	of	Motor	Motor	Energy	Energy	Energy
Savings due to ECM	Evaporator Fan	Total Power	Load	Use	Use	Savings
Motor Upgrade	Motors Replaced	(W)	Reduction	(kWh)	(kWh)	(kWh)
		F	G	H=	l=	J=
				Fx8760	FxGx8760	J - I
			note 1	1000	1000	
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

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

ECM Motor Replacement Total Savings	5,973 kWh	

11,787

7,661

PROJECT: **Town of Berlin, CT**SUBJECT: **High School Walk-in Cooler Controls & PE Motors**PROJECT No: 142312

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) A	Existing Run Hours B	Proposed Run Hours C	Existing Energy Use (kWh) D = AxB 1000	Proposed Energy Use (kWh) E = AxC 1000	Energy Savings (kWh) F = D - E
Food Cooler A Food Freezer B Food Freezer C	87 262 525	8,760 8,760 8,760	5,212 5,212 5,212	766 2,298 4,597	456 1,367 2,735	310 931 1,862
TOTALS				7,661	4,558	3,103

<sup>1)</sup> ECM Motor Total Power taken from proposed energy demand on Evaporator Fan Motor Upgrade

PROJECT: **Town of Berlin, CT**SUBJECT: **High School Walk-in Cooler Controls & PE Motors**PROJECT No: 142312

DATE: 11/9/2015

### **Door Heater Humidistat Controls**

			Existing	Existing	Estimated	Estimated	Proposed	
			Total	Energy	Proposed	Average	Energy	Energy
Savings Due to Installation	Volts	Amps	Watts	Use	Run	Heater	Use	Savings
of Door Heater Controls			(W)	(kWh)	Hours	Power %	(kWh)	kWh
	Α	В	C =	D =	E	F	G =	H=
			AxB	Cx8760			CxExF	D-G
				1000	Note 1	Note 2	1000	
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

- 1) Estimated run hours of door heaters by operating heaters to maintain 5°F above dew point.
- 2) Estimated average power level of door heaters when operating to maintain 5°F above dew point.

  Based on Select Energy Services, Inc. "Analysis of Cooler Control Energy Conservation Measures" dated March 2004.



# **ECM-7: BUILDING WEATHERIZATION**

**Attachment 7A: Weatherization Savings Calculations** 

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

Ві	uilding Coefficier	nts
Building Type	k	n
1	110.0	0.60
2	80.0	0.65
3	60.0	0.70
4	23.0	0.65



#### WEATHERIZATION SAVINGS - INFILTRATION

				HEATING				COOLING - only sensible				
	Total	Average	Total Crack	Average	Wind Pressure	Infiltration	Fuel Heating	Average	Wind Pressure	Infiltration	Cooling	Cooling
Description	Crack Length	Crack Width	Area	Wind Speed	Differential	Flow	Savings	Wind Speed	Differential	Flow	Savings	Savings
	(ft)	(in)	(SF)	(MPH)	(Pa)	(CFM)	(MBtu/yr)	(MPH)	(Pa)	(CFM)	(MBtu/yr)	(kWh/yr)
	C =	D	E =	F	G =	H =	J =	L =	M =	0 =	P =	Q =
Buck Frame Sealing	AxB/12		CxD/12		(1.6*F)^2x.0464	kxExG^n	1.1*H*HDH/Eff		(1.6*L)^2xp	kxExM^n	1.1*O*CDH	P*Eff/12
				Note 1	2	Note 3	Note 3	Note 2	2	Note 3	Note 3	
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

- 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 Blus to MBtus)

Outside Air	Outdoor Air	Outdoor Air	Ann	ual Bin Hours fo	or Bradley Int'l Air	port	Annual	Annual
Minimum	Maximum	Average					Heating	Cooling
Temperature	Temperature	Temperature	12am-8am	8am-4pm	4pm-12am	TOTAL	Degree-hrs	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	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

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	1
HVAC System Efficiency:	70%	1.00	kW/

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					



#### WEATHERIZATION SAVINGS - INFILTRATION

					HEAT	ΓING			COOLING	6 - only sensibl	e	
	Total	Average	Total Crack	Average	Wind Pressure	Infiltration	Fuel Heating	Average	Wind Pressure	Infiltration	Cooling	Cooling
Description	Crack Length	Crack Width	Area	Wind Speed	Differential	Flow	Savings	Wind Speed	Differential	Flow	Savings	Savings
	(ft)	(in)	(SF)	(MPH)	(Pa)	(CFM)	(MBtu/yr)	(MPH)	(Pa)	(CFM)	(MBtu/yr)	(kWh/yr)
	C =	D	E =	F	G =	H =	J =	L =	M =	O =	P =	Q =
	AxB/12		CxD/12		(1.6*F)^2x.0464	kxExG^n	1.1*H*HDH/Eff		(1.6*L)^2xp	kxExM^n	1.1*O*CDH	P*Eff/12
				Note 1	2	Note 3	Note 3	Note 2	2	Note 3	Note 3	
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

- Average heating season wind speed is taken from NOAA weather data for Bradley Int'l Airport and is based on November through April.
   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 Blus to MBlus)

Outside Air	Outdoor Air	Outdoor Air	Anr	ual Bin Hours fo	or Bradley Int'l Air	port	Annual	Annual
Minimum	Maximum	Average					Heating	Cooling
Temperature	Temperature	Temperature	12am-8am	8am-4pm	4pm-12am	TOTAL	Degree-hrs	Degree-hrs
105	109	107	0	0	0	I 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	Ö
20	24	22	231	89	177	497	14,910	0
15	19	17	135	42	57	234	8,190	Ö
10	14	12	44	7	24	75	3.000	Ö
5	9	7	23	3	1	27	1,215	0
0	4	2	11	0	0	11	550	ō
-5	-1	-3	0	Ö	ō	0	0	ō
-10	-6	-8	0	0	0	0	0	0
-15	-11	-13	0	Ö	Ö	ő	ő	ő
-20	-16	-18	Ö	Ö	Ö	ő	0	ő
-25	-21	-23	0	0	0	ő	0	ő
-30	-26		•	Ĭ	•	0	0	0
	_0						, and a	ľ
			2,920	2,920	2,920	8,760	77,570	20,659

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

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

Bui	Iding Coefficier	nts
Building Type	k	n
1	110.0	0.60
2	80.0	0.65
3	60.0	0.70
4	23.0	0.65



PROJECT NO: 142312 DATE: 10/5/2015

#### WEATHERIZATION SAVINGS - INFILTRATION

					HEAT	ΓING			COOLING	3 - only sensible	е	
	Total	Average	Total Crack	Average	Wind Pressure	Infiltration	Fuel Heating	Average	Wind Pressure	Infiltration	Cooling	Cooling
Description	Crack Length	Crack Width	Area	Wind Speed	Differential	Flow	Savings	Wind Speed	Differential	Flow	Savings	Savings
	(ft)	(in)	(SF)	(MPH)	(Pa)	(CFM)	(MBtu/yr)	(MPH)	(Pa)	(CFM)	(MBtu/yr)	(kWh/yr)
	C =	D	E =	F	G =	H =	J =	L =	M =	O =	P =	Q =
	AxB/12		CxD/12		(1.6*F)^2x.0464	kxExG^n	1.1*H*HDH/Eff		(1.6*L)^2xp	kxExM^n	1.1*O*CDH	P*Eff/12
				Note 1	2	Note 3	Note 3	Note 2	2	Note 3	Note 3	
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

Average heating season wind speed is taken from NOAA weather data for Bradley Int'l Airport and is based on November through April.

Outside Air	Outdoor Air	Outdoor Air	Ann	ual Bin Hours fo	or Bradley Int'l Air	port	Annual	Annual
Minimum	Maximum	Average					Heating	Cooling
Temperature	Temperature	Temperature	12am-8am	8am-4pm	4pm-12am	TOTAL	Degree-hrs	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

<sup>2)</sup> 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)

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				



#### WEATHERIZATION SAVINGS - INFILTRATION

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

- 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 Blus to MBtus)

Outside Air	Outdoor Air	Outdoor Air	Ann	ual Bin Hours fo	or Bradley Int'l Air	port	Annual	Annual
Minimum	Maximum	Average					Heating	Cooling
Temperature	Temperature	Temperature	12am-8am	8am-4pm	4pm-12am	TOTAL	Degree-hrs	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	Ó	0	0
-20	-16	-18	Ö	Ö	Ō	ō	ō	ō
-25	-21	-23	0	0	0	0	0	0
-30	-26	1				ō	ō	0
						· ·	· -	
		•	2,920	2,920	2,920	8,760	77,570	20,659

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

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



#### WEATHERIZATION SAVINGS - INFILTRATION

					HEATING			COOLING - only sensible				
	Total	Average	Total Crack	Average	Wind Pressure	Infiltration	Fuel Heating	Average	Wind Pressure	Infiltration	Cooling	Cooling
Description	Crack Length	Crack Width	Area	Wind Speed	Differential	Flow	Savings	Wind Speed	Differential	Flow	Savings	Savings
•	(ft)	(in)	(SF)	(MPH)	(Pa)	(CFM)	(MBtu/yr)	(MPH)	(Pa)	(CFM)	(MBtu/yr)	(kWh/yr)
	C =	D	E =	F	G =	H =	J =	L =	M =	O =	P =	Q =
Roof Wall Intersection Sealing	AxB/12		CxD/12		(1.6*F)^2x.0464	kxExG^n	1.1*H*HDH/Eff		(1.6*L)^2xp	kxExM^n	1.1*O*CDH	P*Eff/12
				Note 1	2	Note 3	Note 3	Note 2	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
				1								
TOTALS							154,196					4,317

- 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 Blus to MBtus)

Outside Air	Outdoor Air	Outdoor Air	Anr	ual Bin Hours fo	or Bradley Int'l Air	port	Annual	Annual
Minimum	Maximum	Average					Heating	Cooling
Temperature	Temperature	Temperature	12am-8am	8am-4pm	4pm-12am	TOTAL	Degree-hrs	Degree-hrs
	400					ı .		_
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	Ó	0	0
-20	-16	-18	Ö	Ö	Ö	ō	ō	0
-25	-21	-23	Ö	Ö	Ō	ō	ō	ō
-30	-26					0	0	0
			2.920	2.920	2.920	8.760	101.905	33.451



# **ECM-8: HIGH-EFFICIENCY CONDENSING BOILERS**

**Attachment 8A: New Boilers Savings Calculations** 



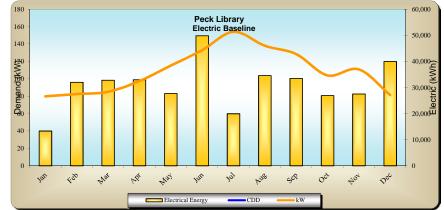


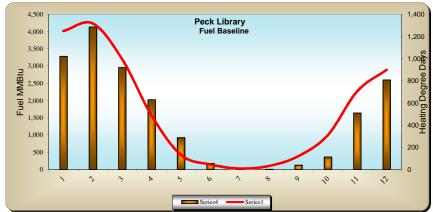
FROM:	May-2014	TO:	Apr-2015								
Month	HDD	CDD	Billed Demand kW	Electrical Energy kWh	Total Electric Cost \$	Blended Unit Cost \$/kWh	Natural Gas CCF	Natural Gas Cost \$	Natural Gas \$/CCF	Total Utility Cost \$	
Jan	1,249		79.8	13,317		\$0.0000	3,283		\$0.00	\$0	
Feb	1,317		82.4	32,000		\$0.0000	4,134		\$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

Mbtu/Sqft

Btu/Sqft/HDD Mbtu/Sqft





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

Facility Name:	Peck Library					
Facility Square Footage	43,71	2 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%				
	Existing	Proposed				
COOLING EQUIPMENT	Efficiency	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	e?
(Normally the answer is No)	y or n	Υ

Typical Occupancy Schedule									
7am to 5pm6 days/week									
12am-8am	n 8am-4pm 4pm-12am Days/Week								
1.0	8.0 1.0 6.0								
7.0		5.0	1.0						
	mq								

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 6.0 1.0								

pm

PROJECT No:

DATE:

142312-86

11/9/2015

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	1.0		
		pm			

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	1.0		
		pm			

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	1.0			
		nm				

SEER/COP/KW/Ton Quick Calculator							
	INPUT	JT OUTPUT Conversion					
	Value	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) 
▼

	<b>Heating Fuel</b> SELECT HEATI	•	Unit	Abbrev Uı	Btu/unit
1	Natural Gas (th	Natural Gas	therms	therm	100,000
2	Natural Gas (co	Natural Gas	ccf	ccf	102,700
3	Natural Gas (N	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

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  $\, \text{ft}^2$  Ceiling Height: 12  $\, \text{ft}$  Total Volume: 524,544  $\, \text{ft}^3$ 

#### **HEATING LOADS**

**Design Conditions** 

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

**Building Envelope Losses** 

Item	Total Wall Area (ft <sup>2</sup> )	Net Wall Area (ft <sup>2</sup> )	Temperature Difference (F)	U-Factor Btu/(hr-F-ft <sup>2</sup> )	Heat Transfer (BtuH)	UA
	A	В	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

			Infiltration	Temperature	Heat	
	Area	Rate	Rate	Difference	Transfer	UA
	(ft <sup>2</sup> )	(CFM/ft <sup>2</sup> )	(CFM)	(F)	(BtuH)	
	Α	В	C =	D	E =	F
			AxB		1.08xCxD	
	12.044	0.15	1.010	70	124 001	
ation	12,064	0.15	1,810	70	136,801	
ation	12,064	0.15	1,810	70	136,801	

Infiltration Losses - Latent

Item	Wall Area (ft <sup>2</sup> )	Infiltration Rate (CFM/ft <sup>2</sup> )	Infiltration Rate (CFM)	Humidity Ratio Difference	Heat Transfer (BtuH)	UA
	A	В	C = AxB	(gr/lb) 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

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 ft²

 Ceiling Height:
 12 ft

 Total Volume:
 524,544 ft³

#### **HEATING LOADS**

#### Ventilation Losses - Sensible

	Number of	Ventilation	Ventilation	Temperature	Heat	
Item	Occupants	Rate	Rate	Difference	Transfer	UA
		(CFM/person)	(CFM)	(F)	(BtuH)	
	Α	В	C =	D	E =	F
			AxB		1.08xCxD	
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
	А	В	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

		(BtuH)	UA
Α	В	C =	D
		AxB	
150 People	250 BtuH/Person	37,500	
43,712 ft <sup>2</sup>	1.71 Btu/ft <sup>2</sup>	74,595	
43,712 ft <sup>2</sup>	2.56 Btu/ft <sup>2</sup>	111,892	
	150 People 43,712 ft <sup>2</sup>	150 People 250 BtuH/Person 43,712 ft <sup>2</sup> 1.71 Btu/ft <sup>2</sup>	150 People 250 BtuH/Person 37,500 43,712 ft <sup>2</sup> 1.71 Btu/ft <sup>2</sup> 74,595

TOTAL TEMP-INDEPENDENT GAINS: 223,986 BTUH

- 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.

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  $\, \text{ft}^2$  Ceiling Height: 12  $\, \text{ft}$  Total Volume: 524,544  $\, \text{ft}^3$ 

#### **COOLING LOADS**

**Design Conditions** 

	Temperature	Humidity	Estimate of Window	/ Solar Gain	
Item	DB	Ratio	Assumptions		
	(F)	(gr/lb)			
			Affected Glass	35%	Percent
Occupied Cooling Setpoint	74	58	Solar Ht Gain <sup>1</sup>	280	Btu/(Hrsq. 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** 

	Total	Net	Temperature		Heat	
Item	Wall Area	Wall Area	Difference	U-Factor	Transfer	UA
	(ft <sup>2</sup> )	(ft <sup>2</sup> )	(F)	Btu/(hr-F-ft <sup>2</sup> )	(BtuH)	
	Α	В	С	D	E =	F =
					BxCxD	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

ltem	Wall Area	Infiltration Rate	Infiltration Rate	Temperature Difference	Heat Transfer	UA
item	(ft <sup>2</sup> )	(CFM/ft <sup>2</sup> )	(CFM)	(F)	(BtuH)	UA
	А	В	C = AxB	D	E = 1.08xCxD	F
Infiltration	12,064	0.15	1,810	17	33,223	

Infiltration Gains - Latent

Item	Wall Area	Infiltration Rate	Infiltration Rate	Humidity Ratio Difference	Heat Transfer	UA
	(ft <sup>2</sup> )	(CFM/ft <sup>2</sup> )	(CFM)	(gr/lb)	(BtuH)	
	A	В	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

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 ft²

 Ceiling Height:
 12 ft

 Total Volume:
 524,544 ft³

#### **COOLING LOADS**

#### Ventilation Gains - Sensible

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

#### Ventilation Gains - Latent

ltem	Number of Occupants	Ventilation Rate (CFM/person)	Ventilation Rate (CFM)	Humidity Ratio Difference (gr/lb)	Heat Transfer (BtuH)	UA
	Α	В	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

			Heat	
Load	Factor 1	Factor 2	Transfer	UA
			(BtuH)	
	А	В	C =	D
			AxB	
People	150 People	450 BtuH/Person	67,500	
Equipment	43,712 ft <sup>2</sup>	1.71 Btu/ft <sup>2</sup>	74,595	
Lighting	43,712 ft <sup>2</sup>	2.56 Btu/ft <sup>2</sup>	111,892	

TOTAL TEMP-INDEPENDENT GAINS: 253,986 BTUH

- 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.



PROJECT: Berlin CT
SUBJECT: Boiler Replacement

FACILITY: Peck Library

	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	Annual Bin Hours	Existing Number of	Proposed Number of	Heating Load	Existing Heating Load	Proposed Heating Load	Existing Heating	Proposed Heating	Existing Standby	Propoosed Standby	Existing Cycling	Propoosed Cycling	Existing NG Use	Proposed NG Use	Saved Energy Use
(F)	DiliTiours	Boilers	Boilers	(%)	(kBh)	(kBh)	Efficiency	Efficiency	Losses	Losses	Losses	Losses	(ccf)	(ccf)	(ccf)
(1)	See Note 1	Dollers	bollers	(70)	(KDII)	(KDII)	Liliciency	Linciency	LUSSES	LUSSES	LUSSES	LUSSES	(CCI)	(CCI)	(CCI)
	Sec Hote 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		į.									į.	16,339	14,575	1,764

PROJECT NO: 142312-86

DATE: 11/9/2015

<sup>1)</sup> Weather from USAF for Hartford Int'l Airport

### **Town Hall Complex**



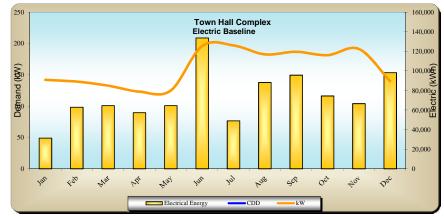


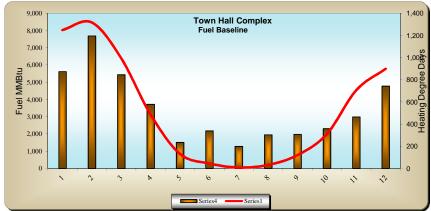
FROM:	May-2014	TO:	Apr-2015							
				Electrical		Blended Unit				Total Utility
Month	HDD	CDD	Billed Demand	Energy	Total Electric	Cost	Natural Gas	Natural Gas	Natural Gas	Cost \$
			kW	kWh	Cost \$	\$/kWh	CCF	Cost \$	\$/CCF	
Jan	1,249		141.8	31,357		\$0.0000	5,620		\$0.00	\$0
Feb	1,317		139.0	62,880		\$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/Saft	_				Mbtu/Saft	\$/Saft

kWh/Sqft 61.7

Mbtu/Sqft

Btu/Sqft/HDD Mbtu/Sqft





PROJECT: Berlin CT

SUBJECT: Facility Information FACILITY: Town Hall Complex

Facility Names	Tax	all Camadan			
Facility Name:		all Complex			
Facility Square Footage	49,018 sq ft				
Weather Data	Hartford Int'l	l Airport			
HEATING EQUIPMENT					
	Existing	Proposed			
	Efficiency	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%			
	Existing	Proposed			
COOLING EQUIPMENT	Efficiency	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	F					
Does setback occur at the end of the	Occupied Time	e?				
(Normally the answer is No) y or n n						
Setback starts	at the end					
of the equipme	nt operating ho	urs.				

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			
		nm				

Current Operating Schedule - Heating						
	continuous					
12am-8am 8am-4pm 4pm-12am Days/Week						
8.0 8.0 7.0						
0.0		12.0	0.0			

am

PROJECT No:

DATE:

142312-86

11/9/2015

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

SEER/COP/KW/Ton Quick Calculator							
INPUT OUTPUT Conversion							
	Value	SEER/EER KW/TON CO					
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	•	Unit	Abbrev Uı	Btu/unit
	SELECT HEATI	NG FUEL			
1	Natural Gas (th	Natural Gas	therms	therm	100,000
2	Natural Gas (co	Natural Gas	ccf	ccf	102,700
3	Natural Gas (N	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

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 ft²
Ceiling Height: 12 ft
Total Volume: 588,216 ft³

#### **HEATING LOADS**

**Design Conditions** 

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

**Building Envelope Losses** 

14	Total	Net	Temperature Difference	II Faatau	Heat	114
Item	Wall Area (ft <sup>2</sup> )	Wall Area (ft²)	(F)	U-Factor Btu/(hr-F-ft <sup>2</sup> )	Transfer (BtuH)	UA
	A	В	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

	Wall	Infiltration	Infiltration	Temperature	Heat	
Item	Area	Rate	Rate	Difference	Transfer	UA
	(ft <sup>2</sup> )	(CFM/ft <sup>2</sup> )	(CFM)	(F)	(BtuH)	
	Α	В	C =	D	E =	F
			AxB		1.08xCxD	
I C'IL L'	12.550	0.15	2.022	70	152.452	
Infiltration	13,550	0.15	2,032	70	153,653	

Infiltration Losses - Latent

	Wall	Infiltration	Infiltration	Humidity Ratio	Heat	
Item	Area	Rate	Rate	Difference	Transfer	UA
	(ft <sup>2</sup> )	(CFM/ft <sup>2</sup> )	(CFM)	(gr/lb)	(BtuH)	
	Α	В	C =	D	E =	F
			AxB		4840xCxD/7000	
Infiltration	13,550	0.15	2,032	0	0	
	.5,555	05	2,002	· ·	· ·	

**TOTAL ENVELOPE LOSSES:** 

905,462 BTUH 12,935 Btu/hr/F

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<sup>2</sup>
Ceiling Height: 12 ft
Total Volume: 588,216 ft<sup>3</sup>

#### **HEATING LOADS**

#### Ventilation Losses - Sensible

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

#### Ventilation Losses - Latent

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

**TOTAL VENTILATION LOSSES:** 

85,050 BTUH 1,215 Btu/hr/F

#### Internal Loads

			Heat	
Load	Factor 1	Factor 2	Transfer	UA
			(BtuH)	
	Α	В	C =	D
			AxB	
People	45 People	250 BtuH/Person	11,250	
Equipment	49,018 ft <sup>2</sup>	1.71 Btu/ft <sup>2</sup>	83,649	
Lighting	49,018 ft <sup>2</sup>	2.56 Btu/ft <sup>2</sup>	125,474	

TOTAL TEMP-INDEPENDENT GAINS: 220,373 BTUH

- 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.

PROJECT: Berlin CT SUBJECT: Load Calculations FACILITY: Town Hall Complex PROJECT No: 142312-86

DATE: 11/9/2015

#### **COOLING LOADS**

**Design Conditions** 

	Temperature	Humidity	Estimate of Window	/ Solar Gain	
Item	DB	Ratio	Assumptions		
	(F)	(gr/lb)			
			Affected Glass	35%	Percent
Occupied Cooling Setpoint	74	58	Solar Ht Gain <sup>1</sup>	280	Btu/(Hrsq. 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** 

	Total	Net	Temperature		Heat	
ltem	Wall Area	Wall Area	Wall Area Difference	U-Factor	Transfer	UA
	(ft <sup>2</sup> )	(ft <sup>2</sup> )	(F)	Btu/(hr-F-ft <sup>2</sup> )	(BtuH)	
	Α	В	С	D	E =	F =
					BxCxD	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	Infiltration Rate	Infiltration Rate	Temperature Difference	Heat Transfer	UA
	(ft <sup>2</sup> )	(CFM/ft <sup>2</sup> )	(CFM)	(F)	(BtuH)	
	А	В	C = AxB	D	E = 1.08xCxD	F
Infiltration	13,550	0.15	2,032	17	37,316	

Infiltration Gains - Latent

Item	Wall Area (ft <sup>2</sup> )	Infiltration Rate (CFM/ft <sup>2</sup> )	Infiltration Rate (CFM)	Humidity Ratio Difference (gr/lb)	Heat Transfer (BtuH)	UA
	А	В	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

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<sup>2</sup>
Ceiling Height: 12 ft
Total Volume: 588,216 ft<sup>3</sup>

#### **COOLING LOADS**

#### Ventilation Gains - Sensible

	Number of	Ventilation	Ventilation	Temperature	Heat	
Item	Occupants	Rate	Rate	Difference	Transfer	UA
		(CFM/person)	(CFM)	(F)	(BtuH)	
	Α	В	C =	D	E =	F
			AxB		1.08xCxD	
Ventilation	45	25	1,125	17	20,655	
ventilation	45	25	1,125	17	20,033	

#### Ventilation Gains - Latent

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

**TOTAL VENTILATION GAINS:** 

71,706 BTUH 4,218 Btu/hr/F

#### Internal Loads

		Heat	
Factor 1	Factor 2	Transfer	UA
		(BtuH)	
Α	В	C =	D
		AxB	
45 People	450 BtuH/Person	20,250	
49,018 ft <sup>2</sup>		83,649	
49,018 ft <sup>2</sup>		125,474	
	45 People 49,018 ft <sup>2</sup>	A B  45 People 450 BtuH/Person 49,018 ft <sup>2</sup> 1.71 Btu/ft <sup>2</sup>	Factor 1 Factor 2 Transfer (BtuH)  A B C = AxB  45 People 450 BtuH/Person 20,250 49,018 ft² 1.71 Btu/ft² 83,649

TOTAL TEMP-INDEPENDENT GAINS: 229,373 BTUH

- 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.



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%	Ö	0	0	Ö	0	ō	0
-13	ō	4	4	100%	770	770	80%	88%	ő	Ö	Ö	ő	Ö	ő	Ö
-18	0	4	4	100%	770	770	80%	88%	0	0	0	0	0	ō	0
-23	0	4	4	100%	770	770	80%	88%	0	0	0	0	0	0	0
	Ĭ	·					0070	3375	ľ		Ĭ				
	8760								ì				41,661	37,167	4,495

<sup>1)</sup> Weather from USAF for Hartford Int'l Airport

# **McGee Middle School**

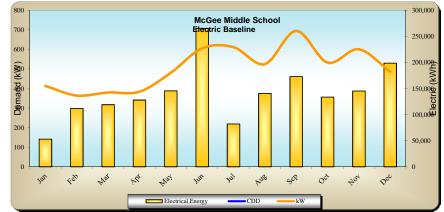
## 142,500 ft<sup>2</sup>

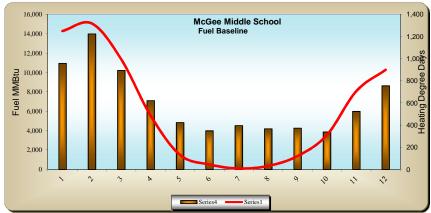


FROM:	May-2014	TO:	Apr-2015								
Month	HDD	CDD	Billed Demand kW	Electrical Energy kWh	Total Electric Cost \$	Blended Unit Cost \$/kWh	Natural Gas CCF	Natural Gas Cost \$	Natural Gas \$/CCF	Total Utility Cost \$	
Jan	1,249		412.4	52,940		\$0.0000	10,945		\$0.00	\$0	
Feb	1,317		363.6	111,744		\$0.0000	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	

Mbtu/Sqft

100.1 Btu/Sqft/HDD Mbtu/Sqft





PROJECT: Berlin CT
SUBJECT: Facility Information

FACILITY: McGee Middle School

Facility Name:	McGoo M	liddle School			
· ·					
Facility Square Footage	142,500 sq ft				
Weather Data	Hartford Int'l	Airport			
HEATING EQUIPMENT					
	Existing	Proposed			
	Efficiency	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%			
	Existing	Proposed			
COOLING EQUIPMENT	Efficiency	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	e Occupied Time	e?				
(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	m-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

PROJECT No:

DATE:

142312-86

11/9/2015

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	2am-8am 8am-4pm 4pm-12am Days/Week					
2.0	8.0	1.0	6.0			
6.0		5.0	1.0			
		nm				

CEED (COD (VAN /T Oviels Celevilete))								
SEER/COP/KW/Ton Quick Calculator								
	INPUT OUTPUT Conversion							
	Value	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 SELECT HEATI	•	Unit	Abbrev Uı	Btu/unit
1	Natural Gas (th	Natural Gas	therms	therm	100,000
2	Natural Gas (co	Natural Gas	ccf	ccf	102,700
3	Natural Gas (N	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

PROJECT: Berlin CT SUBJECT: Load Calculations FACILITY: McGee Middle School PROJECT No: 142312-86 DATE: 11/9/2015

 $\begin{tabular}{llll} Facility Name: & McGee Middle School \\ Floor Area: & 142,500 $ ft^2$ \\ Ceiling Height: & 12 $ ft$ \\ Total Volume: & 1,710,000 $ ft^3$ \\ \end{tabular}$ 

#### **HEATING LOADS**

**Design Conditions** 

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

**Building Envelope Losses** 

	Total	Net	Temperature		Heat	
Item	Wall Area	Wall Area	Wall Area Difference	U-Factor	Transfer	UA
	(ft <sup>2</sup> )	(ft <sup>2</sup> )	(F)	Btu/(hr-F-ft <sup>2</sup> )	(BtuH)	
	Α	В	С	D	E =	F =
					BxCxD	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

	Wall	Infiltration	Infiltration	Temperature	Heat	
Item	Area	Rate	Rate	Difference	Transfer	UA
	(ft <sup>2</sup> )	(CFM/ft <sup>2</sup> )	(CFM)	(F)	(BtuH)	
	Α	В	C =	D	E =	F
			AxB		1.08xCxD	
Infiltration	23,102	0.35	8,086	70	611,292	

Infiltration Losses - Latent

miniciación E055C	Latent					
	Wall	Infiltration	Infiltration	Humidity Ratio	Heat	
Item	Area	Rate	Rate	Difference	Transfer	UA
	(ft <sup>2</sup> )	(CFM/ft <sup>2</sup> )	(CFM)	(gr/lb)	(BtuH)	
	Α	В	C =	D	E =	F
			AxB		4840xCxD/7000	
Infiltration	23,102	0.35	8,086	0	0	

**TOTAL ENVELOPE LOSSES:** 

3,045,223 BTUH 43,503 Btu/hr/F

PROJECT: Berlin CT SUBJECT: Load Calculations FACILITY: McGee Middle School PROJECT No: 142312-86 DATE: 11/9/2015

#### **HEATING LOADS**

#### Ventilation Losses - Sensible

	Number of	Ventilation	Ventilation	Temperature	Heat	
Item	Occupants	Rate	Rate	Difference	Transfer	UA
		(CFM/person)	(CFM)	(F)	(BtuH)	
	Α	В	C =	D	E =	F
			AxB		1.08xCxD	
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
	Α	В	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

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

TOTAL TEMP-INDEPENDENT GAINS: 958,941 BTUH

- 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.

PROJECT: Berlin CT SUBJECT: Load Calculations FACILITY: McGee Middle School PROJECT No: 142312-86 DATE: 11/9/2015

#### **COOLING LOADS**

**Design Conditions** 

	Temperature	Humidity	Estimate of Window	/ Solar Gain	
Item	DB	Ratio	Assumptions		
	(F)	(gr/lb)			
			Affected Glass	35%	Percent
Occupied Cooling Setpoint	74	58	Solar Ht Gain <sup>1</sup>	280	Btu/(Hrsq. 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

	Total	Net	Temperature		Heat	
Item	Wall Area	Wall Area Difference	U-Factor	Transfer	UA	
	(ft <sup>2</sup> )	(ft <sup>2</sup> )	(F)	Btu/(hr-F-ft <sup>2</sup> )	(BtuH)	
	Α	В	С	D	E =	F =
					BxCxD	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

Wall	Infiltration	Infiltration	Temperature	Heat	
Area	Rate	Rate	Difference	Transfer	UA
(ft <sup>2</sup> )	(CFM/ft <sup>2</sup> )	(CFM)	(F)	(BtuH)	
Α	В	C =	D	E =	F
		AxB		1.08xCxD	
00.400	0.05	0.004	4-	440.457	
23,102	0.35	8,086	17	148,457	
	Area (ft²)	Area Rate (ft²) (CFM/ft²)  A B	Area Rate Rate  (ft²) (CFM/ft²) (CFM)  A B C =  AxB	Area Rate Rate Difference  (ft $^2$ ) (CFM/ft $^2$ ) (CFM) (F)  A B C = D  AxB	Area         Rate         Rate         Difference         Transfer           (ft²)         (CFM/ft²)         (CFM)         (F)         (BtuH)           A         B         C =         D         E =           AxB         1.08xCxD

Infiltration Gains - Latent

Item	Wall Area	Infiltration Rate	Infiltration Rate	Humidity Ratio Difference	Heat Transfer	UA
	(ft²) A	(CFM/ft <sup>2</sup> ) B	(CFM) C = AxB	(gr/lb) D	(BtuH) 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

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

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

#### **COOLING LOADS**

#### Ventilation Gains - Sensible

	Number of	Ventilation	Ventilation	Temperature	Heat	
Item	Occupants	Rate	Rate	Difference	Transfer	UA
		(CFM/person)	(CFM)	(F)	(BtuH)	
	Α	В	C =	D	E =	F
			AxB		1.08xCxD	
Ventilation	780	30	22 400	17	420.624	
ventilation	760	30	23,400	17	429,624	

#### Ventilation Gains - Latent

Item	Number of Occupants			Humidity Ratio Difference (gr/lb)	Heat Transfer (BtuH)	UA
	Α	В	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

		Heat		
Factor 1	Factor 2	Transfer	UA	
		(BtuH)		
A	В	C =	D	
		AxB		
780 People	450 BtuH/Person	351,000		
142,500 ft <sup>2</sup>	1.71 Btu/ft <sup>2</sup>	243,176		
142,500 ft <sup>2</sup>	2.56 Btu/ft <sup>2</sup>	364,764		
	780 People 142,500 ft <sup>2</sup>	A B  780 People 450 BtuH/Person 142,500 ft <sup>2</sup> 1.71 Btu/ft <sup>2</sup>	A     B     C = AxB       780 People     450 BtuH/Person 351,000 142,500 ft²     1.71 Btu/ft²     243,176	

TOTAL TEMP-INDEPENDENT GAINS: 958,941 BTUH

- 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.



PROJECT: Berlin CT
SUBJECT: Boiler Replacement
DATE: 11/9/2015

FACILITY: McGee Middle School

	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	Annual Operating	Existing Number of	Proposed Number of	Heating Load	Existing Heating Load	Proposed Heating Load	Existing Heating	Proposed Heating	Existing Standby	Propoosed Standby	Existing Cycling	Propoosed Cycling	Existing NG Use	Proposed NG Use	Saved Energy Use
(F)	Bin Hours	Boilers	Boilers	(%)	(kBh)	(kBh)	Efficiency	Efficiency	Losses	Losses	Losses	Losses	(ccf)	(ccf)	(ccf)
	See Note 1														
															T
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

<sup>1)</sup> Weather from USAF for Hartford Int'l Airport



# **ECM-9: NEW FAN COIL AND AIR HANDLING UNITS**

**Attachment 9A: New HVAC Savings Calculations** 

## **Town Hall Complex**



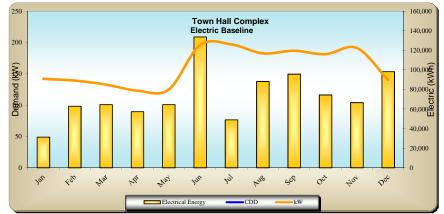


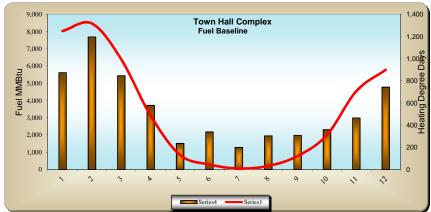
FROM:	May-2014	TO:	Apr-2015								
Month	HDD	CDD	Billed Demand kW	Electrical Energy kWh	Total Electric Cost \$	Blended Unit Cost \$/kWh	Natural Gas CCF	Natural Gas Cost \$	Natural Gas \$/CCF	Total Utility Cost \$	
Jan	1,249		141.8	31,357	Ο03ί ψ	\$0.0000	5,620	Ουσι φ	\$0.00	\$0	
Feb	1,317		139.0	62,880		\$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	

kWh/Sqft 61.7

Mbtu/Sqft

13.8 148.5 Btu/Sqft/HDD Mbtu/Sqft





PROJECT: Berlin CT

SUBJECT: Facility Information FACILITY: Town Hall Complex

Facility Name:	Town Hall Complex			
Facility Square Footage	49,018	sq ft		
Weather Data	Hartford Int'l	Airport		
HEATING EQUIPMENT				
	Existing	Proposed		
	Efficiency	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%		
	Existing	Proposed		
COOLING EQUIPMENT	Efficiency	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	e Occupied Time	e?
(Normally the answer is No)	y or n	n
Setback starts	at the end	
of the equipme	nt operating ho	urs.

		ancy Schedule 6 days/week	
12am-8am	8am-4pm	4pm-12am	Days/Week
1.0	8.0	1.0	6.0
7.0		5.0	1.0
		nm	

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

PROJECT No:

DATE:

142312-86

11/9/2015

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		
		nm			

SEER/COP/KW/Ton Quick Calculator						
	INPUT OUTPUT Conversion					
	Value	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 SELECT HEATI		Unit	Abbrev Uı	Btu/unit
1	Natural Gas (th	Natural Gas	therms	therm	100,000
2	Natural Gas (co	Natural Gas	ccf	ccf	102,700
3	Natural Gas (N	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

PROJECT: Berlin CT SUBJECT: Load Calculations FACILITY: Town Hall Complex PROJECT No: 142312-86 DATE: 11/9/2015

Facility Name:  $\frac{\text{Town Hall Complex}}{\text{Floor Area:}}$  49,018 ft<sup>2</sup> Ceiling Height: 12 ft Total Volume: 588,216 ft<sup>3</sup>

### **HEATING LOADS**

Design Conditions

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

**Building Envelope Losses** 

	Total	Net	Temperature		Heat	
Item	Wall Area	Wall Area	Difference	U-Factor	Transfer	UA
	(ft <sup>2</sup> )	(ft <sup>2</sup> )	(F)	Btu/(hr-F-ft <sup>2</sup> )	(BtuH)	
	Α	В	С	D	E =	F =
					BxCxD	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 <sup>2</sup> )	Infiltration Rate (CFM/ft <sup>2</sup> )	Infiltration Rate (CFM)	Temperature Difference (F)	Heat Transfer (BtuH)	UA
	A	В	C = AxB	D D	E = 1.08xCxD	F
Infiltration	13,550	0.15	2,032	70	153,653	

Infiltration Losses - Latent

mineración E055Cs	Latent					
	Wall	Infiltration	Infiltration	Humidity Ratio	Heat	_
Item	Area	Rate	Rate	Difference	Transfer	UA
	(ft <sup>2</sup> )	(CFM/ft <sup>2</sup> )	(CFM)	(gr/lb)	(BtuH)	
	Α	В	C =	D	E =	F
			AxB		4840xCxD/7000	
Infiltration	13,550	0.15	2,032	0	0	

**TOTAL ENVELOPE LOSSES:** 

905,462 BTUH 12,935 Btu/hr/F

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<sup>2</sup>
Ceiling Height: 12 ft
Total Volume: 588,216 ft<sup>3</sup>

### **HEATING LOADS**

### Ventilation Losses - Sensible

	Number of	Ventilation	Ventilation	Temperature	Heat	
Item	Occupants	Rate	Rate	Difference	Transfer	UA
		(CFM/person)	(CFM)	(F)	(BtuH)	
	Α	В	C =	D	E =	F
			AxB		1.08xCxD	
.,	45	25	1 105	70	05.050	
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
	Α	В	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

		Heat	
Factor 1	Factor 2	Transfer	UA
		(BtuH)	
A	В	C =	D
		AxB	
45 People	250 BtuH/Person	11,250	
		83,649	
49,018 ft <sup>2</sup>	2.56 Btu/ft <sup>2</sup>	125,474	
	45 People 49,018 ft <sup>2</sup>	A B  45 People 250 BtuH/Person 49,018 ft <sup>2</sup> 1.71 Btu/ft <sup>2</sup>	Factor 1 Factor 2 Transfer (BtuH)  A B C = AxB  45 People 250 BtuH/Person 11,250 49,018 ft² 1.71 Btu/ft² 83,649

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.

PROJECT: Berlin CT SUBJECT: Load Calculations FACILITY: Town Hall Complex PROJECT No: 142312-86

DATE: 11/9/2015

### **COOLING LOADS**

**Design Conditions** 

	Temperature	Humidity	Estimate of Window	/ Solar Gain	
Item	DB	Ratio	Assumptions		
	(F)	(gr/lb)			
			Affected Glass	35%	Percent
Occupied Cooling Setpoint	74	58	Solar Ht Gain <sup>1</sup>	280	Btu/(Hrsq. ft.)
Outdoor Design Condition	91	124	SHGF.	0.70	
Design Difference	17	66	SC	0.88	
			1. ASHRAE 1989 Ch	2/ 1b 3-11; 40	NL August 21, noon

**Building Envelope Gains** 

	Total	Net	Temperature		Heat	
ltem	Wall Area	Wall Area	Difference	U-Factor	Transfer	UA
	(ft <sup>2</sup> )	(ft <sup>2</sup> )	(F)	Btu/(hr-F-ft <sup>2</sup> )	(BtuH)	
	Α	В	С	D	E =	F =
					BxCxD	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 (ft²)	Infiltration Rate (CFM/ft <sup>2</sup> )	Infiltration Rate (CFM)	Temperature Difference (F)	Heat Transfer (BtuH)	UA
	A	В	C = AxB	D	E = 1.08xCxD	F
Infiltration	13,550	0.15	2,032	17	37,316	

Infiltration Gains - Latent

ltem	Wall Area	Infiltration Rate	Infiltration Rate	Humidity Ratio Difference	Heat Transfer	UA
	(ft <sup>2</sup> )	(CFM/ft <sup>2</sup> )	(CFM)	(gr/lb)	(BtuH)	
	Α	В	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

PROJECT: Berlin CT SUBJECT: Load Calculations FACILITY: Town Hall Complex PROJECT No: 142312-86 DATE: 11/9/2015

### **COOLING LOADS**

### Ventilation Gains - Sensible

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

#### Ventilation Gains - Latent

ltem	Number of Occupants	Ventilation Rate (CFM/person)	Ventilation Rate (CFM)	Humidity Ratio Difference (gr/lb)	Heat Transfer (BtuH)	UA
	А	В	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	UA
			(BtuH)	
	A	В	C =	D
			AxB	
People	45 People	450 BtuH/Person	20,250	
Equipment	49,018 ft <sup>2</sup>	1.71 Btu/ft <sup>2</sup>	83,649	
Lighting	49,018 ft <sup>2</sup>	2.56 Btu/ft <sup>2</sup>	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.

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

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

Facility Name:	Town Hall C	omplex
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 op	Jse HVAC operating Bins? Y/N						
Outdoor Air	Annual	Annual	Annual	Total			
Bin Temp	Bin Hours	Bin Hours	Bin Hours	Annual			
F	12am-8am	8am-4pm	4pm-12am	Bin Hours			
A	В	С	D	E =			
	l	l	l	B+C+D			
	Hartford Int'l Air	port					
107	0	0	0	0			
107	0	0	0	0			
97	0	4		4			
97	0	34	0	43			
	0						
87 82	4	105 247	22 105	127 356			
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 2	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			
1	I	l	l				

	Typical Occupa	ancy Schedule		ı	Cu	rrent Operating	Schedule - Coo	ling
	7am to 5pm6	days/week				6am to 4pm	7 days/week*	
12am-8am	8am-4pm	4pm-12am	Days/Week		12am-8am	8am-4pm	4pm-12am	Days/Weel
1.0	8.0	1.0	6.0		2.0	8.0	0.0	7.0
JJ.	KK	LL	MM		NN	PP	QQ	RR

Occupied
Bin Hours
12am-8am
F =
BxJJxMM
8 7

KK	LL	MM	NN	PP	QQ	KK	г
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	
G = Cx <u>KK</u> x <u>MM</u> 8 7	H = Dx <u>LL</u> x <u>MM</u> 8 7	J = F+G+H	K = Bx <u>NNxRR</u> 8 7	L = Cx <u>PP</u> xRR 8 7	M = Dx <u>QQ</u> xRR 8 7	N = K+L+M	9
0 0 3 3 29 90 212 208 178 198 257 194 159 111 161 254 190 6 6 6 3 0 0 0	0 0 0 1 2 11 17 20 27 33 31 28 20 17 33 32 19 6 6 3 0 0 0	0 0 3 3 30 92 223 231 213 246 322 254 219 208 317 720 57 120 57	0 0 0 0 1 14 34 50 77 68 73 73 73 73 73 63 46 58 34 11 63	0 0 4 34 105 247 243 208 231 300 226 186 129 188 296 222 160 89 42 7 7 3 0	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0 0 4 34 105 248 257 242 281 377 294 259 368 265 265 265 276 276 277 276 277 276 277 276 277 277	
0 0	0	0	0 0 0	0 0	0 0 0	0	

<			$\rightarrow$	
		EXIST		
ent	Operating	Setforward	Total	- [
ating	Heat Gains	Heat Gains	Electric Use	
ours	MBtu/hr	MBtu/hr	kWh/yr	
=	P =	Q =	R =	- [
+M	(A-AA)x(EE+FF)	(A-CC)xEE	Jx(P+GG) + (N-J)xP + (E-N)xO	
	1000	1000	12/HH	
				Г
	1,684	1,545	0	
	1,429	1,311	0	
	1,174	1,077	247	
1	919	843	2,062	
5	664	609	4,700	
8	408	375	8,700	
7	153	140	5,424	
2	0	0	2,198	
1	0	0	2,543	
7	0	0	3,342	
4	0	0	0	
9	0	0	0	
2	0	0	0	
9	0	0	0	
8	0	0	0	
5	0	0	0	
6	0	0	0	
7	0	0	0	
5	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	

Unoccupied Hours - Systems Shut Down

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			
SS	TT	UU	VV			
Operating	Operating	Operating	Proposed			

22	- 11	UU	VV			\			
					PROPOSED				
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	Total Electric Use kWh/yr			
S = Bx <u>SS</u> x <u>VV</u> 8 7	T = Cx <u>TT</u> x <u>VV</u> 8 7	U = Dx <u>UUxVV</u> 8 7	V = S+T+U	W = (A-BB)x(EE+FF) 1000	X = (A-DD)xEE 1000	Jx(W+GG) + (V-J)xW + (E-V)xX 12/HH			
0 0 0 0 0 1 12 29 43 66 58 62 45 60 2 54 39 50	0 0 3 29 90 212 208 178 198 257 194 159 111 161 254 190 137 76	0 0 0 1 2 11 17 20 27 33 31 28 20 17 33 27 19	0 0 3 3 30 92 224 227 227 267 356 283 250 176 238 348 271 195 145	1,684 1,429 1,174 919 664 408 153 0 0 0 0 0 0	1,264 1,030 796 562 328 94 0 0 0 0 0 0 0 0 0 0 0	0 9 397 1885 4,230 6,989 4,026 2,198 2,343 3,342 0 0 0 0 0			
29 9 5 2 0 0	36 6 3 0 0	6 3 0 0 0	71 18 8 2 0 0	0 0 0 0	0 0 0 0 0 0	0 0 0 0 0			
0	0	0	0	0	0	0			

Unoccupi Hours - Fa Still Runni	ans		Unoccupied ours - Systems Shut Down		
Occupied Hours	_				
		PROPO	DSED		
Operatin Heat Gair MBtu/h	ns	Setforward Heat Gains MBtu/hr	Electi	otal ric Use h/yr	
(A-BB)x(EE 1000	+FF)	X = (A-DD)xEE 1000	Jx(W+GG) + (V	'=	)xX

PROJECT No: DATE:

142312-86 11/9/2015

	Saved Electric kWh/yr
xΧ	Z= R-Y
	0 0 10 1777 4770 1,7711 1,398 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
	3,766

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

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

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

Facility Name:	Town Hall Co	mplex
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

Outdoor Air	Annual	Annual	Annual	Total
Bin Temp	Bin Hours	Bin Hours	Bin Hours	Annual
F	12am-8am	8am-4pm	4pm-12am	Bin Hours
A	В	c	D	E=
			l	B+C+D
	Hartford Int'l Air	port		
107	0	0	0	0
102	0	0	o	o
97	0	4	o	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

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

Occupied	Occupied	Occupied	Current	i	Operating	Operating	Operating	Current
Bin Hours	Bin Hours	Bin Hours	Occupied		Operating Bin Hours	Operating Bin Hours	Bin Hours	Operating
12am-8am	8am-4pm	4pm-12am	Bin Hours		12am-8am	8am-4pm	4pm-12am	Bin Hours
F =	G=	4pm-izam H=	J =		K =	bam-4pm L=	4pm-12am M=	N =
F =	G =	H=	J=		K =	L=	M =	N =
BxJJxMM	CxKKxMM	DxLLxMM	F+G+H		BxNNxRR	CxPPxRR	DxOOxRR	K+I+M
8 7	8 7	8 7			8 7	8 7	8 7	
0	0	0	0		0	0	0	0
0	0	0	0		0	0	0	0
0	3	0	3		0	4	0	4
0	29	1	30		0	34	9	43
0	90	2	92		0	105	22	127
0	212	11	223		4	247	105	356
6	208	17	231		55	243	158	456
15	178	20	213		137	208	183	528
21	198	27	246		199	231	248	678
33	257	33	323		306	300	310	916
29	194	31	254		270	226	289	785
31	159	28	219		291	186	261	738
23	111	20	153		210	129	187	526
30	161	17	208		282	188	155	625
31	254	33	317		288	296	306	890
27	190	27	244		252	222	251	725
20	137	19	176		182	160	177	519
25	76	19	120		231	89	177	497
14	36	6	57		135	42	57	234
5	6	3	13		44	7	24	75
2	3	0	5	ĺ	23	3	1	27
1	0	0	1		11	0	0	11
0	0	0	0	ĺ	0	0	0	0
0	0	0	0		0	0	0	0
0	0	0	0	ĺ	0	0	0	0
0	0	0	0		0	0	0	0

	Still I	d Hours - Fans Running ay be on or off	
	Unocc Hours - S Shut I	Systems	
		Hours	
		EXIS7	
	rating	Setback	Total
Hea	t Loss	Heat Loss	Fuel Us
MB	tu/hr	MBtu/hr	ccf/yr
F	=	Q =	₩ R =
			Jv(P-GG)+f(N-I)vP

(CC-A)xEE 1000

(AA-A)x(EE+FF) 1000

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		

NG Total	SS	TT	UU	VV	_				
Total							PROPO	DSED	
	Operating	Operating	Operating	Proposed		Occupied	Unoccupied	Total	Saved
Fuel Use	Bin Hours	Bin Hours	Bin Hours	Operating		Heat Loss	Heat Loss	Fuel Use	Fuel Use
ccf/yr	12am-8am	8am-4pm	4pm-12am	Bin Hours		MBtu/hr	MBtu/hr	ccf/yr	ocf/yr
** R =	S =	T=	U =	V =		W =	X =	Y=1	Z=
Iv(P-GG) +F(N-1)vP or (N-1)vO1	_			-				Iv(W-GG) + ((V-1)vW or (V-1)vX1	_
+ (E-N)xO	BxSSxVV	CxTTxVV	DxUUxVV	S+T+U	(	BB-A)x(EE+FF)	(DD-A)xEE	+ (E-V)xX	R-Y
103xHH	8 7	8 7	8 7			1000	1000	103xHH	
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0	34	243	20	265		0	0	0	ö
	50	208	23 31	265 312					
0		300	39	312 415		0	0	0	0
	77					0			0
1,292	68	226	36	330		212	129	860	432
1,841	73	186	33	291		283	194	1,386	455
1,745	53	129	23	205		354	259	1,395	350
2,514	71	188	19	278		425	323	2,112	402
4,248	72	296	38	406		495	388	3,654	594
4,084	63	222	31	316		566	453	3,554	530
3,342	46	160	22	228		637	517	2,944	398
3,725	58	89	22	169		708	582	3,254	471
1,943	34	42	7	83		778	647	1,716	228
696	11	7	3	21		849	711	611	85
271	6	3	0	9		920	776	242	30
122	3	0	0	3		991	841	108	14
0	0	0	0	0		1.061	905	0	ö
ō	ō	ō	ō	ō		1.132	970	ō	ŏ
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ŏ	ő	ő	ő	ő		1.274	1.099	ő	ŏ
-	_		1						1 1
25.825	730	2.920	365	4.015	-			21.835	3,990
		_,		.,515				-,-55	

	Hours		
	PROPO		
Occupied	Unoccupied	Total	Saved
Heat Loss	Heat Loss	Fuel Use	Fuel Use
MBtu/hr	MBtu/hr	ccf/yr	ocf/yr
W =	X =	↓ Y=↓	Z =
B-A)x(EE+FF)	(DD-A)xEE	1v(W-GG) + [(V-1)vW or (V-1)vX] + (E-V)xX	R-Y
1000	1000	103xHH	
0	0	0	0
0	0	0	ō
ō	ō	0	ŏ
ō	ō	o o	ō
0	0	0	ō
ō	ō	o o	ō
0	0	0	ō
0	0	0	ó
0	0	0	0
0	0	0	ó
212	129	860	432
283	194	1,386	455
354	259	1,395	350
425	323	2,112	402
495	388	3,654	594
566	453	3,554	530
637	517	2,944	398
708	582	3,254	471
778	647	1,716	228
849	711	611	85
920	776	242	30



# **ECM-10: SOLAR PHOTOVOLTAICS**

**Attachment 10A: PV Savings Calculations** 



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

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## **RESULTS**

# 261,595 kWh per Year \*

Month	Solar Radiation ( kWh / m² / 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
nnual	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

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.



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

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## **RESULTS**

# 174,396 kWh per Year \*

Month	Solar Radiation ( kWh / m² / 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
nnual	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

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.



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

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# **RESULTS**

# 261,595 kWh per Year \*

Month	Solar Radiation ( kWh / m² / 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
nnual	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

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.



Caution: Photovoltaic system performance predictions calculated by PWMat8s include many inherent assumptions and uncertainties and do not reflect variations between PV technologies nor site-specific characteristics except as represented by PWMat8s inputs. For example, PV modules with better performance are not differentiated within PWMat8s from lesser performing modules. Both NREL and private companies provide more sophisticated PV modeling tools (such as the System Advisor Model at http://smm.nel.gov) that allow for more precise and complex modeling of PV systems.

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# **RESULTS**

# 305,194 kWh per Year \*

Month	Solar Radiation ( kWh / m² / 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
ınnual	4.07	305,195	0

### **Location and Station Identification**

Beginsted Leastien	4000 Norten Dd. Barlin, CT
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

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.