

VOLUME III: CHAPTERS 6.7 - 6.12





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NAUGATUCK ĠĒ Ξ







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05 SYSTEM LEVEL RECOMMENDATIONS

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EXECUTIVE SUMMARY

The Naugatuck Valley Community College (Naugatuck) Energy Master Plan aims to identify ways Naugatuck can improve energy use on campus, and be an active participant in Connecticut State Colleges & Universities (CSCU)'s energy management, reduction and conservation efforts. The utility data received indicates Naugatuck is a higher energy use intensity (EUI) campus of the CSCU from an energy perspective (see Figure 1 Naugatuck Valley Energy Dashboard). The EUI method is used for benchmarking and comparison purposes. Energy management efforts in the past have reduced Naugatuck' energy use, through efforts such as de-lamping lighting fixtures and drive upgrades at the Core heating plant.



FIGURE 1: Naugatuck Valley Community College Energy Dashboard

Main contributers to high energy use include inefficient absorption chillers running off of tempered water from the high temperature hot water (HTHW) heating plant and inefficient lighting. The high usage of natural gas can be attributed mostly to the use of absorption chillers, fired by the hot water boilers.

Energy Spend

Table 1 provides a comparison of energy spending comparing Naugatuck to the average of CSCU campuses and the Northeast Region Commercial Sector.

	Naugatuck Valley	Average of CSCU	Average of CSCU	Northeast Region
	Community College	Community College	University	Commercial Sector
Cost per Square Feet	\$ 1.98	\$ 2.49	\$ 2.08	\$ 1.67
Cost per FTE Student	\$ 295	\$ 311	\$ 677	\$ -
Avg. Cost per kWh Electricity from Grid	\$ 0.12	\$ 0.14	\$ 0.14	\$ 0.15
Avg. Cost per MMBtu Natural Gas	\$ 8.16	\$ 10.06	\$ 7.32	\$ 10.03
Total Operating Expenses	\$ 62,717,000	\$ -	\$ -	
Total Energy Spending	\$ 1,292,483	\$ -	\$ -	
% of Operating Expenses	2.06%	1.95%	2.67%	

TABLE 1: Energy Cost Comparison (FY 2014)

Naugatuck's lower natural gas and electricity costs both contribute to the campuses low cost per square foot and FTE student. The use of absorption chillers likely contribute to the lower cost. Absorption chillers can help to reduce electric demand charges, as well as can provide volume discounts on natural gas from greater natural gas use.

Utility Incentives/ Develop Plan for Energy Efficiency Measures (EEMs)

Both of Naugatuck's utilities are through Eversource. This places the campus in a prime position to maximize incentives by combining multiple energy saving opportunities in what is known as a "Comprehensive Project."

Since incentives are based on incremental energy savings, further analysis and collaboration with Eversource is required to determine rebate amounts for each opportunity. Table 2 demonstrates a summary of the EEMs recommended for Naugatuck to pursue.

Opportunity ID	Energy Conservation or Efficiency Opportunity	Associated Building if Applicable	App. Cost (Before Rebate)	Payback w/rebate (Years)	Priority	PORTUNIT
NVCC-1	Add control to HTHW pump VFD for variable flow pumping (first check if system is compatible with variable flow) and open triple-duty valves to 100%.	Core	Minimal	<1 - 2	1	TIES
NVCC-2	Add control to chilled/cooling water pump VFD for variable flow pumping (first check if system is compatible with variable flow with special caution around absorption chiller minimum flow) and open triple-duty valves to 100%.	Core	Minimal	<1 - 2	1	RECO
NVCC-3	Implement outdoor temperature reset strategies for hot water, chilled water, and cooling water with BMS upgrades.	Core	Minimal	<1 - 2	1	OMMEND
NVCC-4	Continue to educate occupants on fume hood sash management as a part of a fume hood sash management campaign with goal to instill an energy efficient culture.	All	Minimal	Varies	1	ATIONS
NVCC-5	Recommission (EBCx) existing Lighting and Controls.	Technology Hall	\$0.50 / sq.ft.	Varies	1	
NVCC-6	Conduct a comprehensive lighting audit.	All	Contact Eversource Rep	Varies	1	-0
NVCC-7	Replace Halogen and T8 Lighting throughout the building with LED.	Technology Hall, Kinney Hall	Contact Eversource Rep	2 - 6	1	LANS
NVCC-8	Use lighting controls with occupancy sensors.	A, S, & L Building	144000	Varies	1	
NVCC-9	Consult with Eversource to install LED parking garage lighting and controls. (in progress)	Ekstrom Parking Garage	\$0.23-0.77 per sq.ft.	1 - 2	1	
NVCC-10	Consult with Eversource to install LED parking garage lighting and controls. (in progress)	Core Garage	\$0.23-0.77 per sq.ft.	1 - 2	1	

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SYSTEM LEVEL ENERGY NEEDS



NVCC-11	Insulate HTHW heat exchangers where insulation is missing.	Ekstrom Hall	\$600 each	<1	1
NVCC-12	Upgrade older BAS system to more current and supportable hardware. Seek competitive bids on a complete Control System upgrade. Metasys is JCI's current proprietary system. Ensure on-site training of operators is included.	All	\$50,000 minimum	Varies	2
NVCC-13	Install heat reflectors behind baseboard radiators	A, S, & L Building	\$20 per 34" long 8" high radiator	Varies	2
NVCC-14	Optimize to minimum air-change rates in laboratories, taking into account minimum flow through fume hoods.	Technology Hall	Minimal	Varies	3
NVCC-15	Check heat exchangers for efficiency and fouling using the TEMA Standard (will require temperature readings on the inlet and outlet of each side of the heat exhanger). Clean or replace when the heat exchanger effective heat transfer coefficient drops below an acceptable threshold.	All	Varies	Varies	3
NVCC-16	Decommission/remove unnecessary fume hoods, i.e. those used for storage.	Technology Hall	Varies	Varies	3
NVCC-17	Use ventilated storage cabinets instead of hoods or entire room ventilation systems to meet air change requirements.	Technology Hall	Varies	Varies	3
NVCC-18	Replace unit ventilators with higher efficiency equipment. Whole system may be replaced with central air connected to a chiller and heating coils to central plant.	Kinney Hall	Varies	Varies	3
NVCC-19	.Replace once through water cooled HTHW circulator pumps with air cooled hot water pumps such as Dean RWA	Core	Varies	Varies	3

TABLE 2: Naugatuck Energy Efficiency Measures

In addition to the priority projects, next steps for Naugatuck are below:

Next Step

Management

The building management system (BMS) and operator understanding both play large roles in operating the energy systems efficiently. Upgrading to a web based BMS greatly improves the operator's or commissioning agent's ability to catch and correct operational issues. This is especially important during the warranty period of any new equipment.

As part of the CSCU Energy Master Plan, it is recommended that CSCU create a template for energy tracking applicable to all campuses. Naugatuck should track energy usage through such a template, as well as compare energy spend against available budgets, and verify consumption reports.

Renewable Energy

Explore power purchase agreements (PPAs) for portions of the building roofs and parking canopy opportunities. It is recommended for Naugatuck to with CSCU to explore PV options. CSCU has received favorable pricing for PPA projects with possible discounts 20% to 50% of purchased power costs. Solar PV should be incorporated into future capital planning building design.

By implementing the suggestions of the Energy Master Plan, Naugatuck has the opportunity to create local and cost-effective power through solar PV and/or CHP, increase energy efficiency operations, and continue to manage energy as the campus evolves in the future.

As part of the CSCU Energy Master Plan, Naugatuck's building infrastructure, energy use and energy management practices were assessed. The ultimate goal was to determine ways Naugatuck could improve its energy use on campus, and be an active participant in CSCU energy reduction efforts. This chapter identifies Naugatuck's historical energy use, future projected needs and energy recommendations.

1.1 NAUGATUCK VALLEY OVERVIEW

Naugatuck is located at 750 Chase Parkway in one of the state's largest cities, Waterbury, Connecticut. Naugatuck is a public two-year non-residential college with the majority of the student population base coming from the greater Waterbury area. The main campus spans 110-acres, the annual enrollment is approximately 14,000 students. Naugatuck consists of a 110-acre Waterbury campus with four buildings and two parking garages. The Danbury campus is located 28 miles from Waterbury at 183 Main Street in downtown Danbury. Naugatuck does not own the Danbury building, so it is not included in the Energy Master Plan.

With the exception of Founders Hall (under construction, currently offline) all campus buildings are interconnected and provide a continuous space. The four interconnected campus buildings are divided into five areas: Kinney Hall, AS&L, Core, Ekstrom Hall, and Technology Hall. Administrative Offices and admissions are located at the first building Kinney Hall. The A,S&L Building is a mixed use building, containing two theaters, recording studios and music studios for the campus' art offerings. The Learning Resource Center provides materials and online resources for students.

The campus' Facilities Department, boilers, chiller and main electrical distribution equipment is located in the Core. The Core also houses public safety and important life safety equipment. The sciences and laboratories are primarily concentrated in Ekstrom Hall, while engineering and manufacturing labs are centered in the adjacent Technology Hall. The campus grounds also feature nine new gardens as part of a campus-wide beautification process. A list of existing buildings on the campus is in Table 1.1.



FIGURE 1.1: Naugatuck Valley Community College Interior

05 SYSTEM LEVEL

01 INTRODUCTION

02 SYSTEN LEVEL EXISTING CONDITIONS

Building	Year Built [Renovated]	Gross Square Feet	Building Function
Kinney Hall	1977	71,940	Administrative/Academic
A, S, & L Building/ Fine Arts Center, Cistulli Student Center and Traurig Learning Resource Center.	1988	144,000	Mixed Use
Core	1977	76,114	Facilities
Ekstrom Hall	1980	206,538	Academic with labs
Technology Hall	2009	99,684	Academic
Founders Hall	2017	70,428	Currently Under Construction
Subtotal		668,704	
Garages			
Ekstrom Parking Garage	1980	54,000	Parking Garage
Core Garage	1977	196,600	Parking Garage
Subtotal		250,600	
Total		919,304	

TABLE 1.1: Naugatuck Building Information





FIGURE 1.2: Naugatuck Campus Map

1.2 PREVIOUS ENERGY STUDIES & PROJECTS

Naugatuck participated in a benchmarking study in 2013 administered by Eastern's Institute for Sustainable Energy (ISE). Findings suggested that Naugatuck had a higher than average Energy Use Intensity than the CSCU community colleges, partially attributed by the campus' sprawling space. Concurrent with the Energy Master Plan, Naugatuck is also participating in their revised Campus Master Plan with a focus on utilities existing conditions.

Previous completed energy projects, driven both by past studies and the campus' desire to optimize efficiency, include:

- Variable frequency drives (VFDs) on primary loop motors
- Low-E window tinting
- Fume hood sash management program (done with Technology hall)

EXISTING CONDITIONS & RECOMMENDATIONS

Information on Naugatuck's existing conditions was captured from campus interviews, energy data and reports provided by the campus. A holistic view of existing practices, material on energy management, energy infrastructure and project implementation processes was reviewed. Analysis of the data and campus walkthroughs helped clarify recommendations with the goal of decreasing energy use, documented after each subheading.

2.1 FACILITY ENERGY BENCHMARKING AND ENERGY CONSUMPTION

Naugatuck's energy dashboard provides a summary of the campus' energy consumption, based on fiscal year 2014 and 2015 data. Appendix A documents information on the assumptions and data sources used for energy benchmarking purposes.



FIGURE 2.1: Naugatuck Valley Community College Energy Dashboard

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Based on the data :

- Naugatuck has a Site EUI of 125 kBtu/sf, higher than the regional median for colleges/universities.
- The corresponding Source EUI, 201 kBtu/sf, is lower than the regional median due to a smaller portion of electric energy use due to the hot water driven absorption chillers.
- Slight decrease in weather normalized energy use from fiscal year 2014 and 2015.

The campus does not have submetering, with the exception of Founders Hall, therefore building level data is not available.

Table 2.1 provides a comparison of FY 2014 energy spending compared to the average of CSCU campuses and the Northeast Region Commercial Sector.

2.3 ENERGY PROCUREMENT

Naugatuck is part of the CSCU's 2013 electric supply procurement contract with Direct Energy (formerly Hess Energy), detailed further in the Energy Master Plan. Their electricity is on Rate 58 denoting the campus' annual maximum demand is greater than 1000 kW per year. Direct Energy is Naugatuck's third party natural gas supplier.

2.4 OPERATIONAL AND ENERGY MANAGEMENT PRACTICES

2.4.1 CURRENT CONDITIONS

Naugatuck's facilities department is responsible for maintaining campus infrastructure and grounds and operates on a budget of approximately \$3 million a year.

	Naugatuck Valley Community College	Average of CSCU Community College	Average of CSCU University	Northeast Region Commercial Sector
Cost per Square Feet	\$ 1.98	\$ 2.49	\$ 2.08	\$ 1.67
Cost per FTE Student	\$ 295	\$ 311	\$ 677	\$ -
Avg. Cost per kWh Electricity from Grid	\$ 0.12	\$ 0.14	\$ 0.14	\$ 0.15
Avg. Cost per MMBtu Natural Gas	\$ 8.16	\$ 10.06	\$ 7.32	\$ 10.03
Total Operating Expenses	\$ 62,717,000	\$ -	\$ -	
Total Energy Spending	\$ 1,292,483	\$ -	\$ -	
% of Operating Expenses	2.06%	1.95%	2.67%	

 TABLE 2.1: Energy Cost Comparison (FY 2014)

Naugatuck's natural gas unit cost is approximately 19% lower than the CSCU community college average, and the all in cost for electricity is approximately 13% lower. Both of these factors contribute to the lower than campus average cost per square foot and per FTE student.

The absorption chiller likely reduces the electrical cost by helping keep the kW demand low and reduces the natural gas cost by using a large volume of gas year round, yielding a volume discount. Despite the apparent advantages, the total energy spending could be further reduced by using modern high efficiency electric chillers which are up to ten times more efficient than absorption chillers. Plans are in place for this type of change.

2.2 CAMPUS UTILITIES AND DISTRIBUTION

The majority of Naugatucks' energy consumption on an MMBtu basis is from natural gas Figure 2.1b. The following is a list of Naugatuck's utility providers:

- Electric: Eversource, Connecticut Light & Power
- Natural Gas: Eversource (formerly Yankee Gas)

Duties include utility provisions, housekeeping, and repairs. The department consists of 36 employees including the Director of Facilities, Building Supervisor II, Supervising Custodian, Lead Stationary Engineer, and Boiler Tender, among other staff . While there is not a designated energy manager, Facilities monitors energy use.

To meet the diverse needs and schedules of its students, Naugatuck offers day, evening, and weekend classes, as well as online and hybrid instruction. Typical operating hours are:

Weekdays	: 6:30-11 PM

Saturday : 7 AM- 7 PM

Variable occupancy is especially a concern for Technology Hall as it currently always needs to be conditioned.

The majority of campus occupancy is between the months of September to December, and late January to May. There is limited building shut down over breaks. due to non-credit and non-academic programs utilizing various building spaces around the primary occupancy and use.

ENERGY USE INFORMATION MANAGEMENT SYSTEM

The campus' building automation system (BAS) is Johnson Controls Metasys. System capabilities include adjusting lighting controls, HVAC set points, and monitoring Central Plant alarms. Lately, Facilities has been experiencing software glitches causing the unscheduled shutdown of chillers, creating a need for an upgraded BAS. They explored updating the BAS in 2009, but the \$50,000 cost for the upgrade was not achievable at the time.



FIGURE 2.2: Energy Use Information Management System

2.4.2 RECOMMENDATIONS

As part of the CSCU Energy Master Plan recommendations in Section 5.2.2, it is recommended that the System Office create a template for energy tracking applicable to all campuses. Naugatuck should use this template to track energy over time. Naugatuck can also use Eversource's Customer Engagement Platform to view its energy use. Building Management Systems (BMS), some known as Energy Management Systems (EMS), can offer an excellent way to track energy use of specific equipment such as an air handler, pump, or boiler. The addition of an EMS is recommended with an energy meter on the electrical power distribution and low temperature side of each building HTHW heat exchanger to better track energy use between buildings.

The campus should consider additional shut downs during summer months when occupancy is limited and engage administration in consolidation of classes by adjusting class scheduling. Ultimately, fewer buildings can be used and for fewer hours. BAS and operator understanding both play large roles in operating the energy systems efficiently. As the campus is already planning on upgrading their BAS, efforts for a new or improved system are recommended to include features such as an open source protocol and web-based connectivity. Documenting system set points, such as outdoor temperature resets operation and building comfort, should be a priority. Upgrading to a web based BMS greatly improves the operator's or commissioning agent's ability to catch and correct operational issues. This is especially important during the warranty period of any new equipment.

2.5 EXISTING BUILDING COMMISSIONING

2.5.1 CURRENT CONDITIONS

No recent building commissioning efforts were reported.

2.5.2 RECOMMENDATIONS

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Buildings with BMS systems with measurable points stand to benefit the most from recommissioning. While Naugatuck's campus buildings aren't fully integrated on a modern BMS, Naugatuck may benefit from manually checking all systems, especially actuators and pneumatic valves, to ensure they operate as intended. As a general rule of thumb:

Recommission existing building systems every 3-5 years

Observations, such as VFD's set to constant speed, show there is room for improvement by recommissioning. Often building systems are commissioned to just get the building working, not optimizing for reducing energy costs. Ensure a Certified Building Commissioning Professional, such as one recognized by the Association of Energy Engineers (AEE) is selected to perform the commissioning.

2.6 MECHANICAL SYSTEMS

2.6.1 CURRENT CONDITIONS

Naugatuck's Core building houses the campuses boiler complex fueled by natural gas with oil switching capabilities. There are plans for replacement of the boilers, hot water distribution pumps, and future inclusion of energy efficiency improvements. Current conditions are well documented in the System Options Study, produced by BVH Integrated Services on May 11, 2016 as part of Sate Project No. BI-CTC-500. Observations from the walk-though audit are listed below.

03 SYSTEM LEVEL ENERGY NEEDS



Mechanical/Electrical:

- Ekstrom Hall (Science Building)
 - **a.** Estimated to be #1 Energy user by staff
 - $\ensuremath{\textbf{b.}}$ Houses IT servers with independent cooling system
 - c. 31 Lab Fume hoods

d. Additional natural gas user is a "teaching kitchen" and science labs

Kinney Hall

a. Estimated to be #2 energy used by staff**b.** 60 Gallon electric hot water heater

ASL (Core)

a. Two 680 Ton single stage absorption chillers, a third is abandoned in-place. Naugatuck will be replacing the existing absorption chillers with electric chillers.

1. Water temperature for the chillers is reduced from the approximately 300 °F high temperature hot water (HTHW) to 240 °F through a mixing valve

2. Only one chiller is needed at peak of summer, but still can't provide enough cooling for building needs because of CHW distribution limitations. At times the chilled water is as high as 52 °F near the end of the loop, which is not cold enough to provide adequate cooling.

3. Chillers are typically started up again after winter when weather is in the mid-60s, typically late April.

4. A two cell, 1400 Ton induced draft cooling tower is used for the chillers and is in good condition. There are plans to relocate the cooling tower to a less visible area in the long term.

b. Two water tube 31,250 MBH input 25,000 MBH (80% eff) output boilers original to building in 1978 produce300-335 °F high temperature hot water.

 The HTHW is reduced through heat exchangers at each building to approximately 160
 °F. Insulation on most heat exchangers was sufficient, while some would greatly benefit from insulation improvements. The infrared photo below shows the high temperature radiating into the mechanical space from one of the HTHW heat exchangers.

2. Primary heating loop pumps are on VFDs at 80% speed.



FIGURE 2.3: Heat Exchanger Infrared View

Technology Hall

a. Difficult to cool since at end of distribution loop, CHW is 52 deg F at the furthest air handling unit (AHU)

b. A Small mini-split heat pump is installed on the roof

c. Mechanical equipment uses setbacks to reduce runtime when not needed

d. Rooftop has gas fired makeup air units but are never used since not needed for the manufacturing center as originally planned

e. Domestic hot water is generated from HTHW through a heat exchanger

Backup Generation

500 kW Emergency Diesel Generator

a. Is no longer use for ENERNOC demand response (since approximately 2014)

SYSTEN LEVEL EXISTING CONDITIONS

SYSTEM LEVEI

2.6.2 RECOMMENDATIONS

The following lists are recommendations by system type that would aid in optimizing efficiency, and reducing energy use.

EKSTROM

HVAC Air Side

Replace Carrier module DX units with four pipe hot and chilled water coils so central heating and cooling can be used.

CORE

Boiler System

Recommendations related to the existing boiler system are limited as major configuration changes are expected. EEMs with only a rapid payback are listed here

- Reduce heating system temperature via outdoor temperature reset when the climate is warmer than design (worst case) conditions.
- Add control to the pump VFD to optimize the pump speed based on variable building needs and fully open the throttling valve at the discharge of the pumps.
- Reinsulate HTHW heat exchangers where insulation is lacking. Even though the boiler replacement project may eliminate these heat exchangers, the payback for insulating should be less than two years.

Chiller System

- Employ a cooling water temperature reset strategy so the water temperature is only as cool as needed by the building.
- Consider piping chillers in series, rather than parallel, to further reduce the water temperature and therefore adequately supply the buildings with cooling while possibly reducing the CHW system flow rates and save energy. The currently inlet/outlet ΔT of only 5 °F at technology hall requires twice as much pumping energy than if the ΔT was 10 °F.
- Add control to the pump VFD to optimize the pump speed based on variable building needs and fully open the throttling valve at the discharge of the pumps.

KINNEY HALL

Domestic Hot Water System

Replace the electric hot water heater with a condensing natural gas unit, heat exchanger connected to the Core heating plant if using CHP, or convert to use a heat pump with the existing storage tank.

HVAC Air Side

All unit ventilators and FCU are constantly running, add • VFDs and use premium efficiency motors

TECHNOLOGY HALL

HVAC Air Side

- Add demand control ventilation (DCV) in machine shop
- Continue to use the fume hood sash management program, and update occupants on proper fume hood use.

ALL BUILDINGS

Additionally, campus wide, approximately 90% of campus HVAC is pneumatically operated, convert to DDC and add HVAC to the BMS system.

2.7 LIGHTING

2.7.1 CURRENT CONDITIONS

Lighting fixtures across Naugatuck varies by building. Kinney Hall and the AS&L have mainly T8s without sensors. Technology Hall has T-5s, with inadequately working controls, as well as approximately 30 150W halogens on timers.

As demonstrated in the picture below, the garage lighting is controlled remotely with the BAS. Facilities has noted there has been issues with photosensor reliability.

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FIGURE 2.4: Lighting Control System

Between Ekstrom and Technology Hall there is a greenhouse which uses high power grow lights. Depending on the greenhouse design and plants grown, there may be opportunities to replace the existing grow lights with LED and can save 40-60% in electricity costs. If the current lights are also factored into the heating design of the greenhouse, upgrading lights is not recommended.

Facilities is pursuing plans for upgrading garage lighting and road lighting with LED, inclusive of new poles and fixtures. Garage lighting for the Core and Ekstrom Garage is being coordinated with Eversource for available rebates.

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FIGURE 2.5: Indoor Lighting

2.7.2 RECOMMENDATIONS

All additional lighting upgrades should continue to be coordinated with Eversource to help maximize the return on investment. As there are numerous opportunities for lighting retrofits, the campus should consider a campus wide lighting and controls audit. Other building specific recommendations are as follows:

- Install switches with occupancy sensors and recommission existing lighting and controls in Technology Hall to address faulty controls. Rewire to add controls or switches.
- Replace HPS exterior Lighting around the student center with LED
- Replacement of Halogen lighting in Technology Hall with LEDs
- Use of lighting controls with occupancy sensors in ASL
- Evaluate replacing high intensity lighting in greenhouse with LED lighting.

2.8 BUILDING ENVELOPE

2.8.1 CURRENT CONDITIONS

With the exception of Technology Hall, all Naugatuck's buildings were constructed pre-1990. The buildings are of concrete slab construction and all windows are dual pane with mostly aluminum sills. The campus makes use of window shades for added insulation of space. New construction and renovated buildings are now required to comply with a difference standard, the Connecticut High Performance (Green) Building Standards as of January 1st, 2009. Founders and Technology Hall likely meet these standards based on their construction dates.

2.8.2 RECOMMENDATIONS

In 1981 Connecticut implemented its first energy-related state wide standards for buildings, with 1981 as their implementation year. Therefore, for buildings constructed prior to 1981, it is assumed there is limited insulation, air sealing and other energy-related building envelope features that are now standard practice. Naugatuck's Kinney Hall, Core and Ekstrom were all constructed before 1981 and therefore are suggested to be the focus for building envelope upgrades.

Baseboard radiator heat reflectors can be added behind the baseboard heaters to help reflect the heat into the room, rather than through poorly insulated walls. Independent performance results from installing radiator heat reflectors indicate measured energy savings of 10% or more. Heat reflectors are typically installed between the radiator and exterior wall to reduce heat loss to the outside.

Heat reflectors typically have the most benefit to buildings built before 1980, as the exterior insulation is typically poor. The estimated cost is approximately \$5,000 to have reflectors installed at 300 radiators.





2.9 DISTRICT ENERGY / COGENERATION

2.9.1 CURRENT CONDITIONS

Naugatuck uses the Core as the heating/cooling center for all buildings except for the new Center for Health Sciences. In August 2016, a schematic design review meeting took place to discuss taking two of the buildings off of the central plant loop. A separate study is taking place to review and evaluate the future replacement of the existing heating/cooling systems. Two of the buildings may be removed from the heating loop and use local distributed systems.

The campus currently has no means of cogeneration. Absorption chillers usually have the most benefit when utilizing "waste" heat, such as from a CHP unit.

2.9.2 RECOMMENDATIONS

Efforts should be made to see what the lowest acceptable HTHW loop temperature is while meeting all of the heating demands of the campus. Plant efficiency can increase by lowering the boiler temperature since radiation losses will be less and boiler efficiency will be greater. It is suggested for the temperature to be reduced gradually, taking into account demands at the end of the loop, absorption chiller temperature requirements, and pumping costs. For proper operation, flow rates may also need to be adjusted accordingly using the pump VFDs and outdoor air temperature.

Central chilled water plants with water cooled electric centrifugal chillers are likely to be the most efficient means of generating chilled water, despite the costs associate with pumping the water throughout the campus from a central location. This fact should be considered in evaluating various central plant versus distributed options.

There is limited occupancy over the summer and utility bills indicate the shoulder months, May and September have the lowest thermal use. The use of absorption chillers has caused the natural gas use to be the highest during the warmest month of July. A CHP application is unlikely to provide additional benefit over the existing boilers if new electric chillers are installed. However, should cooling loads remain the same through the summer, CHP is an excellent way to provide heat to the existing absorption chillers and building heat in the winter months and should be explored. Appendix B provides high level screening of the monthly utility reports and applicability of a CHP unit.

If the absorption chillers were to continue in operation, the strategy to combine the benefits of the proposed systems in the BVH study, and CHP may be as follows.

• Size a CHP unit to handle the minimum year round heating and cooling (with existing absorption chillers) and located in the Core heating plant.

And one or a combination of:

- Add smaller supplemental boilers in the Core heating plant to serve the load above what the CHP can handle.
- Install additional distributed condensing natural gas boilers as planned in the BVH study, except sized to only serve the load above what the CHP can handle.
- Since the first draft of this report, Naugatuck has began to implement an electric chiller replacement program. Based on our initial review, this appears to be the most suitable solution given the lifecycle cost estimates.

2.10 RENEWABLE ENERGY

2.10.1 CURRENT CONDITIONS

Naugatuck has not implemented any renewable energy projects on campus.

2.10.2 RECOMMENDATIONS

Naugatuck's main building has many protrusions creating shadowing, but there may be approximately 15 kW of opportunity on south facing sections. This is dependent on roof condition. Technology Hall presents the most feasible rooftop solar PV option at this time.

Estimated solar production is dependent on setbacks around mechanical equipment. Kinney Hall and Ekstrom Hall both have space availability around mechanical equipment but their roofs are over 30 years old. Along with any roofing replacements, rooftop solar projects are suggested to be considered as this can accommodate any inspections and modifications required by FM Global for insurance. The campus may also consider exploring possibilities for roof top solar thermal and parking lot solar canopies.

Table 2.2 provides an overview of the buildings that may be considered for solar PV in the future. Following the table are images of each of the sites.

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Building Name	Year Built [Renovated]	GSF [FY 2015]	Building Roof sq. ft.	Roof Install/ Replacement Date	Roof Type	Array Size Potential (kW DC)[1]	Annual Generation Potential (MWh)[2]	Solar Suitability Comments	
HIGH PRIORITY PROJECTS									
Technology Hall	2009	99,684	27,272	2009		125-164	164-210	Necessitates closer look at mechanical equipment and obstructions	
Total		99,684	27,272						

TABLE 2.2: Naugatuck Potential Areas for Solar PV

Roof Area size based on Google Earth calculated area of solar outlines. Assumes that each sf of panels can generate between 4.6 and 6 Watts DC (about a third of the PVWatt Output Assumptions. Actual generation values would be calculated if a solar PV study was performed.
 Roof Area size based on Google Earth calculated area of solar outlines. Assumes that each sf of panels can generate between 6 and 7.7 kWh annually (about a third of the PVWatt Output Assumptions). Actual generation values would be calculated if a solar PV study was performed.



FIGURE 2.7: Naugatuck Campus PV Potential

2.11 CAPITAL PLANNING

2.11.1 CURRENT CONDITIONS

To accomplish its energy infrastructure goals, Naugatuck relies on financing and funding from the System Office and the State. The System Office provides annual code compliance and infrastructure funds. Larger capital projects are also funded under CSCU 2020, as of FY 2015. The State Legislature allocates bonds for campus improvement projects, such as Naugatuck's Phase 1 Master Plan.

More information on campus expansion projects is found in Section 3.1.

2.11.2 RECOMMENDATIONS

Naugatuck should continue to collaborate with Eversource for all major building renovations, mechanical, electrical and plumbing (MEP) equipment replacement, and all new construction.

2.12 COLLABORATION / PARTNERSHIP

2.12.1 CURRENT CONDITIONS

Naugatuck collaborates with the System Office and Eversource for energy improvement projects. As stated prior, the campus is working with Eversource for the LED lighting upgrades in the campus garages. The System Office Facilities Department is also available to provide assistance in budgeting, capital planning and technical support for the community college projects.

2.12.2 RECOMMENDATIONS

Naugatuck should work engage Eversource to take advantage of Utility Incentives for the EEMs presented in this plan. Incentives structures range and vary by program, but Eversource has offered incentives of up to 80% of project costs in the past. The campus should also work with the System Office specifically for assistance in RFPs for solar PPAs.

2.13 SUMMARY OF RECOMMENDED ENERGY **EFFICIENCY OPPORTUNITIES**

As a result of the campus walk through energy assessment, and interviews with campus staff, a list of potential Energy Efficiency Measures (EEMs) is presented in Table 2-2. These projects represent both low cost, immediate action measures, as well as projects that may require larger capital and therefore be longerterm.

Many energy-related projects are incentivized through utility rebates. Both of Naugatuck's utilities are through Eversource. This places the campus in a prime position to maximize incentives by combining multiple energy saving opportunities in what is known as a "Comprehensive Project." The primary advantage of a Comprehensive Project is the maximum incentive cap is normally raised from 40% to 50%. Eversource has maximized these incentives in the past, and may also in the future, in the following ways:

- The comprehensive cost cap was increased from 50% to 80% of total cost.
- The incentive was increased from \$0.30/kwh or \$3.50/CCF (with 40% cost cap) to \$0.40/kwh or \$4.00/CCF (with 60% cost cap).

Since incentives are based on incremental energy savings; further analysis and collaboration with Eversource will be required to determine rebate amounts for each opportunity.

To help Naugatuck navigate and prioritize the energy opportunities identified, a summary of opportunities is listed in Table 2.3. Immediate action should be taken to consider priority 1 and 2 opportunities with the goal of combining multiple opportunities for a Comprehensive Project. The simple payback in most cases cannot be reasonably estimated without detailed building models and/or more operating data. The payback periods provided are based upon the performance of past similar projects and are not necessarily indicative of future results.

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Opportunity ID	Energy Conservation or Efficiency Opportunity	Associated Building if Applicable	App. Cost (Before Rebate)	Payback w/rebate (Years)	Priority
NVCC-1	Add control to HTHW pump VFD for variable flow pumping (first check if system is compatible with variable flow) and open triple-duty valves to 100%.	Core	Minimal	<1 - 2	1
NVCC-2	Add control to chilled/cooling water pump VFD for variable flow pumping (first check if system is compatible with variable flow with special caution around absorption chiller minimum flow) and open triple-duty valves to 100%.	Core	Minimal	<1 - 2	1
NVCC-3	Implement outdoor temperature reset strategies for hot water, chilled water, and cooling water with BMS upgrades.	Core	Minimal	<1 - 2	1
NVCC-4	Continue to educate occupants on fume hood sash management as a part of a fume hood sash management campaign with goal to instill an energy efficient culture.	All	Minimal	Varies	1
NVCC-5	Recommission (EBCx) existing Lighting and Controls.	Technology Hall	\$0.50 / sq.ft.	Varies	1
NVCC-6	Conduct a comprehensive lighting audit.	All	Contact Eversource Rep	Varies	1
NVCC-7	Replace Halogen and T8 Lighting throughout the building with LED.	Technology Hall, Kinney Hall	Contact Eversource Rep	2 - 6	1
NVCC-8	Use lighting controls with occupancy sensors.	A, S, & L Building	144000	Varies	1
NVCC-9	Consult with Eversource to install LED parking garage lighting and controls. (in progress)	Ekstrom Parking Garage	\$0.23-0.77 per sq.ft.	1 - 2	1
NVCC-10	Consult with Eversource to install LED parking garage lighting and controls. (in progress)	Core Garage	\$0.23-0.77 per sq.ft.	1 - 2	1
NVCC-11	Insulate HTHW heat exchangers where insulation is missing.	Ekstrom Hall	\$600 each	<1	1
NVCC-12	Upgrade older BAS system to more current and supportable hardware. Seek competitive bids on a complete Control System upgrade. Metasys is JCI's current proprietary system. Ensure on-site training of operators is included.	All	\$50,000 minimum	Varies	2
NVCC-13	Install heat reflectors behind baseboard radiators	A, S, & L Building	\$20 per 34" long 8" high radiator	Varies	2
NVCC-14	Optimize to minimum air-change rates in laboratories, taking into account minimum flow through fume hoods.	Technology Hall	Minimal	Varies	3
NVCC-15	Check heat exchangers for efficiency and fouling using the TEMA Standard (will require temperature readings on the inlet and outlet of each side of the heat exhanger). Clean or replace when the heat exchanger effective heat transfer coefficient drops below an acceptable threshold.	All	Varies	Varies	3
NVCC-16	Decommission/remove unnecessary fume hoods, i.e. those used for storage.	Technology Hall	Varies	Varies	3
NVCC-17	Use ventilated storage cabinets instead of hoods or entire room ventilation systems to meet air change requirements.	Technology Hall	Varies	Varies	3
NVCC-18	Replace unit ventilators with higher efficiency equipment. Whole system may be replaced with central air connected to a chiller and heating coils to central plant.	Kinney Hall	Varies	Varies	3
NVCC-19	.Replace once through water cooled HTHW circulator pumps with air cooled hot water pumps such as Dean RWA	Core	Varies	Varies	3

TABLE 2.3: Naugatuck Energy Efficiency Measures

ENERGY NEEDS

3.1 FUTURE DEVELOPMENT

Naugatuck is in the construction phase for the renovation of the oldest building on campus, Founders Hall. Constructed in 1962, the building served as a manufacturing education building. After the renovation, the facility will house Naugatuck's Allied Health and Nursing program and incorporate smart classrooms, a lecture hall, conference rooms, and laboratories for simulated learning. Upgrades for mechanical, electronic and telecommunication systems will occur simultaneously. The project will be complete in 2017 and is expected to achieve LEED Silver accreditation. Energy efficiency features will include LED lighting, high efficiency MEP systems and natural daylighting.

The need for additional energy infrastructure in unlikely, as Founders is the only building with its own meter. It is important for the building to have proper and complete commissioning to ensure the systems are used as designed.

3.2 ENERGY RESILIENCY RECOMMENDATIONS

In 2015, Naugatuck partook in the CSCU system-wide hazard mitigation initiative. The CSCU Multi-Hazard Mitigation Plan provided recommendations surrounding energy resiliency that are also applicable for the Energy Master Plan. The campus is already equipped with backup power; the Core and ASL buildings can sustain power from a 500 kW emergency generator, while Technology Hall has an independent 200 kW emergency generator. Below are the recommendations from the hazard mitigation plan for improving the energy reliability and resiliency of the campus.

- Build redundancy in electrical feed. •
- Create a policy requiring stronger hazard resiliency in new designs of buildings.
- Expand emergency power generator capabilities on campus . to cover essential services.
- Install emergency power in all IDF and MDF network closets. .
- Improve building envelope

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CONCLUSION / NEXT STEPS

Naugatuck has completed benchmarking studies before and has implemented several of the recommendations, nevertheless, the campus has opportunities to decrease their campus EUI. Several low cost opportunities exist at the Core by adding controls and creating temperature resets. By working with Eversource, the campus can continue to upgrade lighting at a lower cost. Other priority initiatives include:

- *Management:* Naugatuck should explore campus shut downs and classroom consolidation as well as upgrade their BAS.
- *Renewable Energy:* Explore PPAs for portions of the building roof and parking canopy.
- Utility Incentives/ Develop Plan for EEMs: Naugatuck should maximize incentive funding for EEMs by working with Eversource, and combining multiple energy saving opportunities in what is known as a "Comprehensive Project." Further analysis and collaboration with Eversource is required to determine rebate amounts for each opportunity

A summary of further projects and priorities for the campus are listed in Table 2.2. Implementation of recommendations of the plan will aid in decreasing Naugatuck's energy use and costs for the campus.

4.1 CONTACT INFORMATION FOR KEY STAKEHOLDERS

Collecting all the necessary information for this planning effort required a collaborative effort. Below are the stakeholders that were active in providing their expertise about campus current conditions and future needs, and energy related decisions.

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APPENDIX A: NAUGATUCK VALLEY DATA METHODOLOGY, ASSUMPTIONS AND NOTES

The following are the data methodology and assumptions that were used when analyzing and benchmarking data for Naugatuck:

Fiscal years 2013 and 2014 are the only complete years of data. No information to indicate that the campus uses propane, chilled water, or steam.

Electricity: Eversource Summary (FY13,14) and Eversource Utility Bill Scans (FY15)

• Parking lot consumption was estimated based on a power density of 0.19 W/ft2 applied to 75% of the garage GSF. The estimated consumptions were then subtracted from the campus total.

Natural Gas: Yankee Gas Reports (FY13,14)

• Kinney Hall, AS&L,Core,and Ekstrom Hall were assumed to share natural gas accounts.

Fuel Oil: Consumption Reports (FY13,14,15)

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APPENDIX B: NAUGATUCK VALLEY POTENTIAL UTILITIES REPORT

Naugatuck Valley Community College Naugatuck, CT

POTENTIAL UTILITIES REPORT



FACILITY REQUIREMENTS					
Month	Electrical Energy Required	Electrical Power Required	Thermal Energy Required	Excess Therr Energy	
	[kWh]	[kW]	[Therm]	[Therm]	
July	161,365	991	58,825	0	
August	535,080	1,004	38,352	0	
September	551,544	1,134	21,635	0	
October	498,036	1,159	21,728	0	
November	477,456	991	39,841	0	
December	875,294	1,079	47,446	0	
January	162,753	1,037	54,167	0	
February	530,964	1,050	48,361	0	
March	535,080	1,058	45,056	0	
April	502,152	1,021	27,092	0	
May	489,804	991	18,159	0	
June	886,681	1,071	28,985	0	

UTILITY CONSUMPTION WITH CHP						
Electrical Energy Purchase	Electrical Power Purchase	Natural Gas Purchase for CHP	Natural Gas Purchase - Supplimental	Total Natural Ga Purchase		
[kWh]	[kW]	[Therm]	[Therm]	[Therm]		
-259,182	396	35,248	51,083	86,331		
114,534	409	35,248	26,417	61,665		
144,564	539	34,111	6,914	41,025		
77,490	564	35,248	6,388	41,636		
70,476	396	34,111	28,849	62,960		
454,748	484	35,248	37,374	72,622		
-257,793	442	35,248	45,471	80,719		
151,116	455	31,837	40,391	72,228		
114,534	463	35,248	34,494	69,742		
95,172	426	34,111	13,489	47,600		
69,258	396	35,248	2,088	37,336		
479,701	476	34,111	15,770	49,881		





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03 System Level Energy Needs

04 FINANCING/FUNDING OPPORTUNITIES

05 SYSTEM LEVEL RECOMMENDATIONS

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NORTHWESTERN CONNECTICUT COMMUNITY COLLEGE



02 SYSTEN LEVEL EXISTING CONDITIONS

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EXECUTIVE SUMMARY

The Northwestern Connecticut Community College (Northwestern) Energy Master Plan aims to identify ways Northwestern can improve energy use on campus, and be an active participant in Connecticut State Colleges & Universities (CSCU)'s energy management, reduction and conservation efforts. The utility data received indicates Northwestern is a medium performing campus CSCU from an energy perspective (see Figure 1 Northwestern Energy Dashboard). The energy use intensity (EUI) method is used for benchmarking and comparison purposes. Energy management efforts in the past have reduced Northwestern's energy use, through efforts such as effective use of the building management system (BMS) and various HVAC upgrades.



FIGURE 1: Northwestern Community College Energy Dashboard

SYSTEM LEVEL ENERGY NEEDS

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Near-term improvements expected to further reduce Northwestern's energy use include the insulation of the Administration Building, Goulet Building, English Building, and Founders Hall attic.

Energy Spend

Table 1 provides a comparison of energy spending comparing to the average of CSCU campuses and the Northeast Region Commercial Sector.

	Nort	hwestern Connecticut Community College	Average of CSCU Community College	Average of CSCU University	Northeast Region Commercial Sector
Cost per Square Feet	\$	2.49	\$ 2.49	\$ 2.08	\$ 1.67
Cost Per Fall 2013 FTE Student	\$	563	\$ 311	\$ 677	\$ -
Avg. Cost per kWh Electricity from Grid	\$	0.14	\$ 0.14	\$ 0.14	\$ 0.15
Avg. Cost per MMBtu Natural Gas	\$	10.89	\$ 10.06	\$ 7.32	\$ 10.03
Total Operating Expenses	\$	18,437,000	\$ -	\$ -	
Total Energy Spending	\$	459,247	\$ -	\$ -	
% of Operating Expenses		2.49%	1.95%	2.67%	

TABLE 1: Energy Cost Comparison (FY 2014)

Based on the data, the campus spends higher than the average of total energy spending as a percent of its total operating expenses, according to FY 14 data. Northwestern has a cost per square foot equivalent to the average of CSCU's community colleges.

Utility Incentives/ Develop Plan for Energy Efficiency Measures (EEMs)

Both of Northwestern's utilities are through Eversource. This places the campus in a prime position to maximize incentives by combining multiple energy saving opportunities in what is known as a "Comprehensive Project."

Since incentives are based on incremental energy savings, further analysis and collaboration with Eversource is required to determine rebate amounts for each opportunity. Table 2 demonstrates a summary of the EEMs recommended for Northwestern to pursue.

Opportunity ID	Energy Conservation or Efficiency Opportunity	Associated Building if Applicable	App. Cost (Before Rebate)	Payback w/rebate (Years)	Priority
NCCC-1	Reduce building hours or consolidate spaces to reduce energy consumption at times of lower occupancy, especially summer. Building remains open through summer and only a maximum of six people will occupy the building at any given time.	Art and Science Center	Minimal	Instantaneous	1
NCCC-2	Insulation: Conduct EBCx for building envelope on buildings built before 1980, or for buildings with obvious deficiencies such as ice dams and drafts. Insulation should exceed latest building code or ASHRAE 90.1 standard.	English Building	Varies	Varies	1
NCCC-3	Insulation: Conduct EBCx for building envelope on buildings built before 1980, or for buildings with obvious deficiencies such as ice dams and drafts. Insulation should exceed latest building code or ASHRAE 90.1 standard.	Goulet Building	Varies	Varies	1
NCCC-4	Insulation: Conduct EBCx for building envelope on buildings built before 1980, or for buildings with obvious deficiencies such as ice dams and drafts. Insulation should exceed latest building code or ASHRAE 90.1 standard.	Administration Building (NWCC)	Varies	Varies	1
NCCC-5	Continue to upgrade lighting to LED with support from Eversource	All	Varies	2 - 6	1



NCCC-6	Replace Electric heaters with natural gas or heat pumps and reset thermostats. Thermostats should be reset or replaced in interim even before space may be repurposed since the payback is likely less than 3 years. Replacement of heaters may pend remodeling.	White Building	\$8,000 - \$12,000	2 - 5	2
NCCC-7	Upgrade Pneumatic control system to DDC, Siemens or JCI, with full commissioning of the new and existing systems.	Green Woods Hall	\$142,300[1]	< 5	2
NCCC-8	Use natural gas infrared heaters instead of electric and add infrared specific thermostats, should payback be less than 5 years. (building considered for demo 5-10 years from time of study)	Maintenance Garage	Varies	3 - 6	2
NCCC-9	Insulate conditioned spaces, especially roofs, even if minimal for garages and similar.	Maintenance Garage	Varies	Varies	2
NCCC-10	Fume hoods (both lab and paint) are always on 100%, integrate controls for on/off and/or variable speed. Also investigate adding heat recovery to fume hoods.	Art and Science Center	Varies	Varies	2
NCCC-11	Add a high efficiency air-to-water heat pump to electric heater tanks. A Geyser air source heat pump (25,000 Btuh) may be a good option saving 50%-75%.	Art and Science Center	Varies	1 - 3	2
NCCC-12	Install VFDs on chilled water pumps and program speed with JCI Metasys (10HP assumed for cost)	Art and Science Center	\$23,195[2]	2 - 5	2
NCCC-13	Add variable speed drives to hot and chilled water loop piping if pumps are 5HP or larger.	Green Woods Hall	Varies	2 - 5	2
NCCC-14	Replace boilers at end of life with condensing natural gas boilers if low (120 °F) hot water return temperature can be maintained for a majority of the year. Ensure all new systems are properly commissioned per ASHRAE Standard 0.	Founders Hall	\$18/MBH +installation	Instantaneous	3
NCCC-15	Replace boilers at end of life with condensing natural gas boilers if low (120 °F) hot water return temperature can be maintained for a majority of the year. Ensure all new systems are properly commissioned per ASHRAE Standard 0. (Project may be complete by the time this report is issued)	Green Woods Hall	\$18/MBH +installation	Instantaneous	3

 TABLE 2: Northwestern Energy Efficiency Measures

In addition to the priority projects, next steps for Northwestern are below:

Next Steps

Management

The operator tracks energy usage as time allows. The BMS and operator understanding both play large roles in operating the energy systems efficiently. Currently, not all of the BMSs communicate on the same platform. Efforts should be made to combine the BMSs onto a single platform. Documenting system set points, such as outdoor temperature reset to enable condensing boiler operation and building comfort, should be a priority.

As part of the CSCU Energy Master Plan, CSCU should create a template for energy tracking applicable to all campuses. Northwestern should continue to track energy usage through such a template, as well as compare energy spend against available budgets, and verify consumption reports.

Fume Hoods

Implement a fume hood sash management program to ensure hoods are closed and turned off when not in use.

Renewable Energy

Explore power purchase agreements (PPAs) for the Learning Resource Center and Greenwoods Hall and consider including renewable energy development in capital planning.

By implementing the suggestions of the Energy Master Plan, Northwestern will be enabled to better manage energy costs through PPAs, energy tracking, and energy efficiency upgrades.

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As part of the Connecticut State Colleges & Universities (CSCU) Energy Master Plan, Northwestern Connecticut Community College (Northwestern)'s building infrastructure, energy use and energy management practices were assessed. The ultimate goal was to determine ways Northwestern could improve its energy use on campus, and be an active participant in CSCU energy reduction efforts. This chapter identifies Northwestern's historical energy use, future projected needs and energy recommendations.

1.1 NORTHWESTERN OVERVIEW

Northwestern is located in Winsted, Connecticut and serves a primarily rural section of the state. As a two-year, non-residential college, Northwestern prepares its students for employment or continuation of a bachelor degree at other Colleges and Universities.

1.2 PREVIOUS ENERGY STUDIES & PROJECTS

According to the campus, all buildings have been audited. The Institute for Sustainable Energy (ISE) at Eastern Connecticut State University conducted a benchmarking study and walkthrough assessment in 2013. The study sited suggestions related to expanding the Siemens BMS to all buildings, increasing insulation to R-38 and completing annual boiler tune ups. Since the study was provided the campus has completed the following projects:

- LED upgrades •
- Building envelope upgrades and insulation for the Administration building
- Replacement of Green Woods Hall boilers with more energy • efficient models

Building	Year Built [Renovated]	Gross Square Feet	Building Function
Administration Building	1860 [1998]	4,075	Office/Administrative
Art and Science Center	2007	32,368	Academic with Labs
English House	1880 [2001]	4,286	Office/Administrative
Founders Hall and Annex	1895 [2002]	54,850	Office/Administrative and Academic
Goulet House	1870 [2001]	5,283	Office/Administrative
Green Woods Hall	1927 [1985]	29,200	Mixed-Use
Joyner Learning Center	1958	24,400	Academic
Learning Resources Center	2003	24,000	Library
Maintenance Garage	1987	2,200	Facilities
White Building	1895	2,360	Other - Veterans' OASIS Studio
Allied Health (150 Wetmore Avenue)	1928 [1960]	1,020	Academic
Total		184,042	

Total

TABLE 1.1: Northwestern Building Information

Northwestern also provides a path to guaranteed admission to the CSCU's State Universities through their 2009 program Transfer Compact. Students have flexibility in terms of when they take classes and what types of programs they pursue, as Northwestern offers day, evening, credit, and noncredit programs.

The Northwestern campus is located adjacent to the Winsted town green, on 16.42 acres of land along Routes 8 and 44. The campus consists of 11 buildings that serve a variety of functions. Northwestern has 23 general classrooms, four science labs (chemistry, anatomy and physiology, general science, and microbiology), a veterinary technology lab, a veterinary surgical suite, two nursing labs, six computer labs, a language lab, a Macintosh computer lab, and separate studios for photography, graphic design, drawing, painting, and ceramics. The campus has 258 parking spaces. A list of existing buildings on the Northwestern campus is available in Table 1.1



FIGURE 1.1: Learning Resources Center

Figure 1.2 displays the campus buildings and outlines the relevant offices and departments within them.



FIGURE 1.2: Northwestern Campus Map

05 SYSTEM LEVEL RECOMMENDATIONS



EXISTING CONDITIONS & RECOMMENDATIONS

Information on Northwestern's existing conditions was captured from campus interviews, energy data and reports provided by the campus. A holistic view of existing practices, material on energy management, energy infrastructure and project implementation processes was reviewed. Analysis of the data and campus walkthroughs helped clarify recommendations with the goal of decreasing energy use, documented after each subheading.

2.1 FACILITY ENERGY BENCHMARKING AND ENERGY CONSUMPTION

The Figure 2.1 provides a summary of Northwestern's energy use for FY14, using the data sources documented in Appendix A. Northwestern's site EUI is the fifth highest of the 12 CSCU community colleges, with a site EUI of 111kbtu/sq ft. In comparison to the Northeast median site EUI for colleges/universities, it is only slightly higher.



FiGURE 2.1: Northwestern Connecticut Community College Energy Dashboard

Note: Northeast Median Site and Source EUI for College/University category, per Department of Energy Building Performance Database.
As Figure 2.1c demonstrates, the weather normalized Site EUI is nearly on par with the regional median at 108 and 105 kBtu/sf for fiscal year 2014 and 2015 respectively.

Near-term improvements are expected to further reduce Northwestern' energy use, including insulation of the Goulet Building, English Building, and Founders Hall attic.

Nine of Northwestern's buildings have their own natural gas and electric meters, with the exception to Founders Hall and the Learning Resource Center which share an account. Figure 2.2 demonstrates FY 2014 building level EUIs. The total energy use is also shown as a weighting factor; focus should be applied first to buildings with a high EUI and energy use.

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FIGURE 2.2: Site EUI by Building

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Based on the data:

- The Art and Science Center, although the newest building, is also the second largest and least energy efficient. This is in part due to the continuous operation of constant volume fume hoods. Naturally, science laboratories are higher energy users than average due in part to this reason. This also translates to a higher cost per square foot per year.
- The Allied Health building has the highest cost per square foot out of all the buildings, but has the lowest energy consumption, and is therefore not a main focus (Figure 2.3).
- The Maintenance Garage has an electric meter but no records were found.







FIGURE 2.3: Energy Cost per sqft per Year

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Table 2.1 provides a comparison of FY 2014 energy spending compared to the average of CSCU campuses and the Northeast Region Commercial Sector.

	Nort	hwestern Connecticut Community College	Average of CSCU Community College	Average of CSCU University	Northeast Region Commercial Sector
Cost per Square Feet	\$	2.49	\$ 2.49	\$ 2.08	\$ 1.67
Cost Per Fall 2013 FTE Student	\$	563	\$ 311	\$ 677	\$ -
Avg. Cost per kWh Electricity from Grid	\$	0.14	\$ 0.14	\$ 0.14	\$ 0.15
Avg. Cost per MMBtu Natural Gas	\$	10.89	\$ 10.06	\$ 7.32	\$ 10.03
Total Operating Expenses	\$	18,437,000	\$ -	\$ -	
Total Energy Spending	\$	459,247	\$ -	\$ -	
% of Operating Expenses		2.49%	1.95%	2.67%	

TABLE 2.1: Energy Cost Comparison (FY 2014)

Northwestern has an average cost per square foot \$2.49, the same as the average CSCU community college cost per square foot. This may be attributed to the larger portion of natural gas consumption compared to electricity consumption (see Figure 2.1b). On a per unit basis, natural gas tends to be less expensive. However, the campus spends higher than the average of total energy spending as a percent of its total operating expenses, according to FY 14 data.

2.2 CAMPUS UTILITIES AND DISTRIBUTION

Northwestern uses only electricity and natural gas. The following is a list of Northwestern's utility providers:

- Electric: Eversource, formerly Connecticut Light & Power
- Natural Gas: Eversource, formerly Yankee Gas

2.3 ENERGY PROCUREMENT

Northwestern is part of the CSCU's 2013 electric supply procurement contract with Direct Energy (formerly Hess Energy), detailed further in the Energy Master Plan. The campus does not have a competitive Natural Gas supplier, but will be a part of CSCU's 2017 bundled RFP for natural gas procurement.

2.4 OPERATIONAL AND ENERGY MANAGEMENT PRACTICES

2.4.1 CURRENT CONDITIONS

The Dean of Administration and the Building Superintendent manage operation of the campus' physical facilities. Facilities staff consists of five building maintenance and groundkeepers, as well as six custodians. The team ensures that all legal and regulatory requirements are met and seeks to improve and upgrade facilities when possible. HVAC systems are maintained on a regular basis; ductwork and grills are vacuumed frequently to preserve indoor air quality. The operator tracks energy usage as time allows. Students have flexibility in terms of when they take classes and what types of programs they pursue, as Northwestern offers day and evening programs. To accommodate the schedule, Northwestern's typical operating hours are:

Monday – Friday : 8-5PM

Saturday/Sunday: Mainly closed, but variable; the Learning Resource Center is occasionally rented out on weekends, and the Art and Science center is open some weekends.

Green Woods Hall, the Art and Science Center and Founders Hall and Annex operate until 9:30 PM on weekdays.



FIGURE 2.4: Arts and Science Building

The campus executes building shut downs during the summer, with the exception of the Art and Science Center. During the summer, the building is occupied by four faculty members, one clerical and one lab technician.

ENERGY USE INFORMATION MANAGEMENT SYSTEMS

Three of Northwestern's buildings are controlled with building management systems. Founders Hall and the Learning Resource Center's operating system is Siemens, while the newer Arts and Science center operates on Johnson controls. Facilities self-performs all controls. There is also a campus-wide work order system that facilities use to track needed and ongoing maintenance.

2.4.2 RECOMMENDATIONS

Tracking data at least on a monthly basis is recommended. As part of the CSCU Energy Master Plan recommendations in Section 5.2.2, it is recommended that the System Office create a template for energy tracking applicable to all campuses. Northwestern should use this template to track energy over time, on a building by building basis. Northwestern can also use Eversource's Customer Engagement Platform to view its energy use.

Currently, not all of the buildings are on a BMS systems, and existing BMSs do not communicate on the same platform. Efforts should be made to combine the BMSs onto a single platform. Documenting system set points, such as outdoor temperature reset to enable condensing boiler operation and building comfort, should be a priority.

Additionally, it is recommended to work with administration and faculty to either close the Art and Science building during the summer, or shorten hours of operations considering there are limited numbers of people using the building.

2.5 EXISTING BUILDING COMMISSIONING

2.5.1 CURRENT CONDITIONS

No recent building commissioning efforts were reported.

2.5.2 RECOMMENDATIONS

Buildings with BMS systems with measurable points stand to benefit the most from recommissioning. Although State buildings built after 2011 are required to have a commissioning agent, it has been observed even new buildings have not been properly and thoroughly commissioned. A properly commissioned building should be turned over with a thorough commissioning report, complete with checklists and testing and balancing (TAB) reports for each piece of equipment, even windows and lighting. If this documentation is not available, it is a good indication the building was not properly commissioned. Newer buildings with a higher than average EUI are also indicative of a poorly commissioned building.

As a general rule of thumb:

• Recommission existing building systems every 3-5 years.

Green Woods Hall still has a pneumatic control system and should be replaced with a direct digital control (DDC) system along with a full commissioning of the HVAC systems.

2.6 MECHANICAL SYSTEMS

2.6.1 CURRENT CONDITIONS

Mechanical systems are spread throughout the campus. Most buildings have dedicated heating and cooling systems. Founders Hall, the Annex, and Learning Resource Center (LRC) all share a common heating/cooling system in the basement of Founders Hall.

BOILER SYSTEMS

Funds are being appropriated for 2017 to replace the boiler systems in Founder Hall. The current pair of boilers are dual fuel and rated for approximately 5.3 MMBtu/hr each.

Residential sized direct vent condensing natural gas boilers with integral domestic hot water heaters were installed in 2015 in the English Building, Goulet Building, and Administration Building. The higher efficiency expected from the new boilers is not reflected in the 2014 EUI.



FIGURE 2.5: Northwestern Boiler System

Greenwoods Hall has had new boilers installed between the time of the walk through audit and issuing of this report. The old boilers, which are reflected in the 2014 energy use data, were a pair of 2.5 MMBtu/hr hydronic boilers originally installed in 1985.

The Art and Science Center uses two 6.1 MMBtu/hr Smith Cast Iron hydronic boilers in the penthouse for baseboard heat and AHU coils. Domestic hot water is provided by a pair of 3kW electric resistance heaters. D4 FINANCING/FUNE

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CHILLER SYSTEM

Founders Hall contains a 271 Ton Carrier condenserless twin screw chiller, which also supplies the Annex and LRC.

Greenwoods uses an air cooled chiller which was installed in 2016.

The Art and Science Center houses a 140 Ton chiller, located in the basement and is original to the building in 2007.



FIGURE 2.6: Chiller System

While the piping systems are well insulated, they are missing easily implemented and low-cost energy saving devices such as VFDs for the pumps.

HVAC AIR SIDE

The English Building, Goulet Building, and Administration Building each use two five Ton Carrier direct expansion VAV units to supply cooling to the building ductwork and were installed in 1998.

Trane XE 80 furnaces in the basements of the old residential buildings are also used for heat. The gas burners are only about 80% efficient where the condensing wall mounted units are well over 90%. It is unknown what percentage of the building heat is provided by the boiler versus the furnace.



FIGURE 2.7: Trane XE 80

Northwestern has several fume hoods for an art studio and science laboratories at the Art and Science Center and each use a common large constant speed fan.

The White Building and Maintenance Garage both have electric only heat.



FIGURE 2.8: Northwestern Fume Hood

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2.6.2 RECOMMENDATIONS

The following lists are recommendations by system type that would aid in optimizing efficiency, and reducing energy.

BOILER SYSTEMS

A general recommendation is to not replace equipment in kind at end of life. An energy study should be done on the existing plant and equipment should be upgraded and resized to meet the current and expected demand and take into consideration total life-cycle cost. New technologies exist, or have a better lifecycle cost.

Other specific recommendations include:

BOILER SYSTEMS

 Add VFDs to hot water pumps and maintain at least a 5 °F difference in supply and return temperature.

a. Installing a VFD and controlling to 70% flow rather than throttling using a balancing valve would yield over \$2,000 a year per 7.5HP pump if operated 4,000 hours per year.

• Reduce heating system temperature via outdoor temperature reset when the climate is warmer than design (worst case) conditions.

Supplement electric resistance hot water heaters with a heat pump to save 50-75% in domestic hot water heating costs. Some models of heat pumps, such as Geyser, will utilize the existing hot water storage tanks and make installation simple.

CHILLER SYSTEMS

- Add VFDs to chilled water pumps and maintain at least a 5 °F difference in supply and return temperature.
- Employ a cooling water temperature reset strategy so the water temperature is only as cool as needed by the building.

2.7 LIGHTING

2.7.1 CURRENT CONDITIONS

Northwestern's campus is generally lit by T8 lighting. T12 lighting is still used at the Maintenance Garage and White Building.

2.7.2 RECOMMENDATIONS

All lighting upgrades should continue be coordinated with Eversource to help maximize the return on investment.

The campus should consider the following recommendations:

- Add occupancy based lighting (and ventilation) controls.
- All exterior lighting should be replaced with LED, followed by interior lighting in common areas, and then individual spaces.
- In areas with study desks or similar, individual task lighting can greatly reduce the lighting density by delamping some of the existing lights, rather than replacing fixtures or bulbs.

2.8 BUILDING ENVELOPE

2.8.1 CURRENT CONDITIONS

Northwestern's campus is comprised of a number of historic and residential buildings. The age of the building contributes to the likelihood for needed envelope upgrades. Based on the site walk, Goulet House and English House both have uninsulated stone foundations. The Goulet House also had a basement door showing daylight from the outdoors through the base.

The campus has planned insulation of the Goulet Building, English Building, and Founders Hall attic (and partial roof replacement) slated for 2016. As part of the campus' many improvement projects, White Building received new windows and a roof replacement.



FIGURE 2.9: Thermal Imaging

Thermal imaging revealed a defunct corner chimney flue was releasing cold air into the space and shows the stratification of the heat and cold air. The image also shows there is little heat loss through the new windows.

While newer windows can save significant energy, they can be the source of higher utility bills when left open, as shown in Figure 2.10.





FIGURE 2.10: Thermal Heat Loss through Open Window

2.8.2 RECOMMENDATIONS

It is recommended for Northwestern to insulate conditioned spaces, especially roofs, even if minimal for garages and similar. Even though the garage will likely be replaced in the next ten years, insulation improvements, especially with utility incentives, are likely to have a quicker payback than five years. The campus should stay up to date on the latest building code standards and meet or exceed the standards for new buildings such as Joyner's Hall. Installing solar window films or shades can also aid in keeping a more consistent temperature in older buildings.

Basements of the residential style buildings with stone basements should be insulated, including the sills and at least three feet below grade. Due to the uneven nature of the stone foundations, one-inch of spray foam along the entire height of the basement walls may be the preferred method. Basement doors should also be insulated and well sealed.

It is also suggested for Northwestern to investigate why windows are left open during colder temperatures, and if the problem stems from mechanical system or HVAC zoning problems. If no problems are found, encourage staff to open office or classroom doors instead of windows except for mild weather.

2.9 DISTRICT ENERGY / COGENERATION

2.9.1 CURRENT CONDITIONS

There is no district energy, other than the small plant located in Founders Hall, or cogeneration at Northwestern.

2.9.2 RECOMMENDATIONS

The sprawl of campus space, smaller heating loads, and campus shut downs during the summer are not conducive to a CHP application. Therefore, CHP is not recommended at this time.

2.10 RENEWABLE ENERGY

2.10.1 CURRENT CONDITIONS

Northwestern has not implemented any renewable energy projects on campus. Table 2.7 provides an overview of the buildings that may be considered for solar PV in the future. Following the table are images of each of the sites.

2.10.2 RECOMMENDATIONS

Northwestern has a sprawling campus. There is limited space for ground-mount solar surrounding Northwestern's buildings- open space adjacent to many campus buildings exists at East End Park, which is owned by the Town of Winsted. A small ground mount may be possible in front of and adjacent to Green Woods Hall.

While there is limited space available on campus, in the long term, there may be possibilities of agreements with building owners for using roofs of surrounding old brick mill buildings.

Building Name	Year Built [Renovated]	GSF [FY 2015]	Building Roof sq. ft.	Roof Install/ Replacement Date	Roof Type	Array Size Potential (kW DC)[1]	Annual Generation Potential (MWh)[2]	Solar Suitability Comments
				HIGH PRIORITY	PROJECTS			
Learning Resources Center	2003	24,000	12,000	1966 / 2016	Flat	108-141	141-181	Has mechanical equipment causing shading, as well as higher roof obscures light from lower roof. Approximately 20% of roof availability
Green Woods Hall	1927 [1985]	29,200	9,733		Flat	44-58	58-74	Flat roof, limited mechanical equipment, though has overhead tower that takes up about 35% of roof, so changed array size potential to 65% of roof
Total		53,200	21,733			495-619	619-821	

TABLE 2.2: Northwestern Potential Areas for Solar PV

Assumes that each sf of panels can generate between 4.6 and 6 Watts DC (about a third of the PVWatt Output Assumptions). Actual generation values would be calculated if a solar PV study was performed.
 Assumes that each sf of panels can generate between 6 and 7.7 kWh annually (about a third of the PVWatt Output Assumptions). Actual generation values would be calculated if a solar PV study was performed.



AVAILABLE ROOF SPACE

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Existing buildings are also from the late 1800s and early 1900s and would likely not support space for a solar installation. The ages and small sizes of many of Northwestern's roofs is a limiting factor for solar installation possibilities. However, Northwestern's Learning Resource Center as well as Green Woods Hall provides some opportunity for roof top solar, totaling approximately 100-130 kW. While Joyner Learning Center's roof is an ideal candidate for solar, it will be demolished and replaced with a newer Joyner Hall. The campus should explore adding solar on the new building, as well as for all capital plans. For example, there are plans for replacing a portion of Founders Hall's roof which may be a potential for solar PV.

2.11 CAPITAL PLANNING

2.11.1 CURRENT CONDITIONS

As indicated in other chapter sections, Northwestern continues to have multiple campus upgrade projects. In addition to roofing and insulation upgrades, there are plans to replace Founders Hall's boilers in the near term. To accomplish its energy infrastructure goals, Northwestern relies on financing and funding from the System Office and the State. The System Office provides annual code compliance and infrastructure funds. For instance, in 2017 Northwestern is appropriating the money for the new boilers. The campus may reconsider project scope and install higher efficiency condensing natural gas boilers. Larger capital projects are also funded under CSCU 2020, as of FY 2015. More information on campus expansion projects is found in Section 3.1.

2.11.2 RECOMMENDATIONS

Northwestern should continue to collaborate with Eversource for all major building renovations, mechanical, electrical and plumbing equipment replacement and all new construction. In general, when the campus is considering mechanical equipment upgrades, it is recommended to replace equipment with more efficient equipment with the best life-cycle costs, not to merely "replace in kind."

2.12 COLLABORATION / PARTNERSHIP

2.12.1 CURRENT CONDITIONS

The System Office Facilities Department is available to provide assistance in budgeting, capital planning and technical support for the community college projects, including Northwestern.

2.12.2 RECOMMENDATIONS

Northwestern should work with Eversource to take advantage of Utility Incentives for the EEMs presented in this plan. Incentives structures range and vary by program, but Eversource has offered incentives of up to 80% of project costs in the past.

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2.13 SUMMARY OF RECOMMENDED ENERGY EFFICIENCY OPPORTUNITIES

As a result of the campus walk through energy assessment, and interviews with campus staff, a list of potential Energy Efficiency Measures (EEMs) is presented in Table 2.3. These projects represent both low cost, immediate action measures, as well as projects that may require larger capital and therefore be longer-term. Many energy-related projects are incentivized through utility rebates. Both of Northwestern's utilities are through Eversource. This places the campus in a prime position to maximize incentives by combining multiple energy saving opportunities in what is known as a "Comprehensive Project." The primary advantage of a Comprehensive Project is the maximum incentive cap is normally raised from 40% to 50%. Eversource has maximized these incentives in the past, and may also in the future, in the following ways:

- The comprehensive cost cap was increased from 50% to 80% of total cost.
- The incentive was increased from \$0.30/kwh or \$3.50/CCF (with 40% cost cap) to \$0.40/kwh or \$4.00/CCF (with 60% cost cap).

Since incentives are based on incremental energy savings; further analysis and collaboration with Eversource will be required to determine rebate amounts for each opportunity. To help Northwestern navigate and prioritize the energy opportunities identified, a summary of opportunities is listed in Table 2.3.

Immediate action should be taken to also consider priority one and two opportunities with the goal of combining multiple opportunities for a Comprehensive Project. The simple payback in most cases cannot be reasonably estimated without detailed building models and/or more operating data. The payback periods provided are based upon the performance of past similar projects and are not necessarily indicative of future results.

Opportunity ID	Energy Conservation or Efficiency Opportunity	Associated Building if Applicable	App. Cost (Before Rebate)	Payback w/rebate (Years)	Priority
NCCC-1	Reduce building hours or consolidate spaces to reduce energy consumption at times of lower occupancy, especially summer. Building remains open through summer and only a maximum of six people will occupy the building at any given time.	Art and Science Center	Minimal	Instantaneous	1
NCCC-2	Insulation: Conduct EBCx for building envelope on buildings built before 1980, or for buildings with obvious deficiencies such as ice dams and drafts. Insulation should exceed latest building code or ASHRAE 90.1 standard.	English Building	Varies	Varies	1
NCCC-3	Insulation: Conduct EBCx for building envelope on buildings built before 1980, or for buildings with obvious deficiencies such as ice dams and drafts. Insulation should exceed latest building code or ASHRAE 90.1 standard.	Goulet Building	Varies	Varies	1
NCCC-4	Insulation: Conduct EBCx for building envelope on buildings built before 1980, or for buildings with obvious deficiencies such as ice dams and drafts. Insulation should exceed latest building code or ASHRAE 90.1 standard.	Administration Building (NWCC)	Varies	Varies	1
NCCC-5	Continue to upgrade lighting to LED with support from Eversource	All	Varies	2 - 6	1
NCCC-6	Replace Electric heaters with natural gas or heat pumps and reset thermostats. Thermostats should be reset or replaced in interim even before space may be repurposed since the payback is likely less than 3 years. Replacement of heaters may pend remodeling.	White Building	\$8,000 - \$12,000	2 - 5	2
NCCC-7	Upgrade Pneumatic control system to DDC, Siemens or JCI, with full commissioning of the new and existing systems.	Green Woods Hall	\$142,300[1]	< 5	2

NCCC-8	Use natural gas infrared heaters instead of electric and add infrared specific thermostats, should payback be less than 5 years. (building considered for demo 5-10 years from time of study)	Maintenance Garage	Varies	3 - 6	2	01 INTRODUCT
NCCC-9	Insulate conditioned spaces, especially roofs, even if minimal for garages and similar.	Maintenance Garage	Varies	Varies	2	ION
NCCC-10	Fume hoods (both lab and paint) are always on 100%, integrate controls for on/off and/or variable speed. Also investigate adding heat recovery to fume hoods.	Art and Science Center	Varies	Varies	2	E S O
NCCC-11	Add a high efficiency air-to-water heat pump to electric heater tanks. A Geyser air source heat pump (25,000 Btuh) may be a good option saving 50%-75%.	Art and Science Center	Varies	1 - 3	2	2 STEN LEVEL
NCCC-12	Install VFDs on chilled water pumps and program speed with JCI Metasys (10HP assumed for cost)	Art and Science Center	\$23,195[2]	2 - 5	2	DITIONS
NCCC-13	Add variable speed drives to hot and chilled water loop piping if pumps are 5HP or larger.	Green Woods Hall	Varies	2 - 5	2	т 0 О
NCCC-14	Replace boilers at end of life with condensing natural gas boilers if low (120 °F) hot water return temperature can be maintained for a majority of the year. Ensure all new systems are properly commissioned per ASHRAE Standard 0.	Founders Hall	\$18/MBH +installation	Instantaneous	3)3 YSTEM LEVEL NERGY NEEDS
NCCC-15	Replace boilers at end of life with condensing natural gas boilers if low (120 °F) hot water return temperature can be maintained for a majority of the year. Ensure all new systems are properly commissioned per ASHRAE Standard 0. (Project may be complete by the time this report is issued)	Green Woods Hall	\$18/MBH +installation	Instantaneous	3	O4 FINANG OPPOR

TABLE 2.3: Northwestern Energy Efficiency Measures

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ENERGY NEEDS

3.1 FUTURE DEVELOPMENT

Northwestern developed a Facilities Master Plan in 1998, and the campus is now entering into the final phases of implementation. Construction projects include renovations to the exterior of Green Woods Hall and development of a new 24,000 square foot Veterinary Technology Facility to replace the Elizabeth H. Joyner Learning Center. In July 2015, the State Bond Commission allocated \$24.65 million toward the project. The building is currently under construction, and a completion date in the Spring of 2017. The building is expected to be LEED Silver equivalent. At a projected cost of \$1 million, Green Woods Hall will receive a new roof, window repairs and HVAC system upgrades. The campus is currently updating its Master Plan, which is expected to be adopted in 2017. Since the update coincided with the energy master planning effort, its findings are not fully incorporated into this Energy Master Plan.

Other campus changes and considerations include:

- Repurposing of the White Building which houses Veterans' Oasis; it is unclear what the building function will be and how it might impact the campus' energy use.
- Potential plans to demolish the Maintenance Garage in the next 5-10 years which will eliminate one energy user.
- The White Building and Maintenance garage have energy improvement recommendations, which, depending on the timeline for building changes could be deferred.

As the campus expands, ensuring energy reliability as continuous energy efficient improvements should be a priority. To support the electric needs in case of power outages and unreliable energy situations, Northwestern should consider expanding its generator capabilities. Founders Hall Annex, Library, and Art & Science Center do have generators that power essential equipment.

3.2 ENERGY RESILIENCY RECOMMENDATIONS

Northwestern partook in the CSCU system-wide hazard mitigation initiative. The CSCU Multi-Hazard Mitigation Plan provided recommendations surrounding energy resiliency that are also applicable for the Energy Master Plan. Below are recommendations from the hazard mitigation plan for improving the energy reliability and resiliency of the campus:

- Expand emergency generator capacity.
- Improve building envelope
- Bury power lines to provide uninterrupted power after severe winds
- Retrofit laboratory area, such as by adding insulation to prevent pipes from freezing.

01 INTRODUCTION

CONCLUSION / NEXT STEPS

Northwestern is a medium performing campus in comparison to the other CSCU community colleges. The campus continues to change and expand with new energy and capital projects. These upgrades will assist in lowering their EUI which is currently about the Northeast regional average for colleges and Universities.

To continue on a path of energy reductions, top priority initiatives include:

- *Management:* Northwestern should track energy use, consolidate or alter occupancy schedules based on building use, and combine BMS where possible.
- *Renewable Energy:* Explore solar on building roofs and include solar PV in future capital plans, especially considering attractive PPA options.
- Utility Incentives/ Develop Plan for EEMs: Northwestern should maximize incentive funding for EEMs by working with Eversource, and combining multiple energy saving opportunities in what is known as a "Comprehensive Project." Further analysis and collaboration with Eversource is required to determine rebate amounts for each opportunity

A summary of further projects and priorities for the campus are listed in Table 2.3.

By implementing the suggested building envelope upgrades, HVAC and mechanical system upgrades, and renewable energy opportunities, Northwestern is poised to capture significant operating budget and energy savings.

4.1 CONTACT INFORMATION FOR KEY STAKEHOLDERS

Collecting all the necessary information for this planning effort required a collaborative effort. Below are the stakeholders that were active in providing their expertise about campus current conditions and future needs, and energy related decisions.

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APPENDIX A: NORTHWESTERN DATA SOURCES

The following are the data sources that were used when analyzing and benchmarking data for Northwestern:

Electricity: Eversource Online Data (FY13,15) and Eversource Utility Bills (FY14)

Yankee Gas Utility Bills (FY14)

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05 SYSTEM LEVEL RECOMMENDATIONS



EXECUTIVE SUMMARY

The Norwalk Community College (Norwalk) Energy Master Plan aims to identify ways Norwalk can improve energy use on campus, and be an active participant in Connecticut State Colleges & Universities (CSCU)'s energy management, reduction and conservation efforts. The utility data received indicates Norwalk is a higher energy intensity campus among CSCU from an energy perspective (see Figure 1 Norwalk Energy Dashboard). The energy use intensity (EUI) method is used for benchmarking and comparison purposes. Energy management and efficiency efforts in the past have reduced Norwalk's energy use, through projects such as lighting retrofits, HVAC upgrades, high efficiency motors, lighting controls and through construction of the LEED Silver Center for Science, Health & Wellness.



02 SYSTEN LEVEL EXISTING CONDITIONS

03 System Level Energy Needs

OPH OPH

Based on Eversource online data, Norwalk has a site EUI of 138 kBtu/sf, higher than the regional median for colleges/universities.

Energy Spend

Table 1 provides a comparison of energy spending comparing to the average of CSCU campuses and the Northeast Region Commercial Sector.

	Norwalk	Community College	Average of CSCU Community College	Average of CSCU University	Northeast Region Commercial Sector
Cost per Square Feet	\$	2.93	\$ 2.49	\$ 2.08	\$ 1.67
Cost Per Fall 2013 FTE Student	\$	262	\$ 311	\$ 677	\$ -
Avg. Cost per kWh Electricity from Grid	\$	0.14	\$ 0.14	\$ 0.14	\$ 0.15
Avg. Cost per MMBtu Natural Gas	\$	8.18	\$ 10.06	\$ 7.32	\$ 10.03
Avg. Cost per Gallon Diesel/Fuel Oil		Cost not available	\$ 3.46	\$ 3.77	
Total Operating Expenses	\$	55,287,000	\$ -	\$ -	
Total Energy Spending	\$	1,009,857	\$ -	\$ -	
% of Operating Expenses		1.83%	1.95%	2.67%	

TABLE 1: Energy Cost Comparison (FY 2014)

On a per square foot basis, Norwalk has a more cost intensive energy use. However, the campus pays about average for electricity and below average for natural gas, and also has a smaller cost per FTE student.

Utility Incentives/ Develop Plan for Energy Efficiency Measures (EEMs)

Both of Norwalk's utilities are through Eversource. This places the campus in a prime position to maximize incentives by combining multiple energy saving opportunities in what is known as a "Comprehensive Project."

Since incentives are based on incremental energy savings, further analysis and collaboration with Eversource is required to determine rebate amounts for each opportunity. Table 2 demonstrates a summary of the EEMs recommended for Norwalk to pursue.

					Ő
Opportunity ID	Energy Conservation or Efficiency Opportunity	App. Cost (Before Rebate)	Payback w/rebate (Years)	Priority	RTUNITIE
NCC-1	Steam trap maintenance program. (50-70 trap estimate)	\$13/trap surveyed + repair costs	(Utility pays up to %100)	1	0,
NCC-2	Recommission West campus energy systems and East Campus after chiller upgrades. Recommissioning buildings every 3-5 years.	\$0.50 - \$3.50 /sf	<2	1	RECO
NCC-3	Continue to retrofit lighting with LED and dimming controls for daylight harvesting.	Varies	2-6	1	MMENI
NCC-4	Continue to pursue Virtual Net Metering (VNM) agreement for solar PV. Also, explore on campus renewable energy with rooftop and parking canopy solar PV.	PPA	Instantaneo us	1	DATIONS
NCC-5	Continue to upgrade from pneumatic to DDC on East Campus HVAC, adding controls. (63 VAV boxes remain)	\$130,000	Varies	1	
NCC-6	Insulation improvements for B Wing HVAC	\$0.75 - \$1.30 /sf insulation [1]	Varies	1	PLA
NCC-7	Ensure training procedures are in place with updates to BAS and new staff every time new equipment is installed.	Varies	Varies	2	SN
NCC-8	Replace inefficient D-Wing DX Air Conditioning units with an efficient Chilled Water System and replace the DX coils in Air Handlers and install chilled water coils. Also provide outside air to air handlers for economizing and VFD. (D Wing)	Varies	Varies	2	

NCC-9	New Chiller: Install a new high-efficiency chiller, 450 Ion planned for 2017 to replace DX units. Select chiller based on the highest IPLV which indicates the efficiency year round, not just peak.	\$550,000 [2]	Varies	3
NCC-10	Complete implementation of Campus Energy Dashboard to increase energy use awareness.	Varies	Varies	3
NCC-11	Explore building integrated solar for future window replacements. (sky bridge walkway)	Varies	Varies	3

TABLE 2: Norwalk Energy Efficiency Measures

Next Step

In addition to the priority projects, next steps for Norwalk are below:

Management

Norwalk uses a Siemens BMS for energy management. As part of the CSCU Energy Master Plan, it is recommended that CSCU create a template for energy tracking applicable to all campuses. Norwalk should track energy usage through such a template, as well as compare energy spend against available budgets.

Fume Hoods

Implement a fume hood sash management program to ensure hoods are closed and turned off when not in use.

Renewable Energy

Explore power purchase agreements (PPAs) for portions of the building roof and parking canopies. Continue to pursue virtual net metering.

Benefits of implementing the suggestions in the Energy Master Plan include increased sustainability with local PV power, cost reductions and continued optimization of existing equipment.

^[1] Insulation cost based on home/small industrial duct insulation cost calculator. Homewyse. Cost of Duct Insulation, 2016. Web.http://www.homewyse.com/costs/

^[1] Insulation cost based on Trane pricing information (scaled for inflation) and assumptions based on Florida Power and Light's White Paper; FPL. Water-Cooled Chillers. Web. https://www.fpl.com/business/pdf/water-cooled-chillers-primer.pdf Trane. Quick Reference for Efficient System Design, 2000. Web. https://www.trane.com/ commercial/uploads/pdf/865/ctv-trt-001-en.pdf

INTRODUCTION

As part of the Connecticut State Colleges & Universities (CSCU) Energy Master Plan, Norwalk Community College (Norwalk)'s building infrastructure, energy use and energy management practices were assessed. The ultimate goal was to determine ways Norwalk could improve its energy use on campus, and be an active participant in CSCU energy reduction efforts. This chapter identifies Norwalk's historical energy use, future projected needs and energy recommendations. The building locations are often classified by past expansion projects, for instance the West Campus is comprised of the William H. Schwab Center for Information Technology (CIT), the Center for Science, Health, and Wellness and "B" and "D" Wings. Like the East Campus building, the West Campus has a central faculty office to support faculty with offices in the building.

1.2 PREVIOUS ENERGY STUDIES & PROJECTS

1.1 NORWALK OVERVIEW

Norwalk is the fifth largest college of the CSCU Community Colleges, and its campus is located at 188 Richards Avenue in the City of Norwalk. The two-year college offers 45 associate degree and 26 certificate programs, including degrees such as an Associate in Arts, Associate in Science, and Associate in Applied Science.

The Norwalk campus is located on a 31.47-acre complex and consists of two campuses, East and West. The two campuses are located across from each other on either side of Richards Avenue, surrounded by student parking.

In 2012, Norwalk completed its first Climate Action Plan, which outlines sustainability goals including adding a fleet of renewable energy projects and other energy-related infrastructure on campus. Some of the desired projects include adding cogeneration plants, solar photovoltaics, and geothermal. Norwalk has completed several energy surveys, with the most recent completed in 2013. The energy audit included a walkthrough of both Campuses. Based on the audits and via the facilities department initiative, several projects were completed. According to Norwalk's 2014 Self-Study report, retrofits have been a large contributor to energy savings:

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nealth	OPP	FIN/
	ORTUNIT	ANCING/F

BuildingYear Built [Renovated]Gross Square FeetBuilding FunctionEast Campus Building1990136,756Mixed UseWest Campus Building1961 [2003/2011]214,000Mixed Use includes CIT and health
and WellnessTotal350,756

TABLE 1.1: Norwalk Campus Building Information

Each campus contains one main building serving multi-purpose functions, including academic, administrative and student service roles. Norwalk's East Campus building is three-story, 136,756 square foot building, housing classrooms, specialized laboratories, the library, art gallery, 300-seat theatre, and career counseling. It also serves administrative functions including the financial aid office, student activities office, and a central faculty services office to support faculty with offices in the building.

Completed in 1961, the West Campus building has gone through several renovations and is currently a 214,009 square foot, threefloor space containing the institution's technical programs. The building houses chemistry, biology, archaeology and other science laboratories. Also located in the building are Norwalk's cafeteria, human resources, purchasing services, athletic facilities, and test lab kitchens for the Restaurant Management program. "Retrofits have reduced our energy use by over 560,000 Kilowatt Hours (kWh) per year, a reduction that translates to over \$78,000 savings per year. In the process, we have received over \$200,000 in rebates."

A summary of Norwalk's energy saving projects separated by campus building are presented in the section.

East Campus:

- LED East Campus light fixture replacement on walkway
- Extended the natural gas service into the East Campus Building in 2015.
- HVAC Upgrades including:

a. High efficiency motors on 9 supply/ return fan motors

b. 100 pneumatic VAV boxes converted to direct digital controls (DDC), including setback, occupancy detection, and demand control ventilation (DCV) controls.





West Campus:

- 2011 LEED Silver Science Health and Wellness Center: CFLs, T8s, lighting controls, high efficiency motors for fans and hot water pump, air-cooled chiller;
- Energy upgrades to the B Wing: Radiation controls, rooftop direct exchange (DX) air unit integration, lighting controls;
- LED Lighting for floodlights in the cafeteria and courtyard
- High performance lighting upgrades in the D Wing

Appendix A presents recommendations from the energy audit as well as a more detailed list of completed projects.

EXISTING CONDITIONS & RECOMMENDATIONS

Information on Norwalk's existing conditions was captured from campus interviews, energy data and reports provided by the campus. A holistic view of existing practices, material on energy management, energy infrastructure and project implementation processes was reviewed. Analysis of the data and campus walkthroughs helped clarify recommendations with the goal of decreasing energy use, documented after each subheading.

2.1 FACILITY ENERGY BENCHMARKING AND ENERGY CONSUMPTION

Norwalk's energy dashboard provides of summary of Norwalk's energy use.

Appendix B documents information on the assumptions and data sources used for energy benchmarking purposes. Norwalk's site EUI is the second largest of the CSCU community colleges. The horizontal dashed lines represent the Northeast regional median EUI for benchmarking comparison purposes.

Note:

• The electric consumption of the West Campus parking lot has been excluded from the EUI calculations and accounts for less than ½ of 1%.







FIGURE 2.1: Norwalk Community College Energy Dashboard

Figure 2.1c: Campus Weather Normalized Site EUI by Fiscal Year



01 INTRODUCTION

02 SYSTEN LEVEL EXISTING CONDITIONS

03 System Level Energy Needs

04 FINANCING/FUNDIN OPPORTUNITIES

05 SYSTEM LEVEL RECOMMENDATIONS

> OG CAMPU PLANS



Eversource's Customer Engagement Platform was used for collecting data on the campus' electricity and gas. This was contrasted with the campus reported spreadsheets. Table 2-1 shows that the data reported by Eversource Online is approximately 6% to 13% higher than the campus reported spreadsheets (1 CCF = 100 kBtu conversion factor used).

Based on the data:

- Norwalk has a site EUI of 138 kBtu/sf based on Eversource Online data, higher than the regional median for colleges/ universities.
- The site EUI is reduced to 125 when evaluated using the campus reporting spreadsheets

		Fiscal Year	Eversource Online	Campus Reporting	% Difference
	Electricity	2014	5,827,319 kWh	5,086,297 kWh	12.70%
	Liectricity	2015	6,024,066 kWh	5,667,745 kWh	5.90%
	Gas	2014	25,777 MMBtu	23,759 MMBtu	7.80%
	Gas	2015	26.391 MMBtu	24.641 MMBtu	6.60%

TABLE 2.1: Energy Consumption Reporting Differences by Fiscal Year

Figure 2.2 provides an analysis of site EUIs by campus and fuel source and demonstrates the nearly quadruple natural gas site EUI at the West Campus Building.



On a per square foot basis, Norwalk has a more cost intensive energy use than the average CSCU community college. However, the campus pays about average for electricity and below average for natural gas.

2.2 CAMPUS UTILITIES AND DISTRIBUTION

Norwalk uses fuel oil, natural gas and electricity to supply energy to their campuses. Natural gas use is more than half of the energy use (Energy Dashboard). The following are the campus' utility providers.

- Electric: Eversource (formerly Connecticut Light & Power)
- Natural Gas: Eversource (formerly Yankee Gas)

Prior to 2015, East Campus did not have a natural gas supply. In 2015, gas service was extended to the East Campus Building.

2.3 ENERGY PROCUREMENT

As of 2013, Norwalk's electric supply is provided by Direct Energy, in a bundled CSCU contract, detailed further in the Energy Master Plan. The campus' natural gas supplier is their local distribution company, Eversource.

2.4 OPERATIONAL AND ENERGY MANAGEMENT PRACTICES

2.4.1 CURRENT CONDITIONS

Norwalk's maintenance team is responsible for the upkeep of campus facilities, including maintenance of infrastructure, utilities, and management of custodial responsibilities. Although not a residential campus, Norwalk is open year round to students. In the summer and winter break campus occupancy decreases, but there are no shut downs. Typical operating hours are:

Monday –Friday	: 6:30 AM-10 PM
Saturday	: 8AM-6PM

			Average of CSCU	Average of CSCU	Northeast Region
	Norwall	k Community College	Community College	University	Commercial Sector
Cost per Square Feet	\$	2.93	\$ 2.49	\$ 2.08	\$ 1.67
Cost Per Fall 2013 FTE Student	\$	262	\$ 311	\$ 677	\$ -
Avg. Cost per kWh Electricity from Grid	\$	0.14	\$ 0.14	\$ 0.14	\$ 0.15
Avg. Cost per MMBtu Natural Gas	\$	8.18	\$ 10.06	\$ 7.32	\$ 10.03
Avg. Cost per Gallon Diesel/Fuel Oil		Cost not available	\$ 3.46	\$ 3.77	
Total Operating Expenses	\$	55,287,000	\$ -	\$ -	
Total Energy Spending	\$	1,009,857	\$ -	\$ -	
% of Operating Expenses		1.83%	1.95%	2.67%	

TABLE 2.2: Energy Cost Comparison (FY 2014)

These operational hours are extended in comparison to other non-residential CSCU campuses.

Facilities uses the Siemens building management system (BMS) for a portion of the equipment and lighting controls, which control the lighting and setback for equipment based on time and day. The B Wing has wall sensors for lighting and occupancy sensors are used for the D Wing and Health buildings. Approximately 100 upgraded variable air volume (VAV) air handlers use demand control ventilation (DVC) to reduce ventilation to the minimum acceptable to save energy. Approximately 63 VAV remain to be upgraded.

ENERGY USE INFORMATION MANAGEMENT SYSTEM

Norwalk uses a Siemens Continuum BMS for energy management and also uses internal energy tracking software. Energy use is tracked on a monthly basis and compared to past months. The East and West Buildings have separate electric meters, and as of FY 15 there is separate metering for natural gas. This granularity of data aids in comparing the campuses. Another BMS vendor, Johnson Controls, is also used for lighting and other controls in some locations. Current staff use these tools to manage energy effectively. In an effort to make energy management and sustainability efforts more transparent to the campus, Norwalk has attempted for several years to install a campus visible energy dashboard.

2.4.2 RECOMMENDATIONS

As part of the CSCU Energy Master Plan, it is recommended that CSCU create a template for energy tracking applicable to all campuses. Norwalk should track energy usage through such a template, as well as compare energy spend against available budgets. Norwalk can also use Eversource's Customer Engagement Platform to view its energy use. This data should be compared to the self-reported data as there are variations in overall energy use. The most reliable energy data should be used.

2.5 EXISTING BUILDING COMMISSIONING

2.5.1 CURRENT CONDITIONS

No recent building commissioning efforts were reported.

2.5.2 RECOMMENDATIONS

Buildings with BMSs with measurable points stand to benefit the most from recommissioning. Tips for selecting the best candidates for existing building commissioning (EBCx) are available in the system wide Master Plan. Although State buildings built after 2011 are required to have a commissioning agent, it has been observed even new buildings have not been properly and thoroughly commissioned at numerous other campuses.

A properly commissioned building should be turned over with a thorough commissioning report, complete with checklists and testing and balancing (TAB) reports for each piece of equipment, even windows and lighting. If this documentation is not available, it is a good indication the building was not properly commissioned. Newer buildings with a higher than average EUI are also indicative of a poorly commissioned building.

As a general rule of thumb:

• Recommission existing building systems every 3-5 years.

2.6 MECHANICAL SYSTEMS

2.6.1 CURRENT CONDITIONS

Norwalk has two distinct separate energy systems, one for the East Campus, and the other for the West Campus.

BOILER SYSTEM

The West Campus uses a low pressure steam system with two Wel-McLain boilers and two High Efficiency A.O. Smith cast iron boilers for heating, installed in 2007 and 2010 respectively. All boilers are tuned at least yearly.

Norwalk uses an A.O. Smith Cyclone Xi for domestic hot water, heating the water at up to 96% efficiency.

The East Campus uses a hydronic system with two Weil-McLain boilers, installed in 1992 with new burners installed in 2013. The burners are dual fuel.

A pre-packaged VFD pump system by Armstrong International offers high efficiency pumping.



FIGURE 2.3: Pre-packaged VFD pump system by Armstrong International

05 SYSTEM LEVEL RECOMMENDATIONS

DAMPL

CHILLER SYSTEM

Multiple cooling systems are operated throughout the campus. The West Campus uses an air cooled 200 Ton Daikin McQuay chiller, installed in 2010, as well as multiple smaller 30 Ton systems and window units in the B Wing. Direct Expansion (DX) air cooled units and a 150 Ton McQuay water cooled chiller are used for the West Campus (D Wing).

HVAC AIR SIDE

Norwalk has been updating and upgrading many air VAV boxes as funds allow. Currently 100 VAV boxes have been upgraded and 63 remain on the East Campus. The transition from pneumatic to DDC offers many opportunities for energy savings as covered in the Energy Master Plan.

2.6.2 RECOMMENDATIONS

The following lists are recommendations by system type that would aid in optimizing efficiency, and reducing energy.

BOILER SYSTEM

• Conduct a steam trap survey and implement a steam trap audit with Eversource.

a. 100% of the audit cost can be covered when recommendations and deficiencies found during the audit are repaired. The payback from steam trap repairs are usually less than a couple months.

- Recover as much of the condensate at the hottest temperature possible for the steam system.
- Eventually, consider replacing the steam system with a more efficient hydronic system where condensing boilers can be used.

CHILLER SYSTEM

• Replace less efficient DX units with larger more efficient chillers when possible. Purchase the chiller based on life-cycle cost, factoring in the part load efficiency over the course of the cooling season.

HVAC AIR SIDE

- Continue to upgrade air handling units with DDC and occupancy controls, with CO2 sensors.
- Insulate all ductwork and piping

OTHER

• Complete the installation of the Campus Energy Dashboard to increase energy use awareness and highlight energy efficiency.

2.7 LIGHTING

2.7.1 CURRENT CONDITIONS

Norwalk has completed numerous lighting upgrades throughout the campuses. An excel tracking sheet is used to document the types of completed lighting projects with associated costs. Of the 168 listed projects, approximately 80% have been completed. Norwalk has replaced most lights with either T8 or T5 bulbs. The campus makes use of occupancy sensors and Siemens lighting controls in the A Wing. The B wing has wall sensors, while the D wing and Health portion of the main building use occupancy sensors.

Plans are in place to replace approximately 100 downlights, 150 Watt cylinders and T12s at the campus Library with LEDs and higher efficiency lamps .



FIGURE 2.4: Indoor Lighting

2.7.2 RECOMMENDATIONS

Norwalk has done a successful job of tracking and implementing lighting upgrades. Norwalk should continue to retrofit lighting with LED and dimming controls for daylight harvesting. The campus should continue to work with Eversource for funding of these projects, to maximize the return on investment. There are additional opportunities for occupancy based lighting where schedules frequently change and where there is intermittent occupancy. The campus should consider replacing all exterior lighting with LED and have photo sensors installed to replace timers, especially if the timers are not connected to the solar calendar in the BMS.

2.8 BUILDING ENVELOPE

2.8.1 CURRENT CONDITIONS

Both the East and West campuses are of brick construction, originally constructed prior to 1990.

WEST CAMPUS

The B Wing of the West campus has excessive expanses of glass on the exterior walls. Windows are single pane with aluminum frames. However, there are future potential demolition plans for the B Wing which alters the campus' priorities for projects. The CIT center in the West campus is in need of better sealant and weather stripping. Windows curtains in A wing help with added insulation.

EAST CAMPUS

The East Campus building roof will be replaced within the next two years. Door seals were noted to be needed in East campus to reduce air infiltration, however the campus will be replacing all doors on the East Campus which will aid in resolving the issue and reduce energy use.

2.8.2 RECOMMENDATIONS

When replacing roofing, Norwalk should consider also increasing insulation levels to R-38 or the latest building codes.

2.9 DISTRICT ENERGY / COGENERATION

2.9.1 CURRENT CONDITIONS

There is no district energy or cogeneration at Norwalk.

2.9.2 RECOMMENDATIONS

There is summer thermal use on campus, but the loads, primarily domestic hot water, are not enough to warrant study of a combined heat and power (CHP) study. CHP application is unlikely to provide additional benefit over the existing boilers.

2.10 RENEWABLE ENERGY

2.10.1 CURRENT CONDITIONS

Norwalk's climate action plan includes a goal of 20% energy generated from renewable sources by 2020, which may be aided with the addition of solar. In the past, Norwalk pursued a virtual net metering contract for a 2 MW solar system, which is currently on hold due to procedural issues.

2.10.2 RECOMMENDATIONS

Norwalk's East and West Campus Buildings have availability for small solar arrays. The East Campus Building roof mostly slopes either west or east but there may be a possibility for a small rooftop over the library, depending on roof replacement schedule. The West Campus Building has mechanical equipment obstructions, but there are opportunities (See Figure 2.5). The West Campus Building was constructed in 1961 and has had renovations in 2011 with their Science Building addition.

The campus is largely surrounded by parking areas, which may provide an opportunity for solar canopy. The two example parking lots have contiguous and the largest areas, representing over approximately 700 kW of solar.

Ground-mount space is more limited, but there may be opportunities adjacent to the body of water on the west portion of the campus, given an understanding of potential flooding.

The campus should continue to pursue virtual net metering, where possible. Table 2.3 provides an overview of the buildings that may be considered for solar PV in the future.



Building Name	Year Built [Renovated]	GSF [FY 2015]	Building Roof sq. ft.	Roof Install/ Replacement Date	Roof Type	Array Size Potential (kW DC)[1]	Annual Generation Potential (MWh)[2]	Solar Suitability Comments
				HIGHER PRIC	RITY PROJEC	TS		
East Campus Building	1990	136,756	3,300	To be replaced soon		12-16	16-20	Most of roof slopes either west or east. Only Library and theater roof area selected.
West Campus Building	1961 [2003/2011]	214,009	9,900	2010	Rubber Roof (A wing); Built up (B Wing)	38-48	48-61	Portions of campus, Health/Wellness/Science roof portions, middle section, and northern wing section
Subtotal		350,765				48-64	64-81	
				LOWER PRIO	RITY PROJECT	rs		
West Parking Lot		111,276				512-668	668-857	Solar Canopy, approaches the flood zone - soil conditions and impact of flooding on panels would need to be investigated
Central Parking Lot		58,000				269-351	351-450	Solar Canopy
Subtotal Total		169,276 520,041				781-1091 829-1083	1091-1307 1083-1388	

TABLE 2.3: Norwalk Potential Areas for Solar PV

[1] Assumes that each sf of panels can generate between 4.6 and 6 Watts DC (about a third of the PVWatt Output Assumptions). Actual generation values would be

[1] Assumes that each si of panels can generate between 6 and 7.7 kWh annually (about a third of the PVWatt Output Assumptions). Actual generation values would be calculated if a solar PV study was performed.



FIGURE 2.5: Norwalk Campus PV Potential

2.11 CAPITAL PLANNING

2.11.1 CURRENT CONDITIONS

To accomplish its energy infrastructure goals, Norwalk relies on financing and funding from the System Office and the State. The System Office provides annual code compliance and infrastructure funds. Larger capital projects are also funded under CSCU 2020, as of FY 2015. The State Legislature allocates bonds for campus improvement projects.

Norwalk completed several expansions on the West Campus to provide additional support to students, including:

- A \$16 million, 36,000 square foot William H. Schwab Center for Information Technology (CIT) constructed in 1999. The facility addition features CADD and networking labs, computer rooms, an architectural design studio, and several other technology related classrooms.
- The 55,000 square foot Center for Science, Health, and Wellness constructed in 2011. The health and science building exceeded the state's LEED Silver requirement, achieving Gold certification. Site design features included natural daylighting, and energy efficient HVAC and lighting.



rebates. Both of Norwalk's utilities are through Eversource. This places the campus in a prime position to maximize incentives by combining multiple energy saving opportunities in what is known as a "Comprehensive Project." The primary advantage of a Comprehensive Project is the maximum incentive cap is normally raised from 40% to 50%. Eversource has maximized these incentives in the past, and may also in the future, in the following ways:

- The comprehensive cost cap was increased from 50% to 80% of total cost.
- The incentive was increased from \$0.30/kwh or \$3.50/CCF (with 40% cost cap) to \$0.40/kwh or \$4.00/CCF (with 60% cost cap).

Since incentives are based on incremental energy savings; further analysis and collaboration with Eversource will be required to determine rebate amounts for each opportunity. To help Norwalk navigate and prioritize the energy opportunities identified, a summary of opportunities is listed in Table 2.4. Immediate action should be taken to consider priority one and two opportunities with the goal of combining multiple opportunities for a Comprehensive Project under the same meter with Eversource. The simple payback in most cases cannot be reasonably estimated without detailed building models and/or more operating data. The payback periods provided are based upon the performance of past similar projects and are not necessarily indicative of future results.



As stated in the Energy Master Plan, capital projects are required to comply with Connecticut's building code, inclusive of their energy efficiency and high performance standards.

Section 3.1 provides more information on future campus expansion projects.

2.11.2 RECOMMENDATIONS

Norwalk should continue to collaborate with Eversource for all major building renovations, mechanical, electric and plumbing (MEP) equipment replacement and all new construction

2.12 COLLABORATION / PARTNERSHIP

2.12.1 CURRENT CONDITIONS

Many of the energy projects have been made possible through coordination with the campuses' utilities. Norwalk has secured over \$200,000 in rebates for energy projects. The System Office Facilities Department is also available to provide assistance in budgeting, capital planning and technical support for the community college projects, including Norwalk. Personnel responsible for energy management project and upgrades have limited interaction with other departments or staff.

2.12.2 RECOMMENDATIONS

Norwalk should continue to take advantage of utility incentives for the Energy Efficiency Measures (EEMs) presented in this plan. Incentives structures range and vary by program, but Eversource has offered incentives of up to 80% of project costs in the past.

2.13 SUMMARY OF RECOMMENDED ENERGY **EFFICIENCY OPPORTUNITIES**

interviews with campus staff, a list of potential EEMs is presented in Table 2.4. These projects represent both low cost, immediate action measures, as well as projects that may require larger capital and therefore be longer-term. Many energy-related projects are incentivized through utility



Opportunity ID	Energy Conservation or Efficiency Opportunity	App. Cost (Before Rebate)	Payback w/rebate (Years)	Priority
NCC-1	Steam trap maintenance program. (50-70 trap estimate)	\$13/trap surveyed + repair costs	(Utility pays up to %100)	1
NCC-2	Recommission West campus energy systems and East Campus after chiller upgrades. Recommissioning buildings every 3-5 years.	\$0.50 - \$3.50 /sf	<2	1
NCC-3	Continue to retrofit lighting with LED and dimming controls for daylight harvesting.	Varies	2–6	1
NCC-4	Continue to pursue Virtual Net Metering (VNM) agreement for solar PV. Also, explore on campus renewable energy with rooftop and parking canopy solar PV.	PPA	Instantaneo us	1
NCC-5	Continue to upgrade from pneumatic to DDC on East Campus HVAC, adding controls. (63 VAV boxes remain)	\$130,000	Varies	1
NCC-6	Insulation improvements for B Wing HVAC	\$0.75 - \$1.30 /sf insulation [1]	Varies	1
NCC-7	Ensure training procedures are in place with updates to BAS and new staff every time new equipment is installed.	Varies	Varies	2
NCC-8	Replace inefficient D-Wing DX Air Conditioning units with an efficient Chilled Water System and replace the DX coils in Air Handlers and install chilled water coils. Also provide outside air to air handlers for economizing and VFD. (D Wing)	Varies	Varies	2
NCC-9	New Chiller: Install a new high-efficiency chiller, 450 Ton planned for 2017 to replace DX units. Select chiller based on the highest IPLV which indicates the efficiency year round, not just peak.	\$550,000 [2]	Varies	3
NCC-10	Complete implementation of Campus Energy Dashboard to increase energy use awareness.	Varies	Varies	3
NCC-11	Explore building integrated solar for future window replacements. (sky bridge walkway)	Varies	Varies	3

TABLE 2.4: Norwalk Energy Efficiency Measures

 ^[1] Insulation cost based on home/small industrial duct insulation cost calculator. Homewyse. Cost of Duct Insulation, 2016. Web.http://www.homewyse.com/costs/ cost_of_duct_insulation.html
 [2] Chiller pricing is based on Trane pricing information (scaled for inflation) and assumptions based on Florida Power and Light's White Paper; FPL. Water-Cooled Chillers. Web. https://www.fpl.com/business/pdf/water-cooled-chillers-primer.pdf Trane. Quick Reference for Efficient System Design, 2000. Web. https://www.trane.com/ commercial/uploads/pdf/865/ctv-trt-001-en.pdf

ENERGY NEEDS

3.1 FUTURE DEVELOPMENT

Energy use has the potential to change drastically depending on how a campus evolves, Norwalk is in the third and final phase of the Master Plan. Anticipated changes are inclusive of three overall projects including both renovations and new construction projects. The West Campus building expansion will include a new student center, dining and small kitchen area. A space use study and renovations are also planned for the existing library, culinary laboratory spaces and theatre.

Based on future development plans, it is not anticipated that any additional energy infrastructure will be needed. With the addition of new space use aspects such as a dining and kitchen area, energy patterns may increase on an EUI basis. With these expansions it is important to incorporate energy efficient features such as drives with controls, BMS integration and proper commissioning.

As the campus grows it is important to be able to support the electric needs in case of power outages and unreliable energy situations. Norwalk has two 250 kW generators (one diesel and natural gas) that can provide power to emergency lighting and select IT infrastructure and life safety. According to campus personnel, a new emergency generator will be acquired for the West Campus.

3.2 ENERGY RESILIENCY RECOMMENDATIONS

Norwalk partook the CSCU system-wide hazard mitigation initiative. The CSCU Multi-Hazard Mitigation Plan provided recommendations surrounding energy resiliency that are also applicable for the Energy Master Plan. Below are recommendations from the hazard mitigation plan for improving the energy reliability and resiliency of the campus.

- Expand emergency power generator capabilities on campus to cover essential services (e.g., IT, sump pumps, phone, culinary refrigerators/freezers, alarms, and security cameras, repeaters).
- Evaluate options and implement a microgrid project to build redundancy.
- Evaluate HVAC systems for IT and upgrade areas prone to overheating.
- Incorporate hazard resiliency aspects to new designs of buildings.
- Improve building envelope

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CONCLUSION / NEXT STEPS

Norwalk continues to follow their recommended measures from their 2013 study, and remain committed to meeting their CAP goals. Despite the numerous projects complete, the campuses, in particular West Campus, have a higher than average EUI in comparison to the other CSCU campuses and the Northeast Median average for colleges and Universities. It is suggested for Norwalk to begin energy upgrades with a focus on the West Campus Building. Areas for improvement relate to existing building recommissioning, chiller upgrades and steam trap maintenance programs.

Other top priority initiatives include:

- *Management:* Norwalk should continue to review energy bills, including tracking energy use and comparing energy spend to available budgets.
- *Renewable* Energy: Explore PPAs for building roof and potential parking canopies. Also, continue to explore virtual net metering opportunities.
- Utility Incentives/ Develop Plan for EEMs: It is recommended for Norwalk to maximize incentive funding for EEMs by working with Eversource, and combining multiple energy saving opportunities in what is known as a "Comprehensive Project." Further analysis and collaboration with Eversource is required to determine rebate amounts for each opportunity

A summary of further projects and priorities for the campus are listed in Table 2.4. Norwalk has exemplified a commitment to saving capital for students through past projects, and by focusing on priority projects will be able to further decrease their energy use and work toward their sustainability goals.

4.1 CONTACT INFORMATION FOR KEY STAKEHOLDERS

Collecting all the necessary information for this planning effort required a collaborative effort. Below are the stakeholders that were active in providing their expertise about campus current conditions and future needs, and energy related decisions.

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APPENDIX A: NORWALK 2013 ENERGY STUDY SUMMARY OF RECOMMENDATIONS

RECOMMENDATIONS FROM NCC CAMPUS WALK-THROUGH SURVEY

Energy surveys were conducted for NCC in 2007, 2011 and 2013. The staff was able to implement many of the recommended projects over those years utilizing deferred maintenance funds and small capital project budgets, with the help of incentives from the CT Energy Efficiency Fund. Additional recommendations were also identified in NCC's Green Campus Action Plan developed by the NCC green team, as well as in a walkthrough audit conducted in the spring of 2014 by the William Leahy from the Institute for Sustainable Energy.

Going forward, NCC and the BOR Central Office should consider utilizing Energy Savings Performance Contracting to finance the installation of many of the capital improvements identified in this report. Also, consideration should be given to increasing the annual deferred maintenance budget, which would assist the staff in making cost effective minor improvements.

General Campus Wide Recommendations
Recommended Measures
Replace the outdated building HVAC controls and Energy Management Systems with a modern centralized Building Automation System (BAS).
Remove and replace the pneumatic building control backbone in both buildings and install Direct Digital Controls. West Campus removed, partial on East Campus
A new BAS should include full Graphic User Interface (GUI) and alarms and all facility management technical staff should be fully trained on the system.
The BAS should include sub-metering of all energy sources to provide the facility managers with real-time energy data.
Install Variable Air Volume (VAV), Occupancy Sensors and CO2 sensors in all classrooms, offices, conference rooms, and large public gathering spaces to provide more effective and efficient control of lighting and HVAC.
With new technology available, there are still lots of opportunities to improve the energy efficiency of lighting through both buildings.
Convert exterior HID lighting to more efficient LED lighting fixtures. East Campus done, Partial on West Campus.
Replace all damaged or single glazed windows with energy efficiency Low-E windows.
Replace all Entry Doors that have significant air leaks. Currently out for bidding.
Install Variable Frequency Drives on Domestic Hot Water circulation pumps to provide hot water on demand and to shut off circulators now running 24/7
Install automatic sensors on Sinks, low flow Toilets and waterless Urinals
Replace standard motors with premium high efficiency motors on pumps and fans in HVAC system
Consider installing a large solar Photovoltaic array to generate a significant portion of NCC's electric energy.
Consider the advantages to NCC of installing a Energy and Sustainability Dashboard in both buildings to enhance awareness by student and the public of NCC's green campus initiatives

Comments in bold indicate the current state of the project as of the publication of this Energy Master Plan.

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GENERAL CAMPUS-WIDE RECOMMENDATIONS

1. The current building control systems and HVAC controls have been cobbled together from systems and equipment that were installed over the past 50 years ago with some recent upgrades. Some of the HVAC equipment is controlled by integrated unitary controls; some through the original pneumatic system; and some with Direct Digital components interfacing with newer equipment. A new Building Automation System (BAS) should be installed to serve as the Head End controller for NCC's entire East and West Campus. The new system should be a fully DDC, native BAC-net BAS so the HVAC hardware, building distribution systems and energy use can be properly monitored and controlled the building systems. Most new BAS software has tools to diagnose system problems.

2. It is important to continuously improve your Building Automation Systems (BAS), and its control strategies. With an outdated pneumatic Building Automation System, the buildings will consumes more energy than necessary and could creating problems, including; negative building pressure, uncontrolled moisture and mold. While visiting the boiler room, it was observed that the air compressor which supports the pneumatic system was frequently turning on and off, suggesting that the system has leaks. This will waste energy in excess compressor motor run time and through poor HVAC performance.

3. The BAS upgrade should have its functionality through GUI equipment and systems screens so that settings, alarms, limits and operational changes can be easily made in response to problems and changes in weather. It should also include boiler water reset based on outside temperature, as well as optimal start/stop. Additional equipment should be connected and provided with control including unit heaters in stairways, circulating domestic hot water systems and major lighting systems. The facility managers should receive manuals and training on the BAS system to ensure he can take advantage of the systems full functionality and energy saving capabilities.

4. The facility manager's staff currently does not receive monthly energy or water bills and as a result are unable to quickly respond to changes in building's energy use and water use. You can't effectively manage what you do not measure. Integrating the ability to read meters and sub-metering for electricity, natural gas and water will improve the building's efficiency maximizing the capabilities of the BAS.

5. Classroom and offices not already fitted with Variable Air Volume (VAV) equipment should be upgraded. VAV allows unoccupied rooms to be shut down, reducing the expensive cost of heating or cooling unoccupied spaces. The installation of a Variable Frequency Drive (VFD) on the air handler will respond to closed VAV boxes and slow the fan and pump motors offering additions electric and fuel saving.

6. There are lots of energy saving opportunity at NCC to upgrade lighting systems to meet the "State of the Art" standards for lighting in educational facilities as defined in IECC 2009 code requirements. These standards are defined in watts per square foot and use new technology to comply with the Illumination Engineers lighting level recommendations. Some classrooms and office areas are currently using 1.2 to 1.8 watts per square foot for lighting. Today most areas can be lighted by systems using .7 to 1 watt per square foot.

7. Exterior lighting around the campus should be upgraded from Metal Halide and HPS pole fixtures and wall packs to money and maintenance saving LED fixtures.

8. The East Campus has a number of windows that are in need of replacement because of leaking and out-gassing. Also sections of the West Campus A and B wings still have the original single glass windows. These should be replaced with thermal efficient low-E glass windows.

9. A number of exterior doors on both the East and West Campuses are in need of replacement because of wear and air leakage.

10. The Domestic Hot Water systems on both campuses are tied to circulating systems that currently produces 120 to 140 degree hot water 24 hours a day, 7 days a week throughout the year and continuously pump it around the buildings. These systems should be controlled by the BAS system to only operate when there is demand for hot water.

11. Additional water saving can be achieved by installing low flow faucets with automatic controls, low flush toilets, and waterless urinals.

12. The East and West Campuses both utilize numerous motors for pumps and fans. Replace standard efficiency motors with premium efficiency motors whenever installing VFD, when rebuilding air handlers or whenever motors need replacing.



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13. NCC has both a significant electric daytime electric demand, and a large amount of unobstructed south facing roof that could support a large solar photovoltaic energy system. Consideration should be given to develop a project that could be financed through a Power Purchase Agreement with no upfront funding from the college.

14. NCC should look into a version of the Eco-Screen® sustainability kiosk compatible with their new BAS. This is a tool that enables building facility manager and faculty to showcase the school's energy conservation and sustainability initiatives. By installing an Eco-Screen, tied to your BAS, you can introduce students and building visitors to your building's operating systems, providing them with an interactive presentation of your building's innovative green building features.

NCC	East Campus Recommendations
ECM #	Recommended Measures
15	Extend the Natural Gas service into the East Campus facility. Completed in 2015
16	Upgrade the heating plant by install High Efficient Condensing boilers or Duel Fuel Burners on existing equipment to operate on Natural Gas
17	Install an energy efficient natural gas fueled Domestic Hot Water Heater or point-of-use water heaters.
18	Replace inefficient DX Air Conditioning units with an efficient Chilled Water System and replace the DX coils in Air Handlers and install chilled water coils. Also provide outside air to Ahs for economizing. Also, add VFD (see ECM 5) Project began in 2016, and is currently ongoing with target completion in Spring 2017.
19	Upgrade all outdated Fluorescent and Metal Halide interior lighting with LED, including; Library, Theater, Hallways, and Bathrooms

EAST CAMPUS RECOMMENDATIONS

15. When the East Campus was built, natural gas prices were higher than #2 fuel oil, so the boilers installed only burns #2 fuel oil. Today, and most likely in the future, natural gas will be more available, and more affordable. Natural Gas is currently being used on the West Campus for heating and hot water. Natural Gas has become the preferred fuel for reducing air emission and maintenance costs, and reducing our region's dependence on foreign oil and also reduces the negative impacts of climate change. There is a gas distribution line in the road in front of the East Campus and should be extended to the building. This also allows the school to reduce it use of expensive Propane.

16. The boilers in the East Campus should be replaced with high efficient, natural gas condensing boilers. If not, the existing boilers should be fitted with new duel fuel burners so facility management can choose the most economic fuel available.

17. The oil fired DHW systems should also be replaced with a high efficient natural gas unit. If a study reveals that the hot water use in the East Campus building is minimal, the current system could be replaced with instantaneous point-of-use water heaters.

18. Replace inefficient DX AC units with an efficient Chilled Water System. One of the major electric users on the East Campus at NCC during the summer months is air conditioning. The air conditioning is supplied by a number of inefficient and unreliable DX air cooled chiller systems. Consideration should be given to replace the system with a more efficient central chilled water system. Also, associated Air Handlers (AH) will also need to be rebuilt to accept the chilled water coils. Outside air should be supplied to the AH units to permit economizing.

19. There are some specific lighting retrofits in the East Campus that should be addressed, including; refixture the Library to remove 8 lamp T12 fixtures and 250 watt Halogen wall washers. Also add daylight dimmers in the walkway to the upper library/media area and zone library lighting and add occupancy sensors
| NCC | West Campus Recommendations |
|-------|---|
| ECM # | Recommended Measures |
| 20 | Upgrade BAS to monitor and control the temperature in all rooms and to manage night setback and shutdown during unoccupied times. In A and B wings, add electric controls on finned pipe radiation for individual room control. |
| 21 | Integrate controls for building exhaust fans into BAS to avoid problems with; negative pressure, inadequate makeup air, moisture control and excess run time on fans. |
| 22 | Install a small Condensing Boilers for summer HVAC terminal reheat in CIT and for DHW for A and H wings. |
| 23 | Install new Air Handler in the D wing. Completed in 2015 |
| 24 | Install occupancy sensors in all classrooms, offices, and conference rooms and large public gathering areas to control lighting during low occupancy |
| 25 | Install Daylight dimming controls in CIT Atrium as well as areas in the Academic wing that have plenty of natural lighting |
| 26 | Replace Metal Halide lighting in the CIT Atrium with dimmable LED lamps with a comparable lumen output. Collect to daylight harvesting and BAS for control |
| | Upgrade Air Conditioning in A & B Wing by either installing a centralizing AC system chilled water |
| 27 | system or consolidate the DX units and replace with a more efficient DX air cooled chiller. A-Wing |
| | is remodeled. |
| 28 | Install Exhaust Hood Sensors and New Ventilation Controls in the exhaust hoods in the Culinary Arts Area. |
| 29 | Convert natural gas pilot lights in the culinary and cafeteria kitchen cooking equipment to electronic pilots. |
| 30 | Upgrade Commercial Cooking Equipment to Energy Star level energy efficient equipment. |
| | |

20. The current building controls are cobbled together from systems and equipment that were installed over the past 50 years with some recent upgrades. Some of the equipment is controlled by integrated unitary controls; some through the original pneumatic system; and some with Direct Digital components interfacing directly with equipment. Upgrade the buildings BAS to monitor and control zone temperatures for all rooms and to manage night setback and shutdown during unoccupied times. This would include removing the existing pneumatic control system and replace it with a full DDC system. This new BAS should be connected to a campus-wide centralized BAS. In the West Campus A and B wings, new electric controls should be installed on finned pipe radiation for individual room monitoring and control.

21. Because of moisture problems in the building caused by negative pressure and lack of control on exhaust equipment; monitoring and controlling of rooftop exhaust fans. Time clock and calendar scheduling of control of the larger exhaust fan systems and monitoring total building static pressure and controlling make-up air units to ensure positive or neutral pressure (now at negative pressure) should be included in the BAS program. It is questionable if the current system is providing enough make-up air to offset air being exhausted from the building.

22. Currently, the large steam boilers must operate to supply DHW to the A & B Wings. It would be more efficient to install a small condensing boiler sized to meet the DHW needs for the A & B wing.

23. The air handler to service the D wing is in disrepair and has limited energy efficiency control features. It is recommended that a new air handler (AH) be installed in the D wing.

24. There are many areas of the West Campus could significantly reduce lighting load by turning off lighting or at least dimming the lighting to a minimal level in unoccupied areas. Occupancy sensors should be installed for better lighting control.

25. In the West Campus building, there are at least two areas that would benefit for Daylight Harvesting. Daylight harvesting would be very effective for dimming lighting in CIT Atrium as well as in the east side of the Academic Building when ample daylight is available.

26. In order to initiate daylight harvesting strategies and to improve the overall efficiency of the CIT Atrium, the primary lighting source should be upgraded from 250 watt Halogen lamps to a comparable lumen output, dimmable LED fixture.

27. Upgrade Air Conditioning in B Wing by centralizing the AC system and utilize a chilled water chiller and air handlers with economizer and heat recovery capabilities. At minimum, consolidate the small inefficient DX units and replace them with a more efficient DX air cooled chiller. Replace existing 7 Ductless Split Units and 4 AC Roof Top Units

28. The current exhaust hood controls in the cafeteria and culinary teaching area kitchens are inefficient compared to control systems available today. First, they lack fan motor speed controls. New technology would save significant energy because they would idle fans when operating in non-cooking conditions and vary the fan speed based on the temperature and amount of particulates in the exhaust during partial cooking conditions. This would reduce the energy used by the fan motor up to 90% as well as reduce the need to heat or cool make-up air to replace exhausted conditioned air saving up to 50% of losses from excess exhausting. In addition, a system for providing make-up air to replace the conditioned air being exhausted should be redesigned. CL&P supports a retrofit program with incentives up to 50% to replace Kitchen exhaust fans and their controls through the CT Energy Efficiency program. Examples of Intelli-hood technology, CL&P's preferred contractor.

29. Existing natural gas equipment is currently operating with constant, uncontrolled pilot lights. You can reduce natural gas use significantly by replacing the pilot lights with electronic igniting equipment. There was some cooking equipment where pilots were on even though the equipment will not be used all summer. The Department of Energy reports that each commercial pilot consumes approximately .5 cubic foot of natural gas per hour or over 4,000 cubic feet per year.

30. Commercial cooking is one of the most energy intensive process operations at the school. Some of the cooking equipment could be cost effectively replaced with more energy efficiency modern natural gas and electric equipment. Energy Star estimates the new equipment now on the market is approximately 35% more energy efficiency than your aging kitchen equipment.

APPENDIX B: NORWALK DATA METHODOLOGY, ASSUMPTIONS AND NOTES

The following are the data methodology and assumptions that were used when analyzing and benchmarking data for Norwalk:

All three fiscal years have complete consumption data. There is no information to indicate that the campus uses propane, purchased chilled water or steam.

Electricity: Provided by Campus (FY13,14,15), Eversource Customer Engagement Platform

• The electric consumption of the west campus parking lot has been excluded from the EUI calculation.

Natural Gas: Provided by Campus (FY13,14,15)

• The West Campus had its own natural gas account in FY 14, as the East Campus did not obtain a natural gas service until 2015.

Diesel: Provided by Campus (FY13,14,15)

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QUINEBAUG VALLEY COMMUNITY COLLEGE

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EXECUTIVE SUMMARY

The Quinebaug Valley Community College (Quinebaug) Energy Master Plan aims to identify ways Quinebaug can improve energy use on campus, and be an active participant in Connecticut State Colleges & Universities (CSCU)'s energy management, reduction and conservation efforts. The utility data received indicates Quinebaug is a medium to high performing campus of CSCU from an energy perspective (see Figure 1 Quinebaug Energy Dashboard). The energy use intensity (EUI) method is used for benchmarking and comparison purposes. Energy management efforts in the past have reduced Quinebaug's energy use, through efforts such as lighting retrofits, insulation upgrades, and boiler controls.



Note: The Willimantic Center is not included as it is a leased space, and solar PV generation at the Middle College is not factored.

Energy Spend

Table 1 provides a comparison of energy spending comparing to the average of CSCU campuses and the Northeast Region Commercial Sector.

	Quinebaug Valley Community College	Average of CSCU Community College	Average of CSCU University	Northeast Region Commercial Sector
Cost per Square Feet	\$ 1.85	\$ 2.49	\$ 2.08	\$ 1.67 [1]
Cost per Fall 2013 FTE Student	\$ 242	\$ 311	\$ 677	\$ -
Avg. Cost per kWh Electricity from Grid	\$ 0.13	\$ 0.14	\$ 0.14	\$ 0.15 [2]
Avg. Cost per MMBtu Natural Gas	\$ 12.96	\$ 10.06	\$ 7.32	\$ 10.03 [3]
Total Operating Expenses	\$ 18,052,000	\$ -	\$ -	
Total Energy Spending	\$ 292,756	\$ -	\$ -	
% of Operating Expenses	1.62%	1.95%	2.67%	

TABLE 1: Energy Cost Comparison (FY 2014)

While Quinebaug's average natural gas unit cost is higher than the other CSCU campuses, Quinebaug has both a lower cost per square foot and cost per FTE student than the average of the community colleges.

Utility Incentives/ Develop Plan for Energy Efficiency Measures (EEMs)

Both of Quinebaug's utilities are through Eversource. This places the campus in a prime position to maximize incentives by combining multiple energy saving opportunities in what is known as a "Comprehensive Project."

Since incentives are based on incremental energy savings, further analysis and collaboration with Eversource is required to determine rebate amounts for each opportunity. Table 2 demonstrates a summary of the EEMs recommended for Quinebaug to pursue.

Energy \$/sf in the Northeast region from CBECS 2012 report; education building type - http://www.eia.gov/consumption/commercial/data/2012/c&e/cfm/c6.cfm
Electricity \$/kWh in the Northeast region from EIA Electric Power Monthly June 2014 - http://www.eia.gov/electricity/monthly/current_year/june2014.pdf
Natural gas \$/MMBtu in the Northeast region from EIA Connecticut Price of Natural Gas - http://www.eia.gov/dnav/ng/hist/n3020ct3m.htm



Opportunity ID	Energy Conservation or Efficiency Opportunity	App. Cost (Before Rebate)	Payback w/rebate (Years)	Priority
QVCC-1	Investigate roof-top solar PV opportunities, specifically with new construction or roof renovations, and/or ground mounted arrays through PPA.	PPA	PPA	1
QVCC-2	Open triple-duty valves at pump discharge 100% when using VFDs	None	Instantaneo us	1
QVCC-3	Implement fume hood sash management as a part of a fume hood sash management campaign, add proximity sensors and lower flow rates per through Eversource's Green Labs initiative.	Varies	Varies	1
QVCC-4	Optimize LED lighting upgrades and controls to rely on photo sensors rather than timers in some locations such as gym where schedules are inconsistent.	\$1 / sf	2 - 6[1]	1
QVCC-5	Integration of classroom scheduling with the BMS by using a software package, such as Emergingsoft's SmartScheduler to reduce energy costs by creating a bridge between common scheduling software and the BMS.	Varies	Varies	1
QVCC-6	Migrate manual building controls to automatic, potentially using Continuous Commissioning (CCx) software for analytics.	Varies		2
QVCC-7	Ensure commissioning is performed by a certified professional, such as a C.B.C.P. by the Association of Energy Engineers, and follows through per ASHRAE Standard 0.	\$0.5 - 3 / GSF, or up to 3% of the installed equipment cost	Varies	2
QVCC-8	Use natural gas infrared heaters with infrared thermostats in maintenance shops and garages	Varies	3 - 6	3
QVCC-9	Install energy-efficient transformers. Use an infrared camera to identify high-heat-loss transformers, typically those 15 years old or greater.	Varies	Varies	3

TABLE 2: Quinebaug Energy Efficiency Measures

In addition to the priority projects, next steps for Quinebaug are below:

Next Step

Management

Quinebaug should consider programming BMS to operate automatically rather than requiring manual interaction. A priority is also documentation of system set points for building comfort and optimization of condensing boiler operation. For continuity across the system, and continued benchmarking, Quinebaug should also track their energy using a CSCU template, and compare energy spend against available budgets.

Fume Hoods

Implement a fume hood sash management program to ensure hoods are closed and turned off when not in use.

Renewable Energy

While Quinebaug already has solar PV on campus, Quinebaug should consider pursuing power purchase agreements (PPAs) for portions of the building roof, parking canopies, and possibly ground-mount opportunities.

With consideration and implementation of the suggested energy improvements, Quinebaug will be able to further elevate their energy management best practices and reduce energy costs and energy consumption.

[1] The 2-6 year range assumes the campus combines projects with another energy efficiency project as a comprehensive project.

INTRODUCTION

As part of the Connecticut State Colleges & Universities (CSCU) Energy Master Plan, Quinebaug Community College (Quinebaug)'s building infrastructure, energy use and energy management practices were assessed. The ultimate goal was to determine ways Quinebaug could improve its energy use on campus, and be an active participant in CSCU energy reduction efforts. This chapter identifies Quinebaug's historical energy use, future projected needs and energy recommendations.

1.1 QUINEBAUG OVERVIEW

Quinebaug is a two-year community college located in Danielson, Connecticut. The campus consists of a two-story structure with three wings (East, North, and West) and a central core. The original 65,470-square foot building was constructed in 1983. Since 1983, there have been multiple expansions to the building. Most recently, a 42,000-square foot expansion of the main building was completed in early 2014 to support the Quinebaug Valley Middle College High School, an inter-district magnet high school housed on the Quinebaug campus. The main building layout includes:

 East Wing – Houses classrooms, laboratory classrooms for science, computer, and medical assisting lab classes, faculty offices, Dean of Academic Affairs and Student Services' office, and the IT department.

- North Wing Houses art department classrooms and studio space.
- West Wing Consists of the atrium, Spirol Art Gallery, bookstore, marketing department, classrooms, the physics lab, the President's office, institutional advancement, institutional research, and a community reading room. This wing was a 30,000-square foot addition that opened for the fall 2006 semester.
- Central Core Contains the following: the auditorium, corporate seminar room, cafeteria, fireside lounge, student success center, student affairs office, facilities department, light manufacturing lab, library, learning center, Dean of Administrative Services' office, business office, and human resources office.

In addition to the main building, Quinebaug has a maintenance garage and storage building and a daycare center building on its grounds. During the development of this report, Quinebaug's main building renovation (completed in fall 2016) was under construction and features a new 11,000-gsf Manufacturing Center. Table 1.1 provides a summary of the Quinebaug's buildings, excluding their two leased Willimantic Center and STRIDE buildings.

Building	Year Built [Renovated]	Gross Square Feet	Building Function)RTU
Main Building	1983 [2006/2014]	138,658	Mixed Use	NI
Maintenance Building	1994	3,024	Facilities	TE
Steppingstones Daycare	1973	1,600	Other	
Total		143.282		

TABLE 1.1: Quinebaug Campus Building Information



FIGURE 1.1: Quinebaug First Floor Plan



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SYSTEM LEVE

1.2 PREVIOUS ENERGY STUDIES & PROJECTS

In 2013, Quinebaug became a signatory of the American Colleges and Universities Climate Change Commitment, now known as the Second Nature Climate Leadership Commitment. The climate action plan outlines their past efforts as well as provides goals to implement additional energy saving projects, and to curb their greenhouse gas emissions. The campus has also done individual studies, such as a 2005 Fuss and O'Neal Energy Audit, and investigation into optimization of their Energy Management System (EMS) in 2009. From the 2009 study it was determined that the EMS could be altered to better meet heating and cooling loads which reduced their natural gas use by over 60%. Additionally, between 2009 and 2011, energy efforts were estimated to have saved the campus \$200,000.

A sample of their multitude of energy initiatives are as follows:

- Building Management Systems (BMS) upgrades, for more controls over equipment shut downs. Many BMS energy best practices are used at the campus including, adjusting boiler set point temperature to optimize efficiency, adjusting AHU setbacks to optimize economizing, and frequent interaction with BMS system.
- Closing and opening of window shades to help regulate temperatures during cooling and warmer periods.
- LEDs at the Middle College
- Upgrades of Seasons Four Air handling units (AHUs) with more efficient AAON models in 2015
- Middle College 1 MMBTU boilers are on outdoor temperature reset
- All pumps are on variable frequency drives (VFDs)
- Replacement of old boilers with more efficient condensing boilers
- Efforts to study utility rates to the campus' advantage.
- Automatic power factor correction with a Myron Zucker Power Correction Cabinet, estimated to save approximately \$10,000 a year
- Energy Management Control System (EMCS) programming and addition of remote access to EMS.

EXISTING CONDITIONS & RECOMMENDATIONS

Information on Quinebaug's existing conditions was captured from campus interviews, energy data and reports provided by the campus. A holistic view of existing practices, material on energy management, energy infrastructure and project implementation processes was reviewed. Analysis of the data and campus walkthroughs helped clarify recommendations with the goal of decreasing energy use, documented after each subheading.

2.1 FACILITY ENERGY BENCHMARKING AND ENERGY CONSUMPTION

A summary of Quinebaug's energy use is shown in the energy dashboard, based on fiscal year 2014 and 2015 data. Appendix A documents information on the assumptions and data sources used for energy benchmarking purposes. Quinebaug has the fourth smallest site Energy Use Intensity (EUI) of the CSCU community colleges. Quinebaug's site EUI of 77 kbtu/sf is also approximately 25% less than the Northeast median site EUI for colleges/universities.



FY 2014

FIGURE 2.1: Quinebaug Valley Community College Energy Dashboard

Note: The Willimantic Center is not included as it is a leased space, and solar PV generation at the Middle College is not factored.

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FY 2015



01 INTRODUCTION Some contributors to Quinebaug's overall low energy use include:

- Dedicated efforts of HVAC staff passionate about operating campus building systems to maximize energy savings
- Effective Use of BMS with HVAC economizers and scheduling
- Newer, highly efficient HVAC equipment
- Upgraded motors and VFDs
- Solar PV (reduces Source EUI)

2.3 ENERGY PROCUREMENT

Quinebaug is part of the CSCU's 2013 electric supply procurement contract with Direct Energy (formerly Hess Energy), detailed further in the Energy Master Plan. The campus' meters are on rate 30 and rate 10. By understanding their building loads and the corresponding utility rates, the campus was able to optimize costs*. The campus also procured 14.2 kW of solar panels for the campus amounting to a 19 ton reduction in carbon dioxide annually.

	Quinebaug Valley	Average of CSCU	Average of CSCU	Northeast Region
	Community College	Community College	University	Commercial Sector
Cost per Square Feet	\$ 1.85	\$ 2.49	\$ 2.08	\$ 1.67 [1]
Cost per Fall 2013 FTE Student	\$ 242	\$ 311	\$ 677	\$ -
Avg. Cost per kWh Electricity from Grid	\$ 0.13	\$ 0.14	\$ 0.14	\$ 0.15 [2]
Avg. Cost per MMBtu Natural Gas	\$ 12.96	\$ 10.06	\$ 7.32	\$ 10.03 [3]
Total Operating Expenses	\$ 18,052,000	\$ -	\$ -	
Total Energy Spending	\$ 292,756	\$ -	\$ -	
% of Operating Expenses	1.62%	1.95%	2.67%	

TABLE 2.1: Energy Cost Comparison (FY 2014)

Energy \$/sf in the Northeast region from CBECS 2012 report; education building type - http://www.eia.gov/consumption/commercial/data/2012/c&e/cfm/c6.cfm
Electricity \$/kWh in the Northeast region from EIA Electric Power Monthly June 2014 - http://www.eia.gov/electricity/monthly/current_year/june2014.pdf
Natural gas \$/MMBtu in the Northeast region from EIA Connecticut Price of Natural Gas - http://www.eia.gov/dnav/ng/hist/n3020ct3m.htm

Table 2.1 provides a comparison of FY 2014 energy spending compared to the average of CSCU campuses and the Northeast Region Commercial Sector.

Quinebaug's natural gas unit cost is higher compared to the average of the CSCU community colleges. Based on provided data, the campus paid a unit price of \$19.11 in FY14. In FY15, the campus was credited \$31,000 in March lowering the FY14 cost to \$12.96. Based on this pricing, the campus has a lower cost per square foot and FTE student than the average CSCU community college.

2.2 CAMPUS UTILITIES AND DISTRIBUTION

As shown in Figure 2.1b, the campus has similar electricity and natural gas use on an MMBTU basis. The following is a list of Quinebaug's utility providers:

- Electric: Eversource, formerly Connecticut Light & Power
- Natural Gas: Eversource, formerly Yankee Gas

The campus has two meters for electricity, one for their 729 Main Street Willimantic Center, and the other for the main campus.

2.4 OPERATIONAL AND ENERGY MANAGEMENT PRACTICES

2.4.1 CURRENT CONDITIONS

Upkeep of infrastructure and utility operations is the responsibility of Quinebaug's Maintenance Department, which consists of a Building Maintenance Supervisor, four technicians, and four custodians. The maintenance department also uses a variety of third-party vendors to provide a variety of facilities services.

ENERGY USE INFORMATION MANAGEMENT SYSTEMS

Although not designated an Energy Manager, the current operator has tracked energy usage in the past with the BMS and is actively engaged in optimizing energy efficiency. The BMS and operator understanding both play large roles in operating the energy systems efficiently. Quinebaug uses Schneider Electric's Andover Continuum system, which allows remote access over the internet. The building Maintenance Supervisor utilizes many BMS best practices. The campus best practices include occupancy monitoring and proper scheduling of building systems through the BMS.

According to stakeholders, other best practices include:

- Schedule AHU's to run only when areas are occupied.
- Use outside air to temper space as much as possible.
- Monitor boiler output and adjust to what is necessary to ٠ maintain heat loads

- Schedule lighting to shut off when areas are unoccupied
- Use the BMS system as a tool to monitor, adjust and maintain building utilities the remote access
- Interior and exterior lighting are manually programed based on the class schedules and operating hours.

Quinebaug also uses an energy management system for monitoring energy consumption. Currently, most of the BMS's functions are operated manually and require frequent interaction from the operator to run optimally. While the current dedicated staff are doing exemplary work and successfully reducing energy by manually managing the BMS functions, it is a concern that this is not a long-term model. It is an individual-centric system that is likely not sustainable with an unexpected change in staffing.



FIGURE 2.2: Energy Management System

2.4.2 RECOMMENDATIONS

Documenting system set points, such as outdoor temperature reset to enable condensing boiler operation and building comfort, should be a priority. While Quinebaug's HVAC staff have made tremendous efforts in optimizing existing systems through many manual as well as automated efforts, it is important to create a longer-term sustainable solution. Staff should use the full automated capabilities of the BMS and fine tune the programming of the system to meet their needs. Using the system automatically rather than manually could reduce the effort required from the operator and allow others to stand-in when needed. It is recommended that the campus continuously migrate manual building controls to automatic controls. Integration of classroom scheduling with the BMSs by using a software package, such as Emergingsoft's SmartScheduler, can greatly reduce energy costs by creating a bridge between common scheduling software and BMSs. Other packages can also monitor detailed energy usage.

As part of the CSCU Energy Master Plan, it is recommended that CSCU create a template for energy tracking applicable to all campuses. Quinebaug should continue to track energy usage through such a template, as well as compare energy spend against available budgets.

2.5 EXISTING BUILDING COMMISSIONING

2.5.1 CURRENT CONDITIONS

Qiunebaug recently commissioned five new air handling units, which were installed last year. Any renovation project of \$2M or greater requires a commissioning authority to oversee the commissioning.

2.5.2 RECOMMENDATIONS

Buildings with BMS systems with measurable points stand to benefit the most from recommissioning. Rooftop package HVAC units (RTUs) can usually benefit by having control loops, such as to enable economizer modes automatically, tuned periodically. As a general rule of thumb:

SYSTEM LEVEL RECOMMENDATIONS

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Recommission existing building systems every 3-5 years.

Often, building systems are commissioned to just get the building working, not optimized for reducing energy costs. Ensure a Certified Building Commissioning Professional, such as one recognized by the Association of Energy Engineers (AEE) is selected to perform the commissioning on any existing, or new building systems.

2.6 MECHANICAL SYSTEMS

2.6.1 CURRENT CONDITIONS

Quinebaug has extremely efficient heating and cooling equipment and appears to be operating the equipment near peak efficiency.

Less efficient, approximately 83%, Cleaver Brooks fire tube boilers were replaced with over 90% efficient condensing Camus DynaForce 3000 boilers. A pair of Aerco Benchmark 1000 boilers are also used for the Middle College. Outlet temperatures were observed to be below 130°F, which is an indication the boilers were enabling condensing and achieving higher than traditional boiler efficiencies. Outdoor temperature reset is used to only heat the water as high as needed, without overheating.



SYSTEN LEVEL EXISTING CONDITIONS

SYSTEM LEVEL ENERGY NEEDS



FIGURE 2.3: Lochinvar Knight boiler with storage tank

Domestic hot water is heated through highly efficient condensing Lochinvar Knight boiler with storage tank.

Nearly all pumps and HVAC system fan motors have variable frequency drives (VFDs) which also help to reduce operating costs.

\$3-4 million in HVAC system upgrades replaced the aging, nearly 30-year-old, original equipment. Efforts are made to maximize use of economizer modes to save energy.

Fume hoods were observed to have varying degrees of use. Some sashes were properly closed, while others were half opened and unused. In some cases, fume hoods were observed to be used for paperwork or storage for faculty.



FIGURE 2.4: Fume Hoods

2.6.2 RECOMMENDATIONS

The following lists are recommendations by system type that would aid in optimizing efficiency, and reducing energy.

BOILER SYSTEM

 Continue to operate condensing boilers at 130°F or below. Decreasing hot water return temperature to 120°F or below, when possible, will help maximize condensing in condensing boilers.

FUME HOODS

 Implement a fume hood sash management program to ensure that hoods are closed and turned off when not in use. Educate users to focus on use with a culture centered around energy efficiency as well as safety.

2.7 LIGHTING

2.7.1 CURRENT CONDITIONS

Quinebaug lighting is a mixture of upgraded lighting and T8s. The Middle College is equipped with LEDs, while the main building still has pull start fixtures. The campus is currently pursuing lighting upgrades for their library and café.

2.7.2 RECOMMENDATIONS

All lighting upgrades should be coordinated with Eversource to help maximize the return on investment. The campus should consider the following recommendations:

- LED lighting upgrades and controls could be optimized to rely on photo or occupancy sensors rather than timers in some locations, especially the Middle College where schedules are different.
- Continue to conduct lighting and controls audits.
- All exterior lighting should be replaced with LED and have photo sensors installed to replace timers.

2.8 BUILDING ENVELOPE

2.8.1 CURRENT CONDITIONS

The two-story buildings are mostly of concrete masonry units (CMU) and brick with some curtain walls and other construction for the Middle College. Windows are tinted and a structural overhang helps prevent direct sunlight from entering the highest points in the day. There were no obvious building envelope deficiencies to the main buildings. Otherwise, the maintenance garages appeared to have no insulation and are CMU construction.

02 SYSTEN LEVEL EXISTING CONDITIONS

SYSTEM LEVEL

2.8.2 RECOMMENDATIONS

There are discussions around replacing the maintenance buildings in the near future, but no plans are yet in place. Insulation in combination with using infrared heaters are recommended as they both typically have a payback of less than five years.

2.9 DISTRICT ENERGY / COGENERATION

2.9.1 CURRENT CONDITIONS

There is no district energy or cogeneration at Quinebaug.

2.9.2 RECOMMENDATIONS

Since there is limited use for summer thermal from CHP, a CHP application is unlikely to provide additional benefit over the existing boilers.

2.10 RENEWABLE ENERGY

2.10.1 CURRENT CONDITIONS

Quinebaug's Middle College High School, on the eastern portion of the campus, currently has a small solar PV, but there may be opportunities for a larger system on the roof.

The current system is estimated to be approximately 14.2 kW for a generation near 18,000 kWh annually with an annual energy value near \$1,500. Quinebaug is also in the process of a solar PPA RFP which has yet to be released.

Quinebaug also has plans for installation of a 55-ton geothermal system with the addition of a new Advanced Manufacturing Technology Center, described further in the Energy Needs section.

2.10.2 RECOMMENDATIONS

Quinebaug's campus space is highly utilized, whether by parking lots, athletic fields, or the designated area for the new Advanced Technology. However, there some opportunities for small rooftop arrays, ground-mount and solar canopies. The main building's roof is south facing and has spaces clear of obstructions, providing an opportunity for solar (Figure 2.5). On the southern portion of the campus, there is land area availability for groundmount, and otherwise the campus is comprised mostly of parking lots. Clearing of trees would provide additional ground-mount opportunity around the perimeter of the campus.

Table 2.2 provides an overview of the buildings that may be considered for solar PV in the future.

Building Name	Year Built	GSF [FY 2015]	Building Roof sq. ft.	Roof Install/ Replacement Date	Roof Type	Array Size Potential (kW DC)[1]	Annual Generation Potential (MWh)[2]	Solar Suitability Comments
				HIGH PRIORITY	PROJECTS			
Southern Campus Land Area						310-404	404-519	Ground-mount
Main Building	1983 [2006/2014]	138,658	19,395			89-116	116-149	Assumed 100% availability based on area
Subtotal		138,658	19,395			399-520	520-668	

TABLE 2.2: Quinebaug Potential Areas for Solar PV

Assumes that each sf of panels can generate between 4.6 and 6 Watts DC (about a third of the PVWatt Output Assumptions). Actual generation values would be calculated if a solar PV study was performed.
Assumes that each sf of panels can generate between 6 and 7.7 kWh annually (about a third of the PVWatt Output Assumptions). Actual generation values would be calculated if a solar PV study was performed.





FIGURE 2.5: Quinebaug Campus PV Potential

2.11 CAPITAL PLANNING

2.11.1 CURRENT CONDITIONS

Several infrastructure renovations and improvements have taken place at Quinebaug over the past ten years. Projects include energy conservation improvements, HVAC system upgrades, the addition of their energy management control system, lighting retrofits, insulation upgrades, and a new fire protection system. The campus' fifth Strategic Plan goal incorporates the campus' capital planning motivation. The goal is to periodically review the campus master plan with a focus on "environmental sustainability and inclusion of green technologies." Quinebaug is also conscious of opportunities to achieve LEED certification or equivalent when completing projects. The state also requires capital projects over \$5 million to meet LEED silver, or equivalent and the most up to date building standards.

To accomplish its energy infrastructure goals, Quinebaug relies on financing and funding from the System Office and the State. The System Office provides annual code compliance and infrastructure funds. Larger capital projects are also funded under CSCU 2020, as of FY 2015. The State Legislature allocates bonds for campus improvement projects, such as Quinebaug's Phase 1 Master Plan. The campus has also been supported in the past by Eversource for HVAC upgrades.

More information on campus expansion projects is found in Section 3.1

2.11.2 RECOMMENDATIONS

It is recommended for Quinebaug to continue to collaborate with Eversource for all major building renovations, mechanical, electrical and plumbing equipment upgrades, and all new construction, as well as to continue to pursue the campus' strategic plans.

2.12 COLLABORATION / PARTNERSHIP

2.12.1 CURRENT CONDITIONS

Quinebaug's facility department apprises the Dean of Administration on their improvements and projects. The department has also worked with Eversource, and will continue to collaborate with Eversource on a LED replacement project. This partnership will aid the campus in lowering upfront costs through utility incentives. Additionally, the System Office Facilities Department is available to provide assistance in budgeting, capital planning and technical support for the community college projects, including Quinebaug.

2.12.2 RECOMMENDATIONS

It is suggested for Quinebaug to continue work with Eversource to take advantage of Utility Incentives for the EEMs presented in this plan. Incentives structures range and vary by program, but Eversource has offered incentives of up to 80% of project costs in the past.

02 SYSTEN LEVEL EXISTING CONDITIONS

03 System Level Energy Needs

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2.13 SUMMARY OF RECOMMENDED ENERGY EFFICIENCY OPPORTUNITIES

As a result of the campus walk through energy assessment, and interviews with campus staff, a list of potential Energy Efficiency Measures (EEMs) is presented in Table 2.3. These projects represent both low cost, immediate action measures, as well as projects that may require larger capital and therefore be longer-term.

Many energy-related projects are incentivized through utility rebates. Both of Quinebaug's utilities are through Eversource. This places the campus in a prime position to maximize incentives by combining multiple energy saving opportunities in what is known as a "Comprehensive Project." The primary advantage of a Comprehensive Project is the maximum incentive cap is normally raised from 40% to 50%. Eversource has maximized these incentives in the past, and may also in the future, in the following ways:

- The comprehensive cost cap was increased from 50% to 80% of total cost.
- The incentive was increased from \$0.30/kwh or \$3.50/CCF (with 40% cost cap) to \$0.40/kwh or \$4.00/CCF (with 60% cost cap).

Since incentives are based on incremental energy savings; further analysis and collaboration with Eversource will be required to determine rebate amounts for each opportunity. To help Quinebaug navigate and prioritize the energy opportunities identified, a summary of opportunities is listed in Table 2.3. Immediate action should be taken to consider priority one and two opportunities with the goal of combining multiple opportunities for a Comprehensive Project. The simple payback in most cases cannot be reasonably estimated without detailed building models and/or more operating data. The payback periods provided are based upon the performance of past similar projects and are not necessarily indicative of future results.

Opportunity ID	Energy Conservation or Efficiency Opportunity	App. Cost (Before Rebate)	Payback w/rebate (Years)	Priority
QVCC-1	Investigate roof-top solar PV opportunities, specifically with new construction or roof renovations, and/or ground mounted arrays through PPA.	PPA	PPA	1
QVCC-2	Open triple-duty valves at pump discharge 100% when using VFDs	None	Instantaneo us	1
QVCC-3	Implement fume hood sash management as a part of a fume hood sash management campaign, add proximity sensors and lower flow rates per through Eversource's Green Labs initiative.	Varies	Varies	1
QVCC-4	Optimize LED lighting upgrades and controls to rely on photo sensors rather than timers in some locations such as gym where schedules are inconsistent.	\$1 / sf	2 - 6[1]	1
QVCC-5	Integration of classroom scheduling with the BMS by using a software package, such as Emergingsoft's SmartScheduler to reduce energy costs by creating a bridge between common scheduling software and the BMS.	Varies	Varies	1
QVCC-6	Migrate manual building controls to automatic, potentially using Continuous Commissioning (CCx) software for analytics.	Varies		2
QVCC-7	Ensure commissioning is performed by a certified professional, such as a C.B.C.P. by the Association of Energy Engineers, and follows through per ASHRAE Standard 0.	\$0.5 - 3 / GSF, or up to 3% of the installed equipment cost	Varies	2
QVCC-8	Use natural gas infrared heaters with infrared thermostats in maintenance shops and garages	Varies	3 - 6	3
QVCC-9	Install energy-efficient transformers. Use an infrared camera to identify high-heat-loss transformers, typically those 15 years old or greater.	Varies	Varies	3
TABLE 2.3: Quinebaug	Energy Efficiency Measures			

[1] The 2-6 year range assumes the campus combines projects with another energy efficiency project as a comprehensive project.



ENERGY NEEDS

3.1 FUTURE DEVELOPMENT

Energy use has the potential to change depending on campus renovation and improvements. Expansion at Quinebaug includes an 11,000 GSF Advanced Manufacturing Technology Center. The building is likely to be more energy intensive due to manufacturing equipment, however; some energy use could be mitigated by Quinebaug's plans for a 55-ton geothermal system. The project will be completed in 2016 along with commissioning.

With expansion of systems and facilities, it is important to ensure energy reliability. Quinebaug possesses one generator in case of power outages to provide power key systems on the campus. The campus does not have full emergency generator back-up for the entire campus, but it is suggested for the campus to explore generator expansion capabilities.

3.2 ENERGY RESILIENCY RECOMMENDATIONS

Quinebaug partook in the CSCU system-wide hazard mitigation initiative. The CSCU Multi-Hazard Mitigation Plan provided recommendations surrounding energy resiliency that are also applicable for the Energy Master Plan. The list below presents the recommendations from the hazard mitigation plan for improving the energy reliability and resiliency of the campus.

- Expand the existing emergency/stand-by generator to provide sufficient power for emergencies.
- Upgrade existing flat roofing systems
- Improve building envelope
- Bury power lines to provide uninterrupted power after severe winds

01 INTRODUCTION

CONCLUSION / NEXT STEPS

Quinebaug's focus on energy management and scheduling has saved the campus substantially on energy use and associated costs in the past. There are still opportunities to fine tune energy management with automation of previous manual programming. Priority initiatives include:

- Management: Quinebaug should continue to review energy use, including tracking energy use and comparing energy spend to available budgets. The campus may also consider implementing a fume hood sash program.
- *Renewable Energy:* Explore PPAs for a ground mounted array, a parking canopy, and on portions of the building roof.
- Utility Incentives/ Develop Plan for EEMs: Quinebaug should maximize incentive funding for EEMs by working with Eversource, and combining multiple energy saving opportunities in what is known as a "Comprehensive Project." Further analysis and collaboration with Eversource is required to determine rebate amounts for each opportunity

A summary of further projects and priorities for the campus are listed in Table 2.3. Quinebaug has the fourth lowest site EUI among the community colleges and with additional efforts documented in the master plan can continue to lower their energy footprint and support campus CAP and CSCU Energy Master Plan goals.

4.1 CONTACT INFORMATION FOR KEY STAKEHOLDERS

Collecting all the necessary information for this planning effort required a collaborative effort. Below are the stakeholders that were active in providing their expertise about campus current conditions and future needs, and energy related decisions.

QUINEBAUG VALLEY COMMUNITY COLLEGE

MARTIN CHARETTE

Building Maintenance Supervisor mcharette@qvcc.commet.edu 860-932-4157

EVERSOURCE

JAMES WILLIAMSON

Energy Efficiency Consultant *james.williamson@eversource.com* 860-665-2283

04 FINANCING/FUNDING OPPORTUNITIES

05 SYSTEM LEVEL RECOMMENDATIONS

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APPENDIX A: QUINEBAUG VALLEY DATA METHODOLOGY, ASSUMPTIONS AND NOTES

The following are the data methodology and assumptions that were used when analyzing and benchmarking data for Quinebaug:

All three fiscal years have complete consumption data. No information to indicate that the campus uses propane, fuel oil, purchased chilled water or steam.

Electricity: Quinebaug Utility Bill Summaries (FY13,14,15)

Natural Gas: Quinebaug Utility Bill Summaries(FY13,14,15)

FY 14 Natural gas costs presented in this chapter reflect a credit that was provided to the campus in FY 15. This is transferred to the \$/FTE and \$/GSF calculations as well.

However, in Chapter 1-5 of the Energy Master Plan, the total cost, \$/FTE and \$/GSF included for the campus factor the actual costs that campus spent in FY14 (not including the credit).

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FIGURE 1: THREE RIVERS COMMUNITY COLLEGE ENERGY DASHBOARD

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EXECUTIVE SUMMARY

The Three Rivers Community College (Three Rivers) Energy Master Plan aims to identify ways Three Rivers can improve energy use on campus, and be an active participant in Connecticut State Colleges & Universities (CSCU)'s energy management, reduction and conservation efforts. The utility data received indicates Three Rivers is a medium performing campus of the CSCU from an energy perspective (see Figure 1 Three Rivers Energy Dashboard). The energy use intensity (EUI) method is used for benchmarking and comparison purposes. Energy management efforts in the past have reduced Three Rivers' energy use, through effective use of the building management system (BMS), variable air volume (VAV) air handling units (AHUs), and central heating/cooling plant.



FIGURE 1: Three Rivers Community College Energy Dashboard

01 INTRODUCTION

02 SYSTEN LEVEL EXISTING CONDITIONS

03 SYSTEM LEVEL ENERGY NEEDS

Improvements implemented after FY 2014 that are expected to further reduce Three Rivers' energy use include:

- Cascaded condensing natural gas boilers
- New windows
- LED exterior lighting

Energy Spend

Table 1 provides a summary of energy spending comparing to the average of CSCU campuses and the Northeast Region Commercial Sector.

	T	hree Rivers Community College	Average of CSCU Community College	Average of CSCU University	No Con	ortheast Region nmercial Sector
Cost per Square Feet	\$	2.50	\$ 2.49	\$ 2.08	\$	1.67
Cost per FTE Student	\$	268	\$ 311	\$ 677	\$	-
Avg. Cost per kWh Electricity from Grid	\$	0.13	\$ 0.14	\$ 0.14	\$	0.15
Avg. Cost per MMBtu Natural Gas	\$	12.83	\$ 10.06	\$ 7.32	\$	10.03
Total Operating Expenses	\$	39,444,000	\$ -	\$ -		
Total Energy Spending	\$	736,721	\$ -	\$ -		
% of Operating Expenses		1.87%	1.95%	2.67%		

TABLE 1: Energy Cost Comparison (FY 2014)

Utility Incentives/ Develop Plan for Energy Efficiency Measures (EEMs)

Table 2 demonstrates a summary of the EEMs recommended for Three Rivers to pursue. Three Rivers should continue to collaborate with its utility provider Norwich Public Utilities to capture rebates and incentives for improving their energy use.

Opportunity ID	Energy Conservation or Efficiency Opportunity	App. Cost (Before Rebate)	Payback w/rebate (Years)	Priority	0 11
TRCC-1	Review Phoenix Controls settings for laboratory fume hoods so that fans do not run when unnecessary (recommission)	Minimal	Instantaneous	1) PPORTL
TRCC-2	Implement a fume hood sash management program to ensure that hoods are closed and turned off when not in use. Also conduct an audit to possibly lower the sash face velocity and in turn lower the volume of air unnecessarily removed from the building.	Varies	Varies	1	NG/FUNDING JNITIES
TRCC-3	Explore rooftop and parking canopy solar PPAs.	PPA	PPA	1	
TRCC-4	Open triple-duty valve 100% when using VFDs.	None	Instantaneous	1	SYS ⁻ REC
TRCC-5	Install all new LED interior lighting per scope developed with the utility.	Varies	2 - 6	1	omme
TRCC-6	Recommission each building/wing HVAC system every 3-5 years to ensure building is functioning properly and efficiently. HVAC systems may not have been properly commissioned through testing and balancing (TAB), in which case retrocommission as soon as possible.	\$0.5 - \$3 per S.F.	Varies	1	EVEL
TRCC-7	Complete on-site training for web-based BMS with operators.	Staff time	Varies	1	
TRCC-8	Adding CO2 sensors for demand control ventilation (DCV) are recommended to improve air quality while not over ventilating.	\$250 / Sensor+ Integration	Varies	2	CAMP PLAN
TRCC-9	Install additional thermostat or adjust controls to reduce heating and cooling in the clock tower.	\$300	Varies	2	S S S
TRCC-10	Explore continuous commissioning software package to monitor points until dedicated staff can be provided.	\$40,000 per year	Varies	2	

TABLE 2: Three Rivers Energy Efficiency Measures



Next Steps

In addition to the priority projects, next steps for Three Rivers are below:

Management

The BMS and operator understanding both play large roles in operating energy systems efficiently. Documenting system set points, such as outdoor temperature reset to enable condensing boiler operation and building comfort, should be a priority. The web-based BMS greatly improves the operator's or commissioning agent's ability to identify and correct operational issues. Training should be completed to familiarize operators with all of the building systems and the web-based functionality.

As part of the CSCU Energy Master Plan, CSCU should create a template for energy tracking applicable to all campuses. Three Rivers should track energy usage through such a template, as well as compare energy spend against available budgets, and verify consumption reports.

Fume Hoods

Although good practices were evident during the walk-through assessment, a fume hood sash management program should be implemented to ensure hoods are closed and turned off when not in use.

Renewable Energy

Explore solar power purchase agreements (PPAs) for portions of the building roof and/or parking canopies. Flood plains may prohibit a large solar array.

By continuing to focus on optimizing systems, and implementing the suggestions of the Energy Master Plan, Three Rivers has the opportunity to create local and cost-effective power through solar PV and increase energy efficiency operations.

INTRODUCTION

As part of the Connecticut State Colleges & Universities (CSCU) Energy Master Plan, Three Rivers Community College (Three Rivers)'s building infrastructure, energy use and energy management practices were assessed. The ultimate goal was to determine ways Three Rivers could improve its energy use on campus, and be an active participant in CSCU energy reduction efforts. This chapter identifies Three Rivers' historical energy use, future projected needs and energy recommendations.

1.1 THREE RIVERS OVERVIEW

Located at 574 New London Turnpike in Norwich, Connecticut, Three Rivers is a single-campus community college serving students throughout southeastern Connecticut. The commuter campus is located on approximately 39 acres of land and features a central plant and one large, multi-winged building. The 280,186 square foot facility supports all campus services, and features 37 state-of-the-art classrooms and a 13,000 square foot library. Amenities at Three River include a full-service dining room, 19 computer labs, a fitness center, bookstore, library commons, and nine conference rooms. The main campus building is organized into Wings A through F. The following list provides a description of the wings.

- Wing A: Student Services: Admissions/Welcome Center. Testing Center, Registration, Cashier, Financial Aid, Veteran's Affairs, Disabilities Services, Academic and Career Counseling, Bookstore, Continuing Education
- Wing B: Classrooms and technology labs
- Wing C: Library/Tutoring Center, Faulty and Administrative ٠ Offices
- Wing D: Liberal arts, technology, and science classrooms
- Wing E: Computer labs, Childcare center
- Wing F: Cafeteria, Student Program's Office, Student Lounge, **Fitness Center**

Three Rivers operates a central plant, which provides heating & cooling to the campus. Three Rivers also has leased an offcampus instructional center located at the Naval Submarine Base (Building 83) in Groton, Connecticut, not included in the current assessment.

Three Rivers' building information is displayed in Table 1.1.



FIGURE 1.1: Building Map



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FIGURE 1.2: Three Rivers Courtyard View

1.2 PREVIOUS ENERGY STUDIES & PROJECTS

Three Rivers has not participated in any past audits, other than a preliminary benchmarking study by the Institute for Sustainable Energy at Eastern. Regardless, the campus' facilities department stays cognizant of campus energy needs. Some energy projects resulted as pure necessity from equipment failure, which can often be the circumstance for smaller campuses with limited funds. The following is a list of recently completed energy-related projects:

NEW EXTERIOR WINDOWS Year: 2013 Associated Building: C, D, E Wings

CONSTRUCTION OF CAMPUS CENTRAL PLANT-ONLY PUMPS AND CHW SYSTEM REMAIN Year: 2008 Associated Building: Central Plant

NEW CONDENSING BOILERS DUE TO EQUIPMENT FAILURE Year: 2015 Associated Building: Central Plant

ROOF (EPDM FIRESTONE) Year: 2015 Associated Building: E Wing

OUTSIDE LIGHTING LED Year: 2016 Associated Building: All

EXISTING CONDITIONS & RECOMMENDATIONS

Information on Three Rivers' existing conditions was captured from campus interviews, energy data and reports provided by the campus. A holistic view of existing practices, material on energy management, energy infrastructure and project implementation processes was reviewed. Analysis of the data and campus walkthroughs helped clarify recommendations with the goal of decreasing energy use, documented after each subheading.

2.1 FACILITY ENERGY BENCHMARKING AND ENERGY CONSUMPTION

Figure 2.1 provides a summary of Three Rivers' energy use. Appendix A documents information on the assumptions and data sources used for energy benchmarking purposes. Three Rivers' site EUI of 99 kbtu/sq ft is below the Northeast median of 104 kbtu/sq ft for colleges/universities. 01 INTRODUCTION



FIGURE 2.1: Energy Dashboard - Three Rivers Community College



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	Three Rivers Community College	Average of CSCU Community College	Average of CSCU University	N Co	lortheast Region mmercial Sector
Cost per Square Feet	\$ 2.50	\$ 2.49	\$ 2.08	\$	1.67
Cost per FTE Student	\$ 268	\$ 311	\$ 677	\$	-
Avg. Cost per kWh Electricity from Grid	\$ 0.13	\$ 0.14	\$ 0.14	\$	0.15
Avg. Cost per MMBtu Natural Gas	\$ 12.83	\$ 10.06	\$ 7.32	\$	10.03
Total Operating Expenses	\$ 39,444,000	\$ -	\$ -		
Total Energy Spending	\$ 736,721	\$ -	\$ -		
% of Operating Expenses	1.87%	1.95%	2.67%		

TABLE 2.1: Energy Spend Comparison

Three Rivers' natural gas unit cost is approximately 28% higher than the CSCU Community College average. Three Rivers is the only campus supplied by Norwich Public Utilities (NPU) and may explain the higher than average cost. A charge called "Gas Capital Tracker" accounts for most of the difference. Combining meters may be a way to reduce the natural gas costs, as has been show at other campuses, however the utility has not favored the option in the past.

Three Rivers has a more favorable unit cost for electricity than the average CSCU community college and pays a smaller portion of the operating budget on energy.

2.2 CAMPUS UTILITIES AND DISTRIBUTION

Three Rivers is located in Norwich Connecticut, which operates its own municipal utility, NPU. The utility provides both electricity and natural gas to the campus. Unlike with the other CSCU campuses which are served by the state regulated investor-owned utilities, NPU is owned by the Norwich municipality and governed by a local commission.

The Central Plant has a separate natural gas and electric feed.

2.3 ENERGY PROCUREMENT

All of Three Rivers' electricity and natural gas supplies are provided by NPU.

2.4 OPERATIONAL AND ENERGY MANAGEMENT PRACTICES

2.4.1 CURRENT CONDITIONS

Three Rivers takes prides in their new campus facilities and has dedicated facility staff to ensure the proper upkeep of campus infrastructure. However, the campus is still in need of additional staff; facilities had a 22-member team and has since decreased to 13 members which are comprised of mainly custodians.

Most staff effort is placed on repairing systems and correcting problems rather than optimizing. Often, problems are not noticed unless due to failure or complaint. Typical operating hours for the campus are:

Monday – Thursday	: 8AM-8PM					
Friday	: 8AM to 4PM					
Saturday	: 9AM-1PM					
Sunday	: 7PM-10PM					

However, over the last two years, the campus has been closed on weekends in order to reduce operating costs. Scheduling of equipment can take place in the building management system (BMS), but achieving optimal room air quality year round is difficult.

The campus has a BMS, but energy management system (EMS) aspects of the system are either not used or available. Other than monthly totalized reporting to the CSCU, energy tracking and monitoring has not been standard practice.

ENERGY USE INFORMATION MANAGEMENT SYSTEM

The BMS and operator understanding both play large roles in operating energy systems efficiently. The system is web-based and allows maintenance staff to adjust equipment set points to conserve energy or address building component dysfunctions through remote access.

2.4.2 RECOMMENDATIONS

Adding a dedicated and properly trained staff member to monitor the building and plant energy systems is recommended. The costs associated with the additional staff would likely be offset by operational and maintenance savings; both energy savings and prolonged equipment life could be realized.

For the BMS, documenting system set points, such as outdoor temperature reset to enable condensing boiler operation and building comfort, should be a priority. Adding CO2 sensors for demand control ventilation (DCV) are recommended to improve air quality while not over ventilating.

02 SYSTEN LEVEL EXISTING CONDITIONS

03 SYSTEM LEVEL ENERGY NEEDS

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EMSs can offer an excellent way to track energy use of specific equipment such as an air handler, pump, or boiler. The implementation of an EMS is recommended to track detailed energy usage, in addition to the macro view of looking at bills regularly.

As part of the CSCU Energy Master Plan recommendations in Section 5.2.2, it is recommended that the System Office create a template for energy tracking applicable to all campuses. Three Rivers should use this template to track energy over time, at a minimum on a monthly basis. Energy tracking should also include monitoring spending against available budgets.

2.5 EXISTING BUILDING COMMISSIONING

2.5.1 CURRENT CONDITIONS

No recent building commissioning efforts were reported. As the campus is currently understaffed, the need for commissioning becomes apparent generally after a problem is noticed due to failure or complaint. According to the campus, new HVAC equipment was installed in 2006 and has not worked as optimally as was expected.

There have been air quality and balancing issues since installation. They have been unable to commission the equipment at this time.

2.5.2 RECOMMENDATIONS

Existing building commissioning (EBCx) is needed based on indoor air quality (IAQ) and temperature complaints. Energy savings may be a side benefit with the primary reason being building air quality.

Recommissioning should include a thorough review of all BAS screens and settings. For example, from the screenshot below, recommissioning may find a leaking heating valve by noticing a rise in temperature across the coils when in economizer mode or the valve is closed. (Note: +/- 2°F air temperature sensor calibration and temperature rise across fan may account for the 6°F rise in this example).

Another recommissioning example may be to analyze the supply and return temperature set points for the boiler system. The return temperature of 128°F is allowing the boilers to condense, but not optimally. If the boiler outlet temperature can be further reduced to allow a lower discharge temperature, and therefore a lower return temperature, perhaps at 120°F, the efficiency will increase from approximately 87% to 91%.



FIGURE 2.2: Three Rivers BMS



Buildings with BMS systems with measurable points stand to benefit the most from recommissioning. A properly commissioned building should be turned over with a thorough commissioning report, complete with checklists and testing and balancing (TAB) reports for each piece of equipment, even windows and lighting. If this documentation is not available, it is a good indication the building was not properly commissioned. Newer buildings with a higher than average EUI are also indicative of a poorly commissioned building.

As a general rule of thumb:

• Recommission existing building systems every 3-5 years.

2.6 MECHANICAL SYSTEMS

2.6.1 CURRENT CONDITIONS

The Three Rivers campus has an immaculate state-of-the-art central heating and cooling plant with six cascaded condensing natural gas boilers integrated into a BMS. Three centrifugal chillers are also located in the central plant. Domestic hot water is generated with two natural gas hot water heaters.

All boilers and one of the hot water heaters are new as of fall 2015 due to failure of the original equipment which were less than ten years old. Water quality and/or condensing of the flue gases are possibilities for the premature equipment failures.

Three Rivers uses a four pipe heating/cooling system for the building, meaning hot water and chilled water each have their own independent supply and return pipe.

Most air handling equipment is new as of 2006, but as previously stated, has not be operating well and have many issues with air quality, humidity, and temperature.



FIGURE 2.3: Centrifugal Water Cooled Chillers

One of the air handling units has had water collecting underneath the unit. Some of the roof top units use natural gas for heating where other units use hot water from the central plant.



FIGURE 2.4: Cascaded Benchmark Condensing Boilers

The following lists are recommendations by system type that would aid in optimizing efficiency, and reducing energy.

BOILER SYSTEM

- Reduce heating system temperature via outdoor temperature reset when the climate is warmer than design (worst case) conditions. The return temperature to the boilers should be as low as possible to enable condensing. The figure in the commissioning section which shows the effect of return temperature on efficiency.
- Open triple duty valves to 100% as the variable frequency drives (VFDs) should be used to control the flow rather than adding the unneeded pressure drop with the balance valves.

CHILLER SYSTEM

- Open triple duty valves to 100% as the VFDs should be used to control the flow rather than adding the unneeded pressure drop with the balance valves.
- Employ a cooling water temperature reset strategy so the water temperature is only as cool as needed by the building.

HVAC AIR SIDE

- Retrocommission equipment.
- Install demand control ventilation (DCV).
- Install additional thermostat or adjust controls to reduce heating and cooling in the clock tower.
FUME HOODS

- Implement a fume hood sash management program to ensure that hoods are closed and turned off when not in use.
- Conduct audit to possibly lower the sash face velocity and in turn lower the volume of air unnecessarily removed from the building. Factoring heating and cooling degree days, as well as CSCU's average fuel costs, the campus could see savings of approximately \$2 per SCFM-year.
- Review Phoenix Controls settings for fume hoods so that fans do not run when unnecessary.



FIGURE 2.5: Fume Hoods

2.7 LIGHTING

2.7.1 CURRENT CONDITIONS

Three Rivers is coordinating with NPU for support and incentives in an initiative to upgrade existing lighting to LED. All exterior lighting was replaced with LED in May and June of 2016. The campus also had a lighting audit and is in the process of creating a scope of work for all interior lighting, where there is much room for improvement. The lighting audit should be referenced for additional information.

Most lights are controlled either manually or with a timer. Some rooms have limited occupancy controls.

2.7.2 RECOMMENDATIONS

The campus should consider the following recommendations:

- Add occupancy based lighting (and ventilation) controls to auditorium.
- All exterior lighting should have photo sensors installed to replace timers.





FIGURE 2.6: Indoor Lighting

2.8 BUILDING ENVELOPE

2.8.1 CURRENT CONDITIONS

In FY 2013, Three Rivers' completed renovations in the "C," "D," and "E" wings to replace existing doors and exterior windows. These kinds of renovations help tighten the building envelope and maintain better consistency of temperatures needed for building heating and cooling. A large courtyard contributes natural light, although at a cost of increased heating and cooling costs due to the additional surface area.

In general, apply energy efficiency measures in the following order:

- Reduce internal loads:
- Reduce building envelope loads;
- Reduce HVAC distribution system losses;
- Decrease HVAC equipment energy consumption; and •
- Make major HVAC reconfigurations.



FIGURE 2.7: Clock tower and infrared version showing temperature stratification more than 10 degrees higher than the setpoint

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05 SYSTEM LEVEL



2.9 DISTRICT ENERGY / COGENERATION

2.9.1 CURRENT CONDITIONS

There is no district energy or cogeneration at Three Rivers.

2.9.2 RECOMMENDATIONS

As there is limited summer thermal use, a cogeneration application is unlikely to provide additional benefit over the existing boilers.

2.10 RENEWABLE ENERGY

2.10.1 CURRENT CONDITIONS

Three Rivers has not implemented any renewable energy projects on campus.

2.10.2 RECOMMENDATIONS

Three Rivers' campus provides substantial opportunities for solar through multiple installations of roof-top, as well as potential ground-mount solar PV. The rooftop available space on the main

building (Figure 2.8) totals approximately 80,000 GSF; assuming 90% availability of space for mechanical equipment setbacks, there is a potential of an estimated 333-434 kW. The Central Utility Plant, constructed in 2008, also has potential for roof-top solar. With any roofing improvements, implementation of solar PV should also be considered at the same time. Integrating solar simultaneously with new roofing can help streamline both projects into one and mitigate issues the insurance provider may have for existing roofs. Solar PV should be incorporated into future capital planning building design.

The campus is surrounded by parking lots which may present a possibility for parking canopies, in particular for the southeast parking lot. However, permitting requirements would need to be explored as the southeast parking lot is within the 100 year flood plain.

Table 2.2 provides an overview of the buildings that may be considered for solar PV in the future. Following the table are images of each of the sites.

Building Name	Year Built [Renovated]	GSF [FY 2015]	Building Roof sq. ft.	Roof Install/ Replacement Date	Roof Type	Array Size Potential (kW DC)[1]	Annual Generation Potential (MWh)[2]	Solar Suitability Comments
				HIGH PR	IORITY PROJE	CTS		
Three Rivers / Thames II Campus Building	1962 [1964/ 1966/ 2009]	280,186	80,412	-	EPD M	333-434	434-557	Only portions of the roof suitable due to mechanical equipment. The building square foot reflects the available space, at 90% availability accounting for set backs
Three Rivers / Thames II Central Plant	2008	15,458	11,104	-	-	51-67	67-86	
Total		295,644	91,516			384-501	501-643	

TABLE 2.2: Three Rivers Potential Areas for Solar PV

[1] Assumes that each sf of panels can generate between 4.6 and 6 Watts DC (about a third of the PVWatt Output Assumptions). Actual generation values would be

[2] Assumes that each sf of panels can generate between 6 and 7.7 kWh annually (about a third of the PVWatt Output Assumptions). Actual generation values would be calculated if a solar PV study was performed.



FIGURE 2.8: Three Rivers Campus Solar Potential

2.11 CAPITAL PLANNING

2.11.1 CURRENT CONDITIONS

The System Office and State financing is necessary to support capital projects such as Three Rivers' 2006 multi-phased campus expansion project . The System Office provides annual code compliance and infrastructure funds. Most recently, in fiscal year 2013, Three Rivers' completed renovations in the "C," "D," and "E" wings to replace existing doors and exterior windows. Larger capital projects are also funded under CSCU 2020, as of FY 2015. The State Legislature allocates bonds for campus improvement projects.

More information on campus expansion projects is found in Section 3.1.

2.11.2 RECOMMENDATIONS

In addition to existing funding methods, Three Rivers should collaborate with NPU for all major building renovations and all new construction.

2.12 COLLABORATION / PARTNERSHIP

2.12.1 CURRENT CONDITIONS

Three Rivers' utility company has an energy efficiency fund in which customers pay a portion of their monthly bill to the fund. The fund helps support energy efficiency projects for the municipal utility's customers. NPU has been supportive of Energy Efficiency Measures (EEMs) the campus has pursued, including building controls, HVAC upgrades, and lighting. Future planned upgrades include further BMS upgrades (from Bacnet to web base) and upgrading to LED lighting.

The System Office Facilities Department is also available to provide assistance in budgeting, capital planning and technical support for the community college projects, including Three Rivers.

2.12.2 RECOMMENDATIONS

Three Rivers should continue to collaborate with NPU and the System Office for capital planning.

2.13 SUMMARY OF RECOMMENDED ENERGY EFFICIENCY OPPORTUNITIES

As a result of the campus walk through energy assessment, and interviews with campus staff, a list of potential EEMs is presented in Table 2.3. These projects represent both low cost, immediate action measures, as well as projects that may require larger capital and therefore be longer-term.

Both of Three Rivers' utilities are through NPU. Previous discussions indicate there is an open channel of communication between Three Rivers and NPU on custom EEM projects and Three Rivers should continue to involve the utility on any new projects or upgrades connected to energy use.

Since incentives are often based on incremental energy savings, further analysis and collaboration with NPU is required to determine rebate amounts for each opportunity. To help Three Rivers navigate and prioritize the energy opportunities identified, a summary of EEMs were identified

The simple payback in most cases cannot be reasonably estimated without detailed building models and/or more operating data. The payback periods provided are based upon the performance of past similar projects and are not necessarily indicative of future results.

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Opportunity ID	Energy Conservation or Efficiency Opportunity	App. Cost (Before Rebate)	Payback w/rebate (Years)	Priority
TRCC-1	Review Phoenix Controls settings for laboratory fume hoods so that fans do not run when unnecessary (recommission)	Minimal	Instantaneous	1
TRCC-2	Implement a fume hood sash management program to ensure that hoods are closed and turned off when not in use. Also conduct an audit to possibly lower the sash face velocity and in turn lower the volume of air unnecessarily removed from the building.	Varies	Varies	1
TRCC-3	Explore rooftop and parking canopy solar PPAs.	PPA	PPA	1
TRCC-4	Open triple-duty valve 100% when using VFDs.	None	Instantaneous	1
TRCC-5	Install all new LED interior lighting per scope developed with the utility.	Varies	2 - 6	1
TRCC-6	Recommission each building/wing HVAC system every 3-5 years to ensure building is functioning properly and efficiently. HVAC systems may not have been properly commissioned through testing and balancing (TAB), in which case retrocommission as soon as possible.	\$0.5 - \$3 per S.F.	Varies	1
TRCC-7	Complete on-site training for web-based BMS with operators.	Staff time	Varies	1
TRCC-8	Adding CO2 sensors for demand control ventilation (DCV) are recommended to improve air quality while not over ventilating.	\$250 / Sensor+ Integration	Varies	2
TRCC-9	Install additional thermostat or adjust controls to reduce heating and cooling in the clock tower.	\$300	Varies	2
TRCC-10	Explore continuous commissioning software package to monitor points until dedicated staff can be provided.	\$40,000 per year	Varies	2

TABLE 2.3: Three Rivers Recommended Energy Efficiency Measures

ENERGY NEEDS

3.1 FUTURE DEVELOPMENT

Campus construction and expansion often has an impact on energy use and energy infrastructure needs. Starting in 2006, Three Rivers underwent a major multi-phased campus expansion project, completed in 2009. There are no current plans for expansion and portions of the property are in the flood plain, which inhibits large expansions.

Based on future development plans, it is not anticipated that any additional energy infrastructure such as electric feeders or new meters will be needed. The campus is a part of a microgrid with NPU, giving it islanding capabilities should a power outage occur. The campus does not frequently experience issues with outages. Three Rivers also has three standby generators, which provide power for IT needs, emergency lighting, and the cafeteria refrigerator.

3.2 ENERGY RESILIENCY RECOMMENDATIONS

Three Rivers partook in system-wide hazard mitigation initiative. The CSCU Multi-Hazard Mitigation Plan provided recommendations surrounding energy resiliency that are also applicable for the Energy Master Plan. The hazard mitigation plan suggested additional building envelope improvements, which would aid in energy conservation.

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03 SYSTEM LEVEL ENERGY NEEDS

04 FINANCING/FUNDING OPPORTUNITIES

05 SYSTEM LEVEL RECOMMENDATIONS

CAMPU:



CONCLUSION / NEXT STEPS

Three Rivers is being proactive to address energy upgrades by coordinating with NPU. As supported by the campus utility data, Three Rivers is performing well and has an EUI below average in comparison to Northeast College and University available data.

The biggest opportunity for the campus relates to building commissioning. As occurred in the past, even recently purchased equipment may not have been properly commissioned and should be recommissioned regularly. More easily implemented energy saving opportunities include upgrading interior lighting as planned and optimizing ventilation rates for fume hoods, bathrooms, and common areas. Other top priority initiatives include:

- *Management:* Three Rivers should take a more active role in tracking energy use and comparing energy spend to available budgets. Additional staff may be needed to focus solely on energy use and efficiency with O&M.
- *Renewable Energy:* Explore PPAs for solar on the main building and central plant.
- *Utility Incentives/ Develop Plan for EEMs:* Three Rivers should maximize incentive funding for EEMs by working with NPU.

A summary of further projects and priorities for the campus are listed in Table 2.3. While Three Rivers has a lower than average EUI among CSCU, there are still opportunities to capture savings, decrease energy use and increase energy reliability and sustainability.

4.1 CONTACT INFORMATION FOR KEY STAKEHOLDERS

Collecting all the necessary information for this planning effort required a collaborative effort. Below are the stakeholders that were active in providing their expertise about campus current conditions and future needs, and energy related decisions.

THREE RIVERS COMMUNITY COLLEGE

ARNIE DELAROSE

Director of Facilities *adelarosa@trcc.commnet.edu* 860-215-9236

APPENDIX A: THREE RIVERS DATA METHODOLOGY, ASSUMPTIONS AND NOTES

All three fiscal years have complete consumption data. No information to indicate that the campus uses propane, fuel oil, purchased chilled water or steam.

Electricity Utility Bill Summaries (FY13,14,15)

Natural Gas: Utility Bill Summaries(FY13,14,15)

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Tunxis Tunxis Community Community Construction

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05 SYSTEM LEVEL RECOMMENDATIONS

PERKINS+WILL WOODARD &CURRAN



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EXECUTIVE SUMMARY

The Tunxis Community College (Tunxis) Energy Master Plan aims to identify ways Tunxis can improve energy use on campus, and be an active participant in Connecticut State Colleges & Universities (CSCU)'s energy management, reduction and conservation efforts. The utility data received indicates Tunxis is a higher energy user out of the CSCU from an energy perspective (see Figure 1 Tunxis Energy Dashboard). The energy use intensity (EUI) method is used for benchmarking and comparison purposes.



FIGURE 1: Energy Dashboard - Tunxis Community College

01 INTRODUCTION

Possible causes for the relatively high energy use at Tunxis relate to the campus' building envelope and mechanical systems. The campus used to be part of a single story retail development. The former retail center, as well as the new buildings have a high amount of space and windows. Also mechanical equipment is less efficient as is the case with chillers, while newer building systems may not be fully or properly commissioned.

Energy Spend

Table 1 provides a summary of energy spending comparing to the average of CSCU campuses and the Northeast Region Commercial Sector.

	Tunxis	s Community College		Average of CSCU Community College		Average of CSCU University		Northeast Region Commercial Sector	YSTEI XISTII
Cost per Square Feet	\$	2.95	\$	2.49	\$	2.08	\$	1.67	Z Z L
Cost per FTE Student	\$	294	\$	311.00	\$	677.00	\$	-	COE
Avg. Cost per kWh Electricity from Grid	\$	0.14	\$	0.14	\$	0.14	\$	0.15	ND F
Avg. Cost per MMBtu Natural Gas	\$	6.97	\$	10.06	\$	7.32	\$	10.03	ITIO
Total Operating Expenses	\$	38,692,000	\$	-	\$	-			NON
Total Energy Spending	\$	757,927	\$	-	\$	-			0,7
% of Operating Expenses		1.96%		1.95%		2.67%			
TABLE 1: Energy Cost Comparison (FY 2014)Tunxis has a lower cost/FTE studentspends less than the average unit cost	than the t of gas a	CSCU campus av ccording to FY 14	verag dat	ge. There were 2,58 a.	32	FTE students in 20	13.	The campus also	03 System Lev Energy Nei
Utility Incentives/ Develop Plan for En	ergy Effic	iency Measures (EEN	ls)					/EL EDS

Utility Incentives/ Develop Plan for Energy Efficiency Measures (EEMs)

Tunxis should work with its electric utility, Eversource, and gas utility, United Illuminating, to capture existing incentives paired with EEMs.

Since incentives are based on incremental energy savings, further analysis and collaboration with the utilities is required to determine rebate amounts for each opportunity. Table 2 demonstrates a summary of the EEMs recommended for Tunxis to pursue.

RECOMMENDATIONS SYSTEM LEVEL ŬП



Opportunity ID	Energy Conservation or Efficiency Opportunity	Associated Building if Applicable	App. Cost (Before Rebate)	Payback w/rebate (Years)	Priority
TCC-1	Upgrade boiler room pumps to premium efficiency and add VFDs (7.5HP).	Academic East (200 Building)	\$ 17,000	1.5 - 3	1
TCC-2	Add variable speed drives to chilled water loop piping (15HP).	Academic East (200 Building)	\$ 26,000	1.5 - 3	1
TCC-3	Adjust the boiler hydronic loop setting to allow the Benchmark boilers to condense more based on outside temperature.	Academic Building (600 Building & Extension)	None	Instantaneo us	1
TCC-4	Replace all building lighting with LED	All	Varies, requires a lighting specific audit	2 - 6	1
TCC-5	Replace parking lot lights with LED and upgrade controls.[1] (This measure was in progress during the production of the report)	Exterior	Varies, requires a lighting specific audit	2 - 6	1
TCC-6	Replace constant volume air handlers with newer VAV equipment	Faculty/Student Services (100 Building)	\$ 309,000	Varies	2
TCC-7	Consider replacing cast iron 80% efficient Hydrotherm boilers with newer 90% - 96% efficient condensing units in near term	Academic East (200 Building)	\$18/MBH +installation	Varies	2
TCC-8	Consider adding a heat exchanger to allow free cooling in shoulder months	Academic East (200 Building)	\$ 358,000	Varies	2
TCC-9	Evaluate building envelope improvements to eliminate the electric ice-melt system, or convert to hot water for use with condensing boilers	Academic East (200 Building)	Varies	Varies	2
TCC-10	Drop ceiling to reduce conditioned space	Academic East (200 Building)	Varies	Varies	2
TCC-11	Use more occupancy based controls vs timer based	Academic West (300 Building)	\$1 per sq.ft. covered on average	Varies	2
TCC-12	Install central HVAC to provide zones and occupancy based ventilation for each perimeter office.	Faculty/Student Services (100 Building)	Varies	Varies	3
TCC-13	Consider using chiller leaving condensing water for building heat (capable of 140 °F) if cooling loads extend into heating season	Faculty/Student Services (100 Building)	Varies	Varies	3

 TABLE 2: Tunxis Energy Efficiency Measures

[1] The Department of Energy (DOE) provides a comprehensive guide for purchasing energy efficient lighting as well as demonstrating cost effectiveness of lighting solutions, here: http://energy.gov/sites/prod/files/2014/02/f7/parking_lots_guide.pdf

In addition to the priority projects, next steps for Tunxis are below:

Next Steps

Management

Efforts should be made to combine Tunxis' building management systems (BMS) onto a single platform.

Tunxis should continue to track energy usage, but using a CSCU template, incorporating use per square foot, as well as compare energy spend against available budgets. EEMs should be considered even when the expected building use life equals the simple payback as buildings may not change or be demolished as soon as planned.

Renewable Energy

Explore power purchase agreements (PPAs) for renewable energy development in capital planning.

By implementing the suggestions of the Energy Master Plan, Tunxis has the opportunity to increase energy efficient operations, and continue to wisely manage energy as the campus evolves in the future.

04

SYSTEM LEVEL RECOMMENDATIONS

05





INTRODUCTION

As part of the Connecticut State Colleges & Universities (CSCU) Energy Master Plan, Tunxis Community College (Tunxis) building infrastructure, energy use and energy management practices were assessed. The ultimate goal was to determine ways Tunxis could improve its energy use on campus, and be an active participant in CSCU energy reduction efforts. This chapter identifies Tunxis' historical energy use, future projected needs and energy recommendations.

1.1 TUNXIS OVERVIEW

Tunxis is a two-year public college located in Hartford County at 271 Scott Swamp Road in Farmington, Connecticut. As of Fall 2015, Tunxis enrolls approximately 4,079 full and part-time students in credit and continuing education classes.

Online courses at Tunxis have the largest enrollment of all the CSCU community colleges.

The campus resides on 13.9 acres of land, which houses four connected buildings (building 100, 200, 300, 600), Bidstrup Hall (500 Building) and the Library (700 building). Buildings 100-300 were originally part of a strip mall. Tunxis also owns a residential house, the Farmington House, located by the campus entrance off Route 6. Tunxis offers workforce development and educational services offsite in a single building located at 430 Main Street in Bristol, Connecticut. The leased facility, referred to as Tunxis@ Bristol, is located approximately five miles from the main campus. Leased buildings are not included in the Energy Master Plan assessment. Table 1.1 provides a summary of Tunxis' buildings included in the energy assessment.



FIGURE 1.1: Building Map

Building	Year Built [Renovated]	Gross Square Feet	Building Function
Faculty/Student Services (100 Building)	1992	49,382	Administrative
Academic East (200 Building)	1964 [2010]	16,797	Academic with Labs
Academic West (300 Building)	1964 [2010]	31,457	Academic
600 Building	2010	113,552	Academic with Labs
Bidstrup Hall (500 Building)	1984	7,772	Office/Administrative
Library Building (700 Building)	2007	37,074	Library
Farmington House	1957	2,065	Other (Meeting Space)
Total		258.099	

TABLE 1.1: Tunxis Campus Building Information

1.2 PREVIOUS ENERGY STUDIES & PROJECTS

Tunxis has been proactive in identifying ways to conserve and save energy. Their 2009-2011 strategic plan had goals to monitor utility usage, optimize space use and existing resources as well as continue to focus on sustainability and new building LEED compliance. In 2011, Tunxis partook in an in depth energy savings plan by Noresco. The study did not include the newer 600 and 700 buildings. Recommendations included optimization of constant speed systems, lighting systems upgrades and increased building system controls, among other suggestions. An energy benchmarking study provided in May 2013 by the Institute for Sustainable Energy (ISE) identified similar findings, as well some lighting opportunities for the newer buildings. A number of previously identified opportunities have not been implemented due to phased demolition plans for buildings with the recommendations.

Some completed energy projects include:

- 600 Classroom building is LEED certified and features rainwater harvesting for restrooms, motion sensor lighting, recycled building products and efficient use of design for daylighting.
- Parking Lot lighting LED upgrades are in completion for • 2016
- Replacement of motor starters at end of life with variable . frequency drives (VFDs)

02



EXISTING CONDITIONS & RECOMMENDATIONS

Information on Tunxis' existing conditions was captured from campus interviews, energy data and reports provided by the campus. A holistic view of existing practices, material on energy management, energy infrastructure and project implementation processes was reviewed. Analysis of the data and campus walkthroughs helped clarify recommendations with the goal of decreasing energy use, documented after each subheading.

2.1 FACILITY ENERGY BENCHMARKING AND ENERGY CONSUMPTION

A summary of Tunxis' energy use is shown in the energy dashboard, based on fiscal year 2014 and 2015 data. Appendix A documents information on the assumptions and data sources used for energy benchmarking purposes. Energy data suggests Tunxis is a higher energy user of the CSCU campuses.



FIGURE 2.1: Tunxis Community College Energy Dashboard

Tunxis' site EUI is approximately a third higher than the Northeast median for colleges/universities per square foot per year at 140kbtu/sqft. The campus has a source EUI of 270 kBtu/sf, the highest of the CSCU campuses. More than half of the campuses energy use is attributed to natural gas consumption (Figure 2.1b). The weather normalized site EUI is similar between fiscal year 2014 and 2015 at 134 and 132 kBtu/sf respectively (Figure 2.1c).

Possible causes for the relatively high energy use at Tunxis include:

- Older buildings were once part of a strip-mall and have high ceilings that account for a high volume of conditioned space per square foot.
- Mechanical spaces in older buildings use constant speed motors and older, less efficient chillers.
- A large amount of unassignable / common areas (i.e. hallways, lobbies) is continuously conditioned and/or illuminated with less efficient lighting than LED.
- Cafeteria
- The new buildings have a high amount of open space and windows.







• Newer building systems may not have been fully or properly commissioned and calibrated after construction

Although some submetering of campus buildings is available, EUI's cannot be determined without more information to line up the account numbers with the corresponding building name. The campus is interested in consolidating utility furnished meters.

A breakout of individual meter natural gas use followed by electric use is shown in Figure 2.2 and 2.3.

The total energy should be used as a weighting factor, focus should be applied first to buildings with a high EUI and energy use.

Table 2.1 provides a comparison of FY 2014 energy spending compared to the average of CSCU campuses and the Northeast Region Commercial Sector.

			Average of CSCU	Average of CSCU	Northeast Region
	Tunxis	Community College	Community College	University	Commercial Sector
Cost per Square Feet	\$	2.95	\$ 2.49	\$ 2.08	\$ 1.67 [1]
Cost per FTE Student	\$	294	\$ 311	\$ 677	\$ -
Avg. Cost per kWh Electricity from Grid	\$	0.14	\$ 0.14	\$ 0.14	\$ 0.15 [2]
Avg. Cost per MMBtu Natural Gas	\$	6.97	\$ 10.06	\$ 7.32	\$ 10.03 [3]
Avg. Cost per Gallon Fuel Oil	\$	3.82	\$ 3.46	\$ 3.77	
Total Operating Expenses FY 12 [4]	\$	38,692,000	\$ -	\$ -	
Total Energy Spending	\$	757,927	\$ -	\$ -	
% of Operating Expenses		1.96%	1.95%	2.67%	

TABLE 2.1: Tunxis FY 14 Energy Spend Comparison

[1] Energy \$/sf in the Northeast region from CBECS 2012 report; education building type - http://www.eia.gov/consumption/commercial/data/2012/c&e/cfm/c6.cfm
 [2] Electricity \$/kWh in the Northeast region from EIA Electric Power Monthly June 2014 - http://www.eia.gov/electricity/monthly/current_year/june2014.pdf
 [3] Natural gas \$/MMBtu in the Northeast region from EIA Connecticut Price of Natural Gas - http://www.eia.gov/dnav/ng/hist/n3020ct3m.htm

05 SYSTEM LEVEL RECOMMENDATIONS The cost per square foot is based on 258,100 GSF and the total energy spending. According to the stakeholders, two years prior, the cost per square foot was \$2.55. Despite having a higher than average cost per square foot, the campus spends less than the average of total energy spending as a percent of its total operating expenses, according to FY 14 data. Tunxis pays slightly more for fuel oil than the average fuel oil cost. To note, as not all campuses had fuel oil costs available so the average cost may not reflect the actual. The campus only uses a minimal amount of fuel oil at a cost of approximately \$5,311 in FY14.

2.2 CAMPUS UTILITY AND DISTRIBUTION

Tunxis uses electricity and natural gas and a small percentage of fuel oil. Tunxis' utility providers are as follows:

- Electricity: Eversource
- Natural Gas: United Illumination Holdings (UIL), formerly Connecticut Natural Gas
- Fuel Oil: Dime Oil

2.3 ENERGY PROCUREMENT

Tunxis is part of the CSCU's 2013 electric supply procurement contract with Direct Energy (formerly Hess Energy), detailed further in the Energy Master Plan. The campus is interested in consolidating meters as there are currently six electric accounts, not including three lighting accounts. Further study would be required to assess exact savings, if any, by consolidating and changing rates through Eversource. Savings would relate to avoiding individual monthly basic service charges and standard demand charges by bundling total campus demand into one rate.

In FY13 and FY 14 the campus' natural gas suppliers were Direct Energy and Santa Energy, but the local distribution company UIL became Tunxis' supplier in FY15.

2.4 OPERATIONAL AND ENERGY MANAGEMENT PRACTICES

2.4.1 CURRENT CONDITIONS

Tunxis' facilities department is comprised of a Director of Facilities Building Superintendent, a Maintainer, two General Trades Workers, Lead Custodian, and eight Custodians. The Department is responsible for overseeing campus infrastructure improvements and maintaining and operating energy systems.

ENERGY USE INFORMATION MANAGEMENT SYSTEM

The building management system (BMS) and operator understanding both play large roles in operating the energy systems efficiently. Currently, not all of the BMSs communicate on the same platform. Two independent BMS systems are used for the campus with the intention of consolidating to a single system. The campus is working with Siemens on updates for their BMS system.

Tunxis does not currently have an energy dashboard, but energy use summaries are currently generated and tracked on a statement period basis.

2.4.2 RECOMMENDATIONS

As part of the CSCU Energy Master Plan recommendations in Section 5.2.2, it is recommended that the System Office create a template for energy tracking applicable to all campuses. Tunxis should continue to track energy usage through such a template, incorporating use per square foot, as well as compare energy spend against available budgets, and verify consumption reports. Tunxis can also use Eversource's Customer Engagement Platform to view its energy use. BMSs, some known as Energy Management Systems (EMS), can offer an excellent way to track energy use of specific equipment such as an air handler, pump, or boiler. The addition of an EMS is recommended with the addition of a congruent platform to combine all system data.

Efforts should be made to combine the BMSs onto a single platform. Documenting system set points, such as outdoor temperature reset to enable condensing boiler operation and building comfort, should be a priority.

2.5 EXISTING BUILDING COMMISSIONING

2.5.1 CURRENT CONDITIONS

Tunxis is currently working with Eversource and a building commissioning firm to recommission the entire campus.

2.5.2 RECOMMENDATIONS

Buildings with BMS systems with measurable points stand to benefit the most from recommissioning. Although State buildings built after 2011 are required to have a commissioning agent, it has been observed even new buildings have not been properly and thoroughly commissioned. A properly commissioned building should be turned over with a thorough commissioning report, complete with checklists and testing and balancing (TAB) reports for each piece of equipment, even windows and lighting.

05 SYSTEM LEVEL RECOMMENDATIONS

If this documentation is not available, it is a good indication the building was not properly commissioned. Newer buildings with a higher than average EUI are also indicative of a poorly commissioned building.

As a general rule of thumb:

Recommission existing building systems every 3-5 years.

2.6 MECHANICAL SYSTEMS

2.6.1 CURRENT CONDITIONS

Mechanical systems are spread throughout the campus buildings. Some areas use roof top units (RTUs), fan coil units (FCUs), cabinet heaters, powered terminal units (PTUs), air handling units (AHUs) as well central chillers and boilers. Although some boiler room equipment is aged, it appears the college maintains their equipment well and take pride in keeping mechanical spaces tidy.

Building 100 Building has the most room for improvement due to the age of equipment.

Some building system upgrades to the 200 building and faculty wing have been deferred as Phase 3 construction would remove or replace those areas entirely.

Major mechanical and energy user systems are identified below.

BOILER SYSTEM

Building 100, 600, and the 600 extension contain boilers and chillers.

Building 100

Building 100 uses two banks of 8 cascading natural gas Hydrotherm boilers. These older boilers were installed in 1991 and are only about 80% efficient, as compared to newer boilers are commonly 85% efficient with condensing models over 90% efficient. Good maintenance practices have kept these boilers going strong into the end of their expected life. Four of the 16 boilers are used for domestic hot water.

The 7.5 HP pumps appeared to be in good condition with high or premium efficiency motors. Flow is controlled using a throttling device to increase the total system pressure drop rather than using a VFD.

Building 600

Building 600 uses two Smith cast iron sectional hydronic boilers and were installed in 2006. The pumps are larger than Building 100 with two 25 HP and two 7.5 HP.

Building 600 Extension

The addition to the 600 building has new high efficiency equipment, including two Benchmark condensing natural gas boilers. The hot water pumps are 5 HP or less.



FIGURE 2.4: Hydrotherm Boilers

CHILLER SYSTEM

Building 100

A 150 Ton Trane Centravac Series R chiller is used in Building 100. The water cooled chiller was installed in 1992 and the condenser is cleaned on a now yearly basis. The cooling tower was recently replaced in 2014 and the sump is original and due for replacement. Although water cooled chillers are typically more efficiency than air cooled, the efficiency can be improved using new high efficiency variable speed chiller. The approximate efficiency of the existing chiller at 50% load and 100% load, in terms of energy required per Ton of cooling is 0.61 and 0.81 kW/ Ton, respectively.

As of 2009, centrifugal chillers in the 150 to 299 Ton range are able to use less than 0.5 kW/ Ton at full load. Upgrading the chiller to one that complies with the latest ASHRAE 90.1 standards would save approximately 25% on electric cooling costs for the 100 Building.

Building 600

Building 600's chiller equipment was installed in 2006. A 400 Ton McQuay air cooled chiller supplies the building with chilled water. The pumps are much larger than Building 100 with two 40 HP and two 25 HP.

Building 600 Extension

The addition to the 600 building has new high efficiency equipment, including a 110 Ton York YVAA air cooled chiller. The integrated part load value (IPLV) for the York YVAA indicated the chiller has notably better efficiency than older chillers. The chilled water pumps are 7.5 HP and 5 HP.

YLAA Efficiency & Annual Energy Cost



FIGURE 2.5: YLAA Efficiency & Annual Energy Cost

HVAC AIR SIDE

Building 100

The 100 building Faculty Wing offices have independent heating and cooling for individual rooms through the use of through wall unit heaters, but lack independent ventilation so windows are sometimes used to ventilate. Ideally, new VAV AHUs or RTUs with economizers or heat recovery would be used.

FUME HOODS

There are four fume hoods with 15 HP fans in building 600. There is difficulty communicating with professors on conserving energy as they like theirs a certain way.

2.6.2 RECOMMENDATIONS

The following lists are recommendations by system type that would aid in optimizing efficiency, and reducing energy use.

BOILER SYSTEM

 Add VFDs to the 100 Building pumps and open the throttling valves to 100%. VFDs can also be used optimize temperature set points and increase system efficiency by actively changing the flow rate to the minimum necessary. Other campuses have realized a payback of less than 2 years with incentives. **a.** Installing a VFD and controlling to 70% flow rather than throttling using a multi-purpose valve could yield over \$2,000 a year per a 7.5 HP pump if operated 4,000 hours per year.

- Reduce heating system temperature via outdoor temperature reset when the climate is warmer than design (worst case) conditions.
- Replace 80% efficient Hydrotherm boilers with high efficiency condensing boilers, provided a return temperature below 130 °F can be maintained for a majority of the year. Condensing boilers can be 90-95% efficient.
- Adjust the 600 Building boiler's hydronic loop setting to allow the Benchmark boilers to condense more based on outside temperature.

CHILLER SYSTEM

 Add VFDs to the 100 Building pumps and open the throttling valves to 100%. VFDs can also be used optimize temperature set points and increase system efficiency by actively changing the flow rate to the minimum necessary. Chilled water pumps typically have the most rapid payback. Other campuses have realized a payback of less than 2 years with incentives.

a. Installing a VFD and controlling to 70% flow rather than throttling using a multi-purpose valve could yield over \$4,000 a year per a 15 HP pump if operated 4,000 hours per year.

- Replace chillers at near end of life with new high efficiency variable speed ASHRAE 90.1 complaint chillers.
- Add a heat exchanger so "free cooling" can be taken advantage of by using the cooling tower to cool without the chiller (many newer chillers have an economizer mode where an additional heat exchanger is not needed).
- Employ a cooling water temperature reset strategy so the water temperature is only as cool as needed by the building.
- Consider using chiller leaving condensing water for building heat (capable of 140 °F) if cooling loads extend into heating season.

HVAC AIR SIDE

- Install central HVAC to provide zones and occupancy based ventilation for each perimeter office in the 100 Building, eliminating the small terminal units.
- Upgrade air handling units with VAV and DDC in the 100 Building if a 5 year or less payback can be realized.

Implement a fume hood sash management program to ensure that hoods are closed and turned off when not in use. The program should focus on achieving the desired sash face velocity when in use and saving energy by properly closing or shutting down.

2.7 LIGHTING

2.7.1 CURRENT CONDITIONS

Tunxis utilizes lighting controls for about 95% of its classrooms. However, lighting in buildings are outdated, even in the most recent construction since the technology improves faster than the state's current design/build process. There are plans to upgrade parking lot lighting in September 2016, with incentives through Eversource. The project will occur in three phases to replace 23 access lights. Unfortunately, bollard lights are not incentivized by Eversource.

Tunxis is also looking to replace lights at their cyber café in the Library. Hurdles first need to be cleared with the rebate on fixtures in the cyber café since the specific LED replacements are not in the list of covered lighting by Eversource. It is estimated about 70% lighting will be upgraded before the end of 2016.

2.7.2 RECOMMENDATIONS

LED lighting upgrades may provide the single largest long term savings for the campus. Although the majority of the campus has lighting controls, the settings should be reevaluated for this building to rely on occupancy and signage should encourage turning off lights without controls.

All lighting upgrades should continue to be coordinated with Eversource to help maximize the return on investment. The campus should consider the following recommendations:

- Conduct a lighting and controls audit, combining with existing building commissioning.
- Integrate BMS lighting schedules with classroom and • building schedules.
- Use more occupancy based controls in addition to scheduled timers where scheduling is difficult.

2.8 BUILDING ENVELOPE

2.8.1 CURRENT CONDITIONS

Tunxis has a variety of building construction types ranging from typical 1960s CMU to modern steel and glass ASHRAE 90.1

The oldest campus buildings include 100, 200, and 300 and were the focus for the walk through. The 100 building has an energy efficient construction with little unused space. The 200 building at one time was a strip mall and still has many of the characteristics such as high ceilings.

2.8.2 RECOMMENDATIONS

A possible solution to the large amount of air flow in the 200 building is to add drop ceilings which reduce the amount of conditioned air, if there is an existing return air ducted system. Building envelope upgrades would also help to eliminate the 200 Building's energy intensive electric ice-melt system. The campus should consider other building envelope upgrades such as insulation improvements at the Farmington House.

2.9 DISTRICT ENERGY / COGENERATION

2.9.1 CURRENT CONDITIONS

There is no district energy or cogeneration at Tunxis.

2.9.2 RECOMMENDATIONS

As there is limited thermal use in the summer from CHP, a CHP application is unlikely to provide additional benefit over the existing boilers.

2.10 RENEWABLE ENERGY

2.10.1 CURRENT CONDITIONS

Tunxis has not implemented any renewable energy projects on campus.

2.10.2 RECOMMENDATIONS

05 SYSTEM LEVEL RECOMMENDATIONS Tunxis' campus is relatively concentrated, centered around the connected main buildings. There are some small south facing portions for solar on the Library, which would result in a minor array. The remaining rooftops have limited opportunities due to mechanical equipment obstructions, roof ages as well as plans for potential demolition (200 building). Similarly, there are not feasible possibilities for ground-mount due to lack of open space. Tunxis may have an opportunity for solar parking canopy structures over their three parallel parking lots (Figure 2.6). The large area provides over a megawatt of solar kW potential, if covering the entirety of the space. The campus should consider solar in future development plans, incorporating solar in the capital planning process.

Campus Area	Land Area via Google Maps	Array Size Potential (kW DC)[1]	Annual Generation Potential (MWh)[2]	Solar Suitability Comments
		HIGH PRIORITY PROJECTS	S	
Parking Lot	228,261	1050-1370	1370-1758	Parking Lot Canopy
Total	228 261			

TABLE 2.2: Tunxis Potential Area for Solar PV

[1] Assumes that each of panels can generate between 4.6 and 6 Watts DC (about a third of the PVWatt Output Assumptions). Actual generation values would be

[2] Assumes that each sf of panels can generate between 6 and 7.7 kWh annually (about a third of the PVWatt Output Assumptions). Actual generation values would be calculated if a solar PV study was performed.



FIGURE 2.6: Tunxis Campus Solar Potential

2.11 CAPITAL PLANNING

2.11.1 CURRENT CONDITIONS

Tunxis is in the midst of a continuing campus development project. The most recent portion of the project was completed in 2013 with the expansion of the 600 building, adding an additional 56,000 square feet. The expansion is LEED certified featuring 20 new general classrooms and office space. Tunxis is scheduled to replace the 200 Building's roof soon.

Tunxis receives states bond funds for new construction, technology infrastructure, technology replacement, and deferred maintenance for the physical plant.

The System Office also provides annual code compliance and infrastructure funds. As of FY 2015, larger capital projects can be funded under CSCU 2020. Project completion is also aided with outside resources, in particular the incentives offered by the campus' utilities.

More information on campus expansion projects is found in Section 3.1.

2.11.2 RECOMMENDATIONS

Tunxis should continue to collaborate with Eversource for all major building renovations and all new construction.

2.12 COLLABORATION / PARTNERSHIP

2.12.1 CURRENT CONDITIONS

Tunxis participates in weekly energy calls with their electric utility, Eversource. The partnership has helped to foster implementation of projects, such as the parking lot lighting upgrades planned for completion in 2016. They are also working with Eversource to recommission the entire campus. The relationship with Eversource's Farmington contact has been a helpful resource, according to the campus.

Another resource for the campus is the CSCU Facilities Department. CSCU is available to provide assistance in budgeting, capital planning and technical support for the community college projects, including Tunxis.

2.12.2 RECOMMENDATIONS

Tunxis should continue to develop their partnership with Eversource and work with Eversource to take advantage of Utility Incentives for the EEMs presented in this plan. Incentives structures range and vary by program, but Eversource has offered incentives of up to 80% of project costs in the past.

2.13 SUMMARY OF RECOMMENDED ENERGY EFFICIENCY OPPORTUNITIES

As a result of the campus walk through energy assessment, and interviews with campus staff, a list of potential Energy Efficiency Measures (EEMs) is presented in Table 2.3. These projects represent both low cost, immediate action measures, as well as projects that may require larger capital and therefore be longer-term.

Many energy-related projects are incentivized through utility rebates. Tunxis' electric utility is Eversource. With Eversource, the campus can maximize incentives by combining multiple energy saving opportunities in what is known as a "Comprehensive Project." The primary advantage of a Comprehensive Project is the maximum incentive cap is normally raised from 40% to 50%. Eversource has maximized these incentives in the past, and may also in the future, in the following ways:

- The comprehensive cost caps was increased from 50% to 80% of total cost.
- The incentive was increased from \$0.30/kwh or \$3.50/CCF (with 40% cost cap) to \$0.40/kwh or \$4.00/CCF (with 60% cost cap).

Since incentives are based on incremental energy savings; further analysis and collaboration with Eversource will be required to determine rebate amounts for each opportunity. To help Tunxis navigate and prioritize the energy opportunities identified, a summary of opportunities is listed in Table 2.3. Immediate action should be taken to consider priority one and two opportunities with the goal of combining multiple opportunities for a Comprehensive Project. The simple payback in most cases cannot be reasonably estimated without detailed building models and/or more operating data. The payback periods provided are based upon the performance of past similar projects and are not necessarily indicative of future results.

02 SYSTEN LEVEL EXISTING CONDITIONS

03 SYSTEM LEVEL ENERGY NEEDS

06 CAMPUS



Opportunity ID	Energy Conservation or Efficiency Opportunity	Associated Building if Applicable	App. Cost (Before Reba	Payback w/rebate ite) (Years)	Priority
TCC-1	Upgrade boiler room pumps to premium efficiency and add VFDs (7.5HP).	Academic East (200 Building)	\$ 17,0	000 1.5 - 3	1
TCC-2	Add variable speed drives to chilled water loop piping (15HP).	Academic East (200 Building)	\$ 26,0	000 1.5 - 3	1
TCC-3	Adjust the boiler hydronic loop setting to allow the Benchmark boilers to condense more based on outside temperature.	Academic Building (600 Building & Extension)	None	Instantaneo us	1
TCC-4	Replace all building lighting with LED	All	Varies, requi a lighting specific aud	res 2 - 6 lit	1
TCC-5	Replace parking lot lights with LED and upgrade controls.[1] (This measure was in progress during the production of the report)	Exterior	Varies, requi a lighting specific auc	res 2 - 6 lit	1
TCC-6	Replace constant volume air handlers with newer VAV equipment	Faculty/Student Services (100 Building)	\$ 309,0	00 Varies	2
TCC-7	Consider replacing cast iron 80% efficient Hydrotherm boilers with newer 90% - 96% efficient condensing units in near term	Academic East (200 Building)	\$18/MBH +installatio	n Varies	2
TCC-8	Consider adding a heat exchanger to allow free cooling in shoulder months	Academic East (200 Building)	\$ 358,0	000 Varies	2
TCC-9	Evaluate building envelope improvements to eliminate the electric ice-melt system, or convert to hot water for use with condensing boilers	Academic East (200 Building)	Varies	Varies	2
TCC-10	Drop ceiling to reduce conditioned space	Academic East (200 Building)	Varies	Varies	2
TCC-11	Use more occupancy based controls vs timer based	Academic West (300 Building)	\$1 per sq.f covered or average	t. v Varies	2
TCC-12	Install central HVAC to provide zones and occupancy based ventilation for each perimeter office.	Faculty/Student Services (100 Building)	Varies	Varies	3
TCC-13	Consider using chiller leaving condensing water for building heat (capable of 140 °F) if cooling loads extend into heating season	Faculty/Student Services (100 Building)	Varies	Varies	3

TABLE 2.3: Tunxis Recommended Energy Efficiency Measures

[1] The Department of Energy (DOE) provides a comprehensive guide for purchasing energy efficient lighting as well as demonstrating cost effectiveness of lighting solutions, here: http://energy.gov/sites/prod/files/2014/02/f7/parking_lots_guide.pdf

ENERGY NEEDS

3.1 FUTURE DEVELOPMENT

Energy patterns on campus may change with plans for campus expansions and improvements. Given funding availability, future development plans may include Phase 3 construction. Plans for the phase include replacing the 200 Building with a new 2-story building. The faculty wing will also be demolished and replaced with an auditorium. The building is expected to meet LEED Silver standards or equivalent. This type of project may improve the overall energy consumption of the campus, as the large ceilings of the building are inherently energy inefficient. There are plans for reorganization of space in the near term, by moving all employees in Bidstrup Hall to the third floor of the 600 Building. Bistrup Hall will be less utilized in the future, with approximately only 4 fulltime staff using the building. There was discussion about moving Continuing Education services to the first floor of Bidstrup Hall, but there are not definitive plans. Based on future plans, current mechanical systems will support campus activities. With campus expansions, Tunxis should continue to deploy decentralized equipment to serve heating and cooling needs.

As the campus landscape changes, it is important to be able to support the electric needs in case of power outages and unreliable energy situations. Tunxis should consider installing back-up generators for campus operational support.

3.2 ENERGY RESILIENCY RECOMMENDATIONS

Tunxis partook in system-wide hazard mitigation initiative. The CSCU Multi-Hazard Mitigation Plan provided recommendations surrounding energy resiliency that are also applicable for the Energy Master Plan.

- Purchase and install emergency generators fueled by natural gas
- Upgrade lightning protection and add to buildings without • them
- Install and maintain surge protection on critical electronic • equipment

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CONCLUSION / NEXT STEPS

Tunxis stakeholders are involved in projects that will improve the campus energy profile by upgrading lighting and altering the BMS system. The campus' above average EUI suggests that additional improvements will be beneficial to the campus. The largest areas for improvement include upgrades of existing systems, such as more efficient boiler room pumps, VFDs, and newer VAV equipment. Lighting upgrades are also a low hanging fruit. Other top priority initiatives include:

- *Management:* Consolidating BMS systems and optimizing use.
- *Renewable Energy:* Explore PPAs for the campus parking lot.
- Utility Incentives/ Develop Plan for EEMs: Tunxis should maximize incentive funding for EEMs by working with Eversource, and combining multiple energy saving opportunities in what is known as a "Comprehensive Project." Further analysis and collaboration with Eversource is required to determine rebate amounts for each opportunity.

A summary of further projects and priorities for the campus are listed in Table 2.3. By implementing the recommended measures, Tunxis has an opportunity to add local electricity generation on campus, participate in needed upgrades and lower overall energy use.

4.1 CONTACT INFORMATION FOR KEY STAKEHOLDERS

Collecting all the necessary information for this planning effort required a collaborative effort. Below are the stakeholders that were active in providing their expertise about campus current conditions and future needs, and energy related decisions.

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APPENDIX A: TUNXIS DATA METHODOLOGY, ASSUMPTIONS AND NOTES

The following are the data methodology and assumptions that were used when analyzing and benchmarking data for Tunxis:

All three fiscal years have complete consumption data. No information to indicate that the campus uses propane, purchased chilled water or steam.

Electricity: Energy Summary (FY13,14,15)

- Not all of the accounts were able to be lined up with their respective buildings. Given the renovations to the campus and the layout of the buildings, it was unclear if an electric meter served one building or metered electricity from various parts of buildings as a remnant from prior construction. For instance, a meter could meter Building 100 only, or meter Building 100 and parts of Building 200.
- The campus total (general information row) equals the sum of the accounts in the Energy Summary excel file excluding the two accounts located in the towns of Bristol and Fairfield because these would definitely not serve any of the buildings under consideration.
- Several accounts in the Energy Summary have no consumption values. These accounts are unable to contribute to the campus EUI calculations until this information is provided.

Natural Gas: Energy Summary (FY13,14,15)

- Natural gas is similar to electricity in that none of the accounts were able to be lined up with buildings, due to layout of buildings. The campus total (general information row) equals the sum of the accounts in the Energy Summary. No accounts needed to be excluded because all the street addresses were for the main campus.
- A single account of gas supply charges from Direct Energy was available. It was assumed that the supply charge combined all • four campus meters together.

Fuel Oil: Energy Summary (FY13,14,15)

The specific building(s) that use the fuel oil were not specified. Annual consumption was just added to the campus total.

SYSTEM LEVEL

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