6.15

SOUTHERN CONNECTICUT STATE UNIVERSITY

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

The Southern Connecticut State University (Southern) Energy Master Plan aims to identify ways Southern can improve energy use on campus, and be an active participant in Connecticut State Colleges and Universities (CSCU)'s energy management, reduction and conservation efforts. Southern adopted a Climate Action Plan in 2009, exemplifying its commitment to energy conservation and sustainability. The campus completed a number of significant energy projects to date including retrocommissioning, multiple lighting re-lamping and re-ballasting and other energy conservation projects. Based on the utility data, Southern has the second smallest site energy use intensity of the CSCU universities, at 110 kbtu/sq ft. (see Figure 1 Southern Energy Dashboard). The energy use intensity (EUI) method is used for benchmarking and comparison purposes.

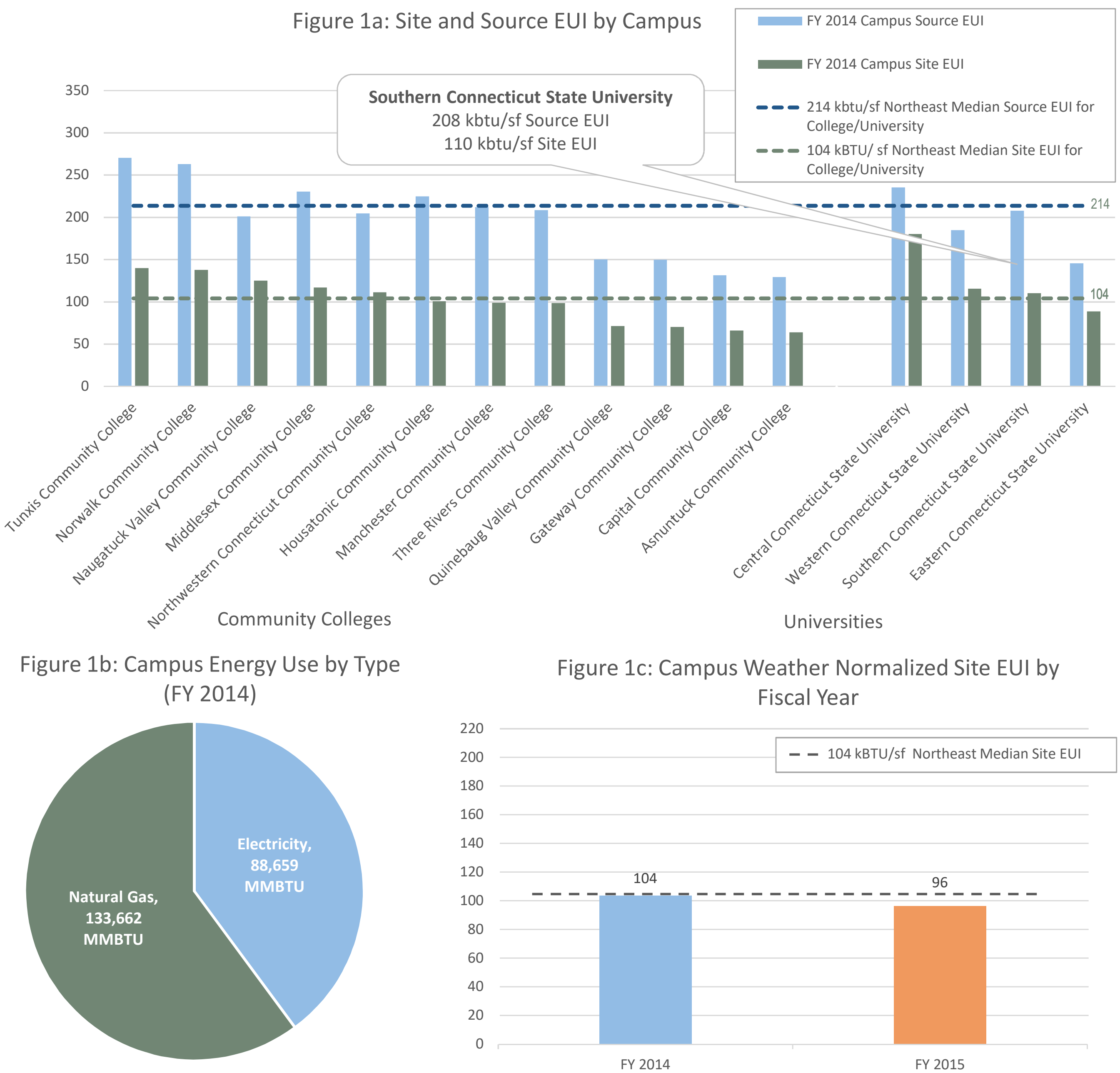


FIGURE 1: Southern Connecticut State University Energy Dashboard

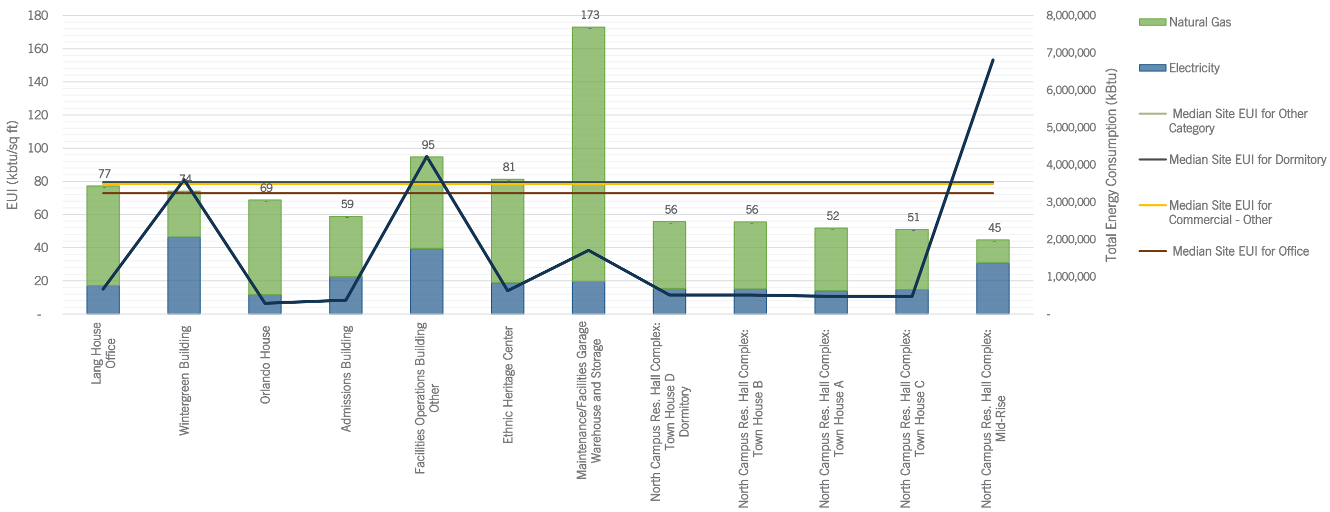


FIGURE 2: Site EUI by Building (FY 2014)

Only buildings with both electricity and fuel submetering data are shown; Southern's many buildings with unmetered steam and hot water heating distribution systems are not shown in the building level EUI figure.

Energy Spending

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

	Southern Connecticut State University	Average of CSCU University	Average of CSCU Community College	Northeast Region Commercial Sector
Cost per Square Feet	$ 2.23	$ 2.08	$ 2.49	$ 1.67
Cost per FTE Student	$ 522	$ 677.00	$ 311	$ -
Avg. Cost per kWh Electricity from Grid	$ 0.14	$ 0.14	$ 0.14	$ 0.15
Avg. Cost per MMBtu Natural Gas	$ 7.23	$ 7.32	$ 10.06	$ 10.03
Total Operating Expenses	$ 215,469,423	$ -	$ -	
Total Energy Spending	$ 4,611,016	$ -	$ -	
% of Operating Expenses	2.14%	2.67%	1.95%	

TABLE 1: Energy Cost Comparison (FY 2014)

Most of Southern's data are consistent with or below the average of the CSCU campuses, while natural gas unit costs are above the average CSCU universities unit cost. A pertinent measurement of energy intensity is cost per square foot; Southern spent less per square foot in FY14 than the average of the CSCU universities. The cost per FTE is above the average of the CSCU campuses. This may be attributed in part to Southern's expansive campus, as well as having buildings, such as residence halls, with longer operational schedules than academic or administrative buildings.

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

Both of Southern' s utilities are through United Illuminating (UI). 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 UI is required to determine rebate amounts for each opportunity. Table 2 demonstrates a summary of the Energy Efficiency Measures (EEMs) recommended for Southern to pursue.

Opportunity ID	Energy Conservation or Efficiency Opportunity	Associated Building if Applicable	App. Cost (Before Rebate)	Payback w/rebate (Years)	Priority
SCSU-1	Implement a steam trap maintenance program.	East Campus	$15 / trap surveyed + repair costs	<1 - 2	1
SCSU-2	Continue recommissioning (in progress).	All	$0.50 - $3.50 /sf ($60k for continuous Cx)[1]	Varies	1
SCSU-3	Optimize BAS with Continuous Cx practices.	All	$20k/ 100k sf / year	Varies	
SCSU-4	Consolidate course offerings to certain buildings to reduce energy consumption at times of lower occupancy (in progress).	All	Varies	Varies	
SCSU-5	Explore use of BAS for capacity charge and demand response management.	All	Administration Time	2016-2017 estimated savings of $9.86/kW-month	
SCSU-6	Implement fume hood sash management as a part of a fume hood sash management campaign with goal to instill an energy efficient culture.	Various	Minimal	Varies	1
SCSU-7	Install variable speed drive for control of fume hoods in Science Labs. Also explore adding heat recovery coils if used frequently.	All	Varies	2 - 5	1
SCSU-8	Install variable speed drives. Fund with UI rebate program (in progress).	All	Varies	2 - 5	1
SCSU-9	Investigate roof-top solar PV opportunities, specifically with new construction or roof renovations, in addition to pending PPA for the Lot 9 PV array. Also investigate ground mount and additional solar canopies.	All	PPA	PPA	1
SCSU-10	Enable trending of energy data through BAS for future benchmarking and EEM savings estimates. Store at least 2-years' worth of data in 15-minute increments.	All	Varies	Varies	1
SCSU-11	Convert 1500-watt metal halide fixtures to LEDs.	Jess Dow Field	Varies	Varies	1
SCSU-12	Creation of an internal policy to promote lighting through motion sensors.	All	Administration time	Minimal	1
SCSU-13	Replace existing lighting with LED.	Pelz Gymnasium	Varies	2 - 6	1
SCSU-14	Change 250-watt metal halide fixtures in LED.	Earl Hall	Varies	2 - 6	1
SCSU-15	Replace existing fixtures with LED in lecture spaces.	Davis Hall	Varies	2 - 6	1
SCSU-16	Increase occupancy based lighting (and ventilation) controls.	Campus	Varies	Varies	2
SCSU-17	Focus energy efficiency projects on buildings with a high EUI and a high total energy consumption.	All	Varies	Varies	2
SCSU-18	Lower temperature and use natural gas infrared heaters with infrared thermostats in maintenance shops and garages.	Maintenance/Facilities Garage	Varies	3 - 6	2
SCSU-19	Add insulation around HTHW valves and fittings.	Connecticut Hall	Varies	1 - 2	2

SCSU-20	Explore or conduct a further study for a 600 kW Internal Combustion CHP engine at the Energy Center, near 600 kW. The system should be sized for year-round operation, and may possibly include a thermal buffer tank. The campus should also explore capturing additional benefits from CHP like reduced natural gas pricing with the LDC waiver. [1]	Energy Center	Varies, $3k - $4k per installed kW capacity	Varies	2
SCSU-21	Upgrade mechanical systems upgrade, including an AHU replacement	Lyman Center for the Performing Arts, Davis Hall	Varies	Varies	2
SCSU-22	Replace all 7 AC units with more efficient models.	Moore Field House	Varies	Varies	2
SCSU-23	Complete a mechanical and electrical systems upgrade, dependent on Master Plan and fate of the building.	Pelz Gymnasium	Varies	Varies	2
SCSU-24	Straightlines: Complete an electrical systems upgrade and a mechanical systems upgrade and piping for AC	Campus	Varies	Varies	2
SCSU-25	North campus mechanical upgrade w/ wireless BAS controls.	North Campus	Varies	Varies	2
SCSU-26	Add ventilation heat recovery for art spaces with high operating hours.	Various	$2 per CFM of capacity	Varies	3
SCSU-27	Connect new buildings to west campus loop (previously recommended).	Future	Varies	Varies	3
SCSU-28	Preheat DHW using condensate return from steam loop.	East Campus	Varies	Varies	3
SCSU-29	Explore ~150 kW backpressure turbine after steam generator on East Steam Loop and connect extra 40 MMBtu Boiler at Energy Center.	East Steam Loop	Varies	Varies	3
SCSU-30	Install Heat Recovery Ventilator (HRV) for pool ventilation and dehumidification, if pool continues to be used (Pelz Gymnasium may be taken offline).	Pelz Gymnasium	$2 per CFM of capacity	Varies	3
SCSU-31	Install condensing economizer on central heating plant boilers and supply low temperature hot water to nearby or new buildings.	Energy Center	$350,000, N.I. demand side modifications	9-10 based on UC Davis and JAX studies	3
SCSU-32	Increase HVAC zoning and/or add individual room controls to BAS.	Various	Varies	Varies	3
SCSU-33	Replace older cooling equipment, especially those greater than twenty years old. Consider replacing DX units with new variable speed compressor units or installing a central water cooled chiller plant when infrastructure permits.	Various	Varies	Varies	3
SCSU-34	Upgrade building envelope including window replacements	Earl Hall	Varies	Varies	3

TABLE 2: Southern Energy Efficiency Measures

In addition to the suggested EEMs, next steps for Southern are below:

Next Steps

Management

Southern maintains a cross-department energy management effort, including working with administration to control summer programs and space use. The campus can expand this effort by working with residence advisors and other on campus groups to educate about the importance of energy management. Southern should continue to monitor building level energy use, including tracking energy use and comparing energy spend to available budgets. The campus should also expand training and staffing capabilities for increased management of BAS controls and advance existing building recommissioning plans and policies. Southern should also focus on managing demand costs on campus, including informing students and faculty of the benefits of curbed consumption during peak times.

Renewable Energy

Southern should continue to explore work with CSCU to implement Power Purchase Agreements (PPAs) for rooftop solar and/or ground mounted arrays. CSCU has received favorable pricing for PPA projects with possible discounts on the order of 20% to 50% of purchased power costs. Solar PV should also be incorporated into future capital planning building design. Southern should also continue to strategically plan for solar locations based on meter sizing and application into the Connecticut Zero Emissions Renewable Energy Credit (ZREC) programs.

Alternative Energy

Southern should further explore the addition of Internal Combustion CHP engine at the Energy Center. A unit sized for year-round operation is suggested, near 600 kW, with the final size and feasibility based on further study. The addition of a CHP unit would also assist with reducing peak demand in the summer months.

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

INTRODUCTION

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

FIGURE 1.1: Southern Buley Library

1.1 SOUTHERN OVERVIEW

Southern is one of four state universities in the Connecticut State Colleges and Universities, located in the City of New Haven, Connecticut (New Haven County), at 501 Crescent Street. In the fall of 2015, Southern enrolled 10,473 students (8,106 undergraduate and 2,367 graduate students)[1], 440 full-time faculty members and an additional 512 part-time lecturers.[2] The campus has 2,617 students in on-campus housing, which represents 38% of the student body.[3]

Southern consists of three campuses- East Campus, West Campus, and North Campus. The three campuses are all connected and situated along Fitch Street (Route 10), Crescent Street, Wintergreen Avenue, Farnham Avenue, and Pine Rock Avenue. Southern is comprised of a total of 171 acres featuring 13 residence halls, an art center, a student center, a central dining hall, a library, an athletic complex, and 21 other administrative and classroom buildings. The campus also features sports fields, 12 main parking lots, and 3 parking garages. Many of Southern's building's hot water and heating needs are supported by the Energy Center on North Campus.

Table 1.1 summarizes the list of existing buildings on the East, West, and North campuses.

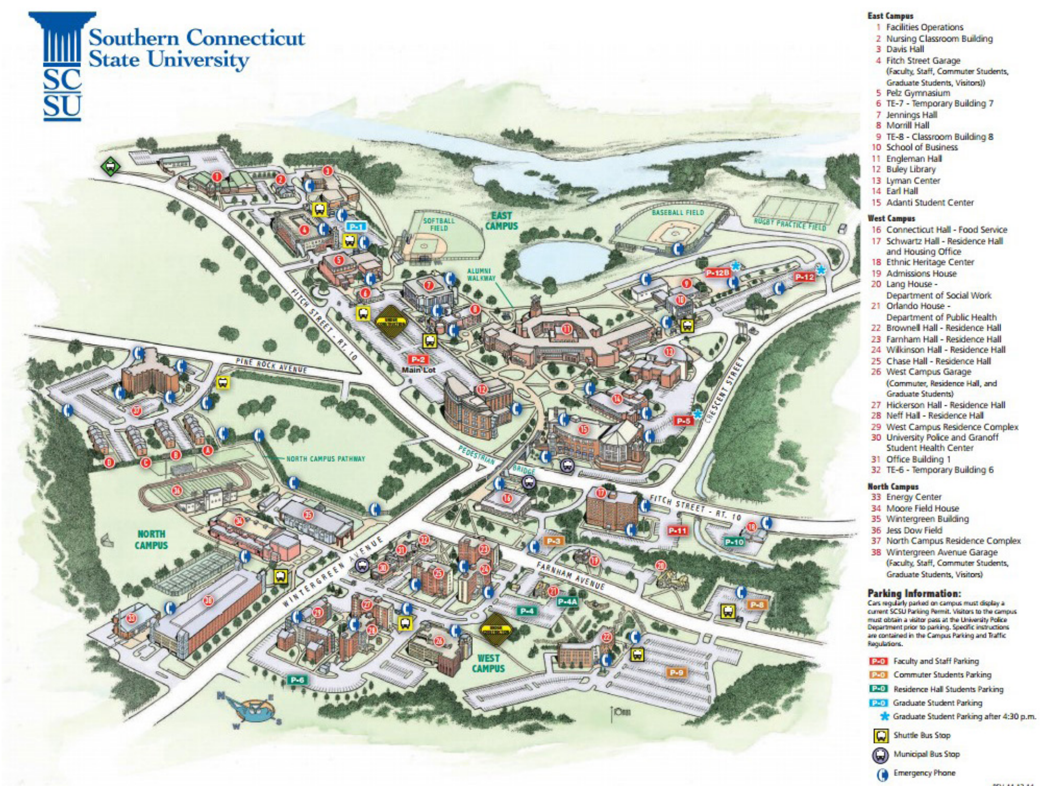


FIGURE 1.2: Southern Campus Map

[1] Southern Connecticut State University. "Fall 2015 Enrollment Information." Web. 10 February 2016. http://www.southernct.edu/offices/management/currentenrollment.html
[2] Southern Connecticut State University "Part-Time Faculty Headcount &FTE by Year." Web. 10 February 2016. http://factbook.southernct.edu/faculty_part_time_headcount_fte_fall.html
[3] Southern Connecticut State University "Campus Housing by Year." Web. 10 February 2016. http://factbook.southernct.edu/campus_housing_fall.html

Campus	Building	Year Built [Renovated]	Gross Square Feet	Building Function
East Campus	Academic Laboratory and Science Building*	2015	103,608	Academic with labs
East Campus	Buley Library	1968 [2015]	249,412	Academic
East Campus	Davis Hall	1969 [1998]	49,614	Academic
East Campus	Earl Hall	1960 [1992]	46,027	Academic
East Campus	Engleman Hall	1953 [2004]	224,599	Academic
East Campus	Facilities Operations Building	2000	44,609	Facilities
East Campus	Jennings Hall	1982	130,026	Academic
East Campus	Lyman Center for the Performing Arts	1967 [1994]	53,058	Academic/Arts
East Campus	Maintenance/Facilities Garage	2000	9,855	Facilities
East Campus	Michael J. Adanti Student Center	2006	129,607	Mixed Use
East Campus	Morrill Hall	1959 [1990]	42,050	Academic
East Campus	Nursing Building	2005	5,000	Academic
East Campus	Pelz Gymnasium (including Pelz Storage Building)	1952 [1993]	71,211	Athletic
East Campus	Student Center (School of Business)	1958 [1959]	100,293	Academic
East Campus	Temporary Bookstore (TE-8)	2001 [2006]	4,961	Other
West Campus	Admissions Building	1900 [1997]	6,299	Office/Administration
West Campus	Connecticut Hall	1973 [1994]	45,569	Dining
West Campus	Ethnic Heritage Center	1970	7,690	Office/Administration
West Campus	Granoff Hall/Police Station/Health Services	1972 [1995]	10,874	Police Building
West Campus	Lang House	1903 [1993]	8,661	Office/Administration
West Campus	Office Building 1 (OB1)	2006	12,000	Office/Administration
West Campus	Orlando House	1890	4,188	Office/Administration
West Campus	Temporary Office Building 6 (TE-6)	2001	6,128	Academic
North Campus	Energy Center	2003	16,580	Facilities
North Campus	Moore Field House	1976 [1996]	145,992	Athletic
North Campus	Wintergreen Building	1994	48,551	Office/Administration
North Campus	Jess Dow Field	1991	1,346	Athletic
Subtotal			1,577,808	
Residential Buildings				
West Campus	Brownell Hall	1982 [1998]	67,157	Residence Hall
West Campus	Chase Hall	1967 [1998]	59,266	Residence Hall
West Campus	Farnham Hall	1964 [1995]	57,047	Residence Hall
West Campus	Hickerson Hall	1967 [1996]	59,266	Residence Hall
West Campus	Neff Hall	1969 [1996]	48,150	Residence Hall
West Campus	Schwartz Hall	1957 [1995]	22,973	Residence Hall
West Campus	West Campus Residence Complex	2004	112,722	Residence Hall
West Campus	Wilkinson Hall	1965 [1998]	63,828	Residence Hall
North Campus	North Campus Res. Hall Complex: Mid-Rise	1985 [1992]	152,517	Residence Hall
North Campus	North Campus Res. Hall Complex: Town House A	1991 [1992]	9,165	Residence Hall
North Campus	North Campus Res. Hall Complex: Town House B	1991 [1992]	9,165	Residence Hall
North Campus	North Campus Res. Hall Complex: Town House C	1991 [1992]	9,165	Residence Hall
North Campus	North Campus Res. Hall Complex: Town House D	1991 [1992]	9,165	Residence Hall
Residence Hall Subtotal			679,586	
Building Total GSF			2,257,394	
Garages				
East Campus	Fitch Street Parking Garage	2000	193,605	Parking Garage
West Campus	West Campus Parking Garage	2004	148,098	Parking Garage
North Campus	Wintergreen Parking Garage	2013	355,172	Parking Garage
Parking Garage Subtotal			696,875	

TABLE 1.1: Southern Campus Building Information

1.2 PREVIOUS ENERGY STUDIES & PROJECTS

Southern takes pride in its campus sustainability efforts and commitment to achieve carbon neutrality by or before 2050. In 2008, Southern signed the Second Nature Climate Leadership Commitment. The program now includes a pledge for climate resilience planning and implementation, which Southern signed. According to the campus, by implementing energy projects, primarily related to switching from fuel oil to natural gas, has led to overall greenhouse gas emission reductions of 1.5%. The reductions occurred even considering a significant increase in gross square feet of additional building expansions. The campus is working on an interim 2020 goal of 20% reduction below 2007-09 baseline in scope 1 and 2 greenhouse gas emissions, aided by plans for onsite solar power.

Southern received the Sustainable Endowments Institute (SEI) and Green Revolving Investment Tracking System (GRITS) first place award for the recommissioning of Adanti Student Center in 2015. Adanti Student Center was awarded for the highest average annual energy savings in a single project for a mid-sized institution. Southern was also nominated for the EBie Award by U.S. Green Building Council for the Adanti recommissioning effort.

Southern has also received recognition for its energy efforts. In 2015, the Princeton Review recognized Southern as one of 332 most environmentally responsible colleges and the University earned statewide recognition when it received the Power of Change Top Building Innovation Award. The new award recognizes state energy efficiency projects, and Southern was among seven awardees. Southern earned the award for its efforts to reduce electricity in nine residence halls during a nationwide electricity and water reduction competition, the College Conservation Nationals (CCN) .

To achieve climate action goals, strategic goals and to recognize savings from utility energy consumption, Southern has completed multiple energy projects and initiatives. The list below provides examples of completed and ongoing projects. Appendix B presents a list of the additional numerous lighting upgrades and residence hall conservation efforts.

CHP

Description: Performance Cogeneration study
Year: 2015
Associated Building: All

SOLAR

Description: Feasibility study for onsite solar through United Illuminating's Business Sustainability Challenge.
Year: 2015
Associated Building: All

Description: RFP for 1 MW solar on campus
Year: In Progress
Associated Building: All

BAS/BMS

Description: Implementation of BAS setbacks for night temperature, lighting based on occupancy schedules and with building HVAC.
Year: Ongoing
Associated Building: All

Description: Optimize BAS
Year: In Progress
Associated Building: All

CAPITAL PLANNING / STRATEGIC

Description: Pursuing incorporating revolving utility rebates into energy projects to accelerate efficiency on campus.
Year: Ongoing
Associated Building: All

Description: Efforts to reduce peak demand
Year: Ongoing
Associated Building: All

Description: Interior renovations
Year: 2015
Associated Building: Wintergreen Building

Description: Completed building renovations
Year: 2012
Associated Building: Farnham Hall

RETROCOMMISSIONING

Description: Ameresco recommissioning projects and reports for optimizing building controls; Recommissioning effort for entire campus
Year: Ongoing
Associated Building: All

Description: Recommissioned building equipment
Year: 2015
Associated Building: Engleman Hall

Description: Recommissioned building equipment
Year: 2014
Associated Building: Adanti Student Center

RENEWABLE ENERGY

Description: Instal solar PV
Year: Planned/Future
Associated Building: All

ENERGY CONSERVATION

Description: Consolidate course offerings to certain buildings to reduce energy consumption at times of lower occupancy.
Year: In Progress
Associated Building: All

Description: Installed low flow showerheads.
Year: 2014
Associated Building: Brownell Hall

Description: Purchased Energy Star rated appliances.

HVAC AIR SIDE

Description: Install variable speed drives.
Year: In Progress

LIGHTING

Description: Replace existing lighting with LEDs.
Year: In Progress
Associated Building: North Campus Res. Hall
Schwartz Hall
Neff Hall
Remaining Parking Garages
Classrooms and Exterior Lighting

Description: Replace existing lighting with LEDs.
Year: 2013
Associated Building: Energy Center

Description: Replace existing lighting with LEDs.
Associated Building: Wintergreen Parking Garage
West Campus Residential Complex

Description: Installed CDM and LED lighting
Associated Building: West Campus Parking Garage

Description: Installed T5 fluorescent bulbs, induction lighting, and LEDs
Associated Building: Pelz Gymnasium

Description: Upgraded lighting
Associated Building: Adanti Student Center

Description: Installed T-5 fluorescent bulbs with sensors
Year: 2014
Associated Building: Moore Field House

CHILLER SYSTEMS

Description: Installed new chiller
Year: 2016
Associated Building: Student Center (School of Business)

Description: Installed new chiller
Year: 2014
Associated Building: Lyman Center for the Performing Arts

LEED

Description: LEED gold/silver certification
Year: 2015
Associated Building: Academic Laboratory and Science Building

Description: LEED gold/silver certification
Year: 2012
Associated Building: Schwartz Hall

BUILDING ENVELOPE

Description: Roof replacement
Year: 2015
Associated Building: Lang House

Description: Roof Replacement
Year: 2014
Associated Building: Moore Field House

OTHER

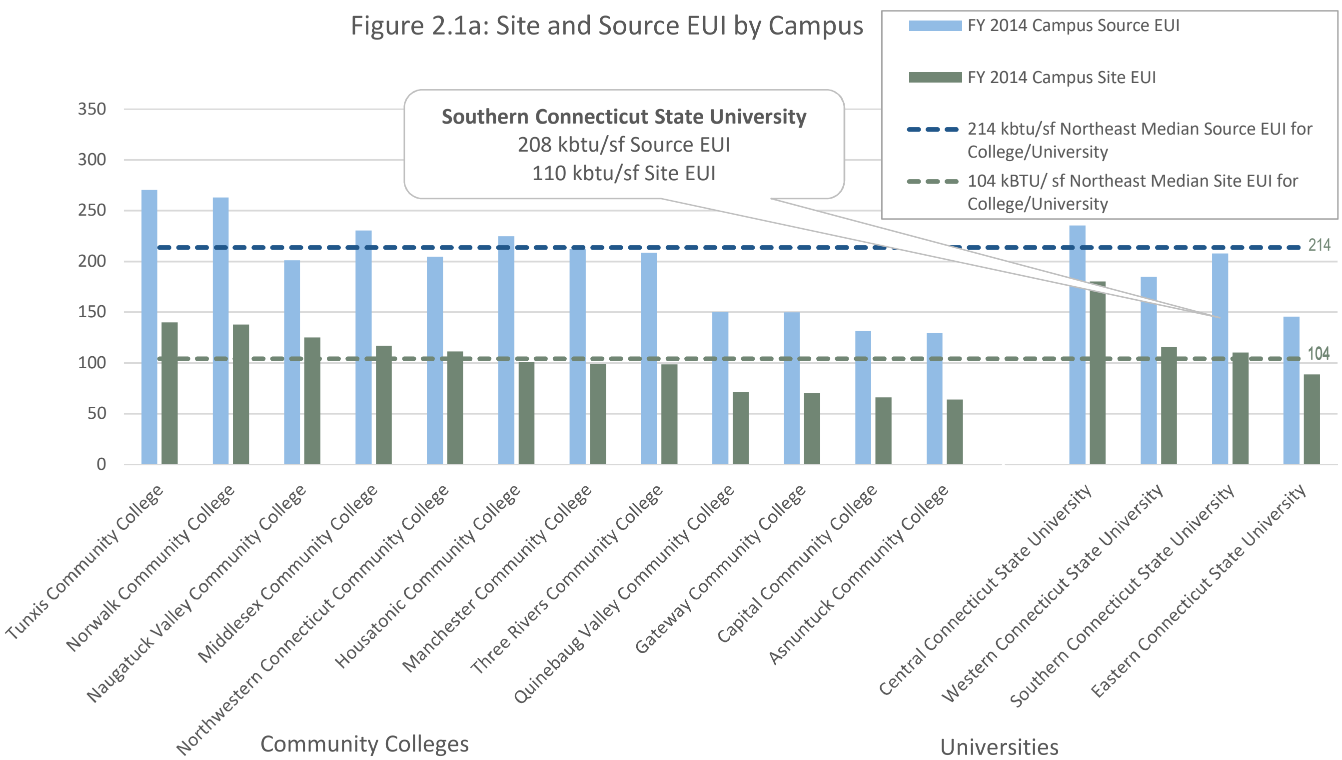
Description: Upgraded electrical systems
Year: 2012
Associated Building: Jennings Hall

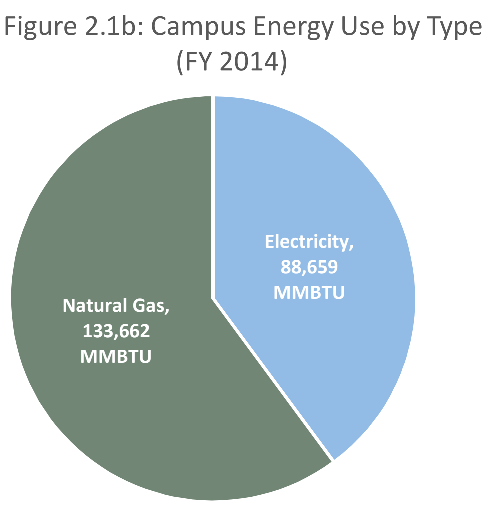
EXISTING CONDITIONS & RECOMMENDATIONS

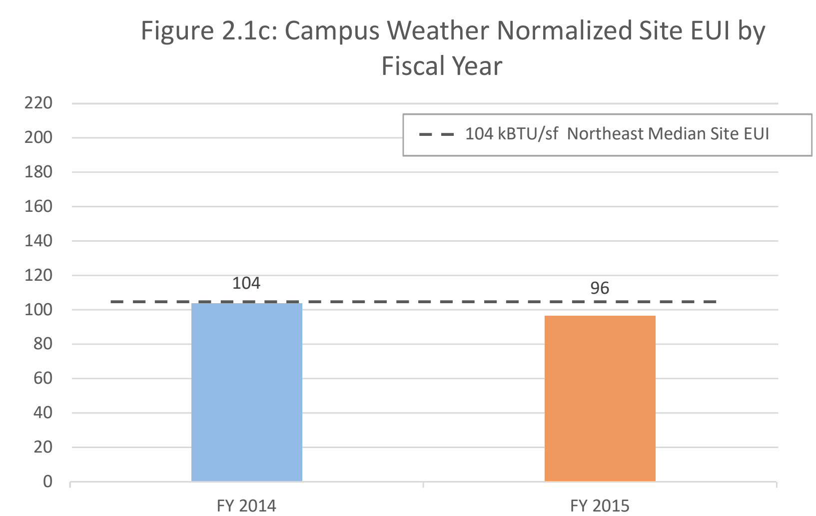
Information on Southern's existing conditions was captured from campus interviews, energy data and reports provided by the campus. A holistic view of existing practices, material on energy management, energy infrastructure and project implementation processes was reviewed. Analysis of the data and campus 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 Southern'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. Southern has the second smallest site energy use intensity of the CSCU universities, at 110 kbtu/sq ft.







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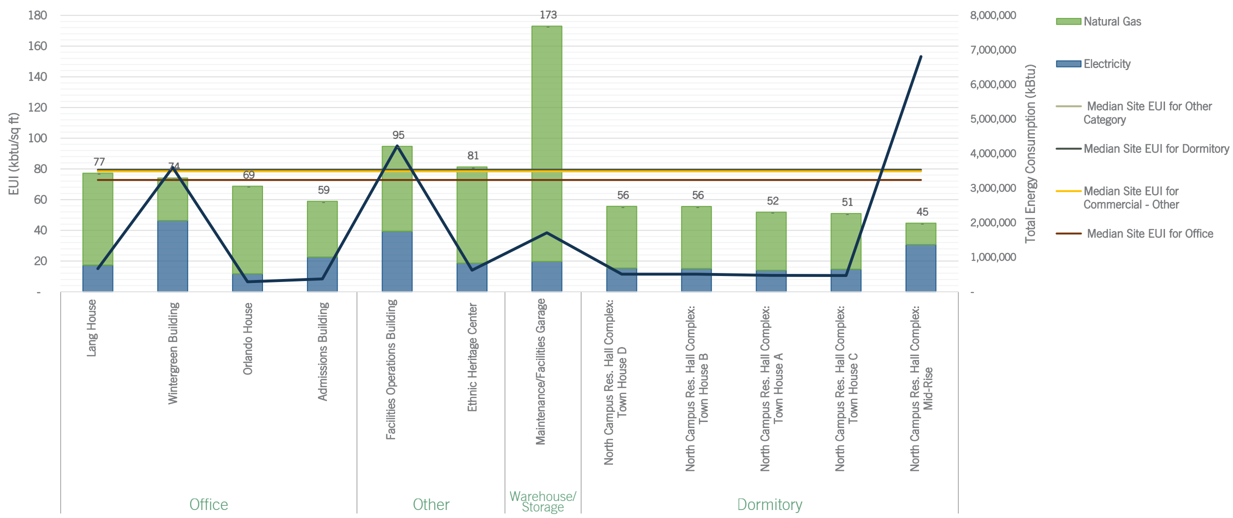

FIGURE 2.2: Site EUI by Building (FY 2014)

The ability to accurately measure energy use intensity (EUI) is dependent on the granularity of building level data. While there are natural gas accounts for a large portion of the buildings, the EUI does not include steam or high temperature hot water (HTHW) from the Energy Center. The buildings in Figure 2.2 represent the buildings that use natural gas and electricity only and are not heated by the Energy Center. The buildings are grouped by category to compare against the Northeast median average site EUIs for buildings of the same type. Particularly in the dormitory category, Southern is far below the median average. The campus has made significant efforts to reduce energy in the residence halls which is reflected by the FY14 data.

The purple line represents the total energy use for the building over FY 14, and can be compared to the site EUI. Buildings such as the Wintergreen Building and Facilities Operations have a higher kBtu/year value and are above the Northeast median average for the category, and therefore would be relevant areas of focus. For the Wintergreen Building, most of the site EUI is attributed to electricity; energy updates related to lighting and increased efficiency of electric equipment would contribute to the lowering of the EUI and decrease overall energy use. An obvious outlier is the Maintenance Facilities Building which has a natural gas EUI of 152 which is more than double the EUIs of other buildings using natural gas. A large energy user with a low EUI is the Mid-Rise Residence Hall.

While there was not adequate data to definitively depict each building's EUI, based on existing available natural gas and electric EUIs, more than 50% of the buildings have natural gas which comprises the majority of the EUI. Opportunities to reduce natural gas use may be targeted, such as through building envelope upgrades that will decrease space heating needs and more efficient heating equipment. Focus should be attributed to buildings that have a higher energy use as well as a high EUI.

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

Southern spends less than the average CSCU Universities per square foot, suggesting lower energy use overall, since unit costs are greater or equal to the average. Southern also spends a smaller percent of its total operating expenses on energy than the CSCU universities on average.

	Southern Connecticut State University	Average of CSCU University	Average of CSCU Community College	Northeast Region Commercial Sector
Cost per Square Feet	$ 2.23	$ 2.08	$ 2.49	$ 1.67
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Total Energy Spending	$ 4,611,016	$ -	$ -	
% of Operating Expenses	2.14%	2.67%	1.95%	

TABLE 2.1: Energy Cost Comparison (FY 2014)

[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

DRAFT

2.2 CAMPUS UTILITIES AND DISTRIBUTION

As shown in Figure 2b, Southern's two sources of energy are electricity and natural gas. In FY 14, natural gas comprised 60% of total energy use. Southern's utility providers and relevant distribution information include:

Electricity

Buildings are fed electricity through three main avenues: the campus utility, United Illuminating (UI), and through the West Campus distribution Loop or through the East Campus distribution loop. The East Campus switchgear originates on Crescent Street and feeds 11 buildings, and the West Campus loop switch gear is located in the Energy Center providing energy to 14 buildings. The remaining 13 buildings are direct from UI.

Note: Only buildings analyzed for EUI benchmarking are summarized; for instance, Wintergreen Parking Garage which is fed by the West Campus Loop is not factored.

Natural Gas

United Illuminating Holdings (UIL), formerly Southern Connecticut Gas, provides natural gas to the campus. Most natural gas use is provided to the Energy Center for distribution as HTHW, which is converted to steam at the building level for domestic hot water and space heating.

Table 2.2 provides a summary of Southern's available building submetering.

	Electricity	Natural Gas
Total Number of Buildings Consuming Energy Type	38	38
Number of Building with Accounts	13	27
Number of Building Submetered or on an Individual Account	38	27
Percent of Buildings with Building Level Data	100%	71%

TABLE 2.2: Southern Submetering by Energy Type

2.3 ENERGY PROCUREMENT

Southern is part of CSCU's 2013 electric supply procurement contract with Direct Energy (formerly Hess Energy), presented further in the Energy Master Plan. In FY13 and FY 14 Direct Energy was also the natural gas supplier, but the local distribution company (LDC) UI became Southern's supplier in FY14.

2.4 OPERATIONAL AND ENERGY MANAGEMENT PRACTICES

Facilities Operations (Facilities) at Southern is largely responsible for the energy-related efforts on campus. Responsibilities range from incorporation of energy efficient design in capital planning, to daily operation of building systems and energy monitoring.

Scheduling

The campus remains widely used throughout the summer for classes, programs, and staff. Moreover, the highest electrical demand month is in August when cooling requirements are at a peak. Southern has been aware of the long term price effects of the high demand in August and has spread awareness and implemented classroom consolidation practices. Southern recently received support from administration to execute scheduling changes during the summer months. Some examples per a May 19, 2016 announcement from the Provost and Vice President for Academic Affairs are:

- The Temporary Bookstore TE-8 will be off line all Summer (there are no bathroom facilities and no offices in the building).
- 3rd Floor of Engleman Hall will be shut down for the month of August.
- Pelz Gymnasium classrooms will be shut down June 26th through August 25th.
- Morrill Hall classrooms shut down August 1st through August 28th.

ENERGY USE INFORMATION MANAGEMENT SYSTEMS

Automated Logic is used as the energy management software (EMS). There is viewer access to Energy Reports (Automated Logic building energy analytics). However, only limited historical data is logged and stored for reference while viewing the system. Only the past 24 hours of information appeared to be readily available. As part of an Ameresco contract, detailed in Section 2.5, Southern also has access to data for 17 buildings on campus. The software provides dynamic trending related to year over year energy use, energy per square foot and other useful comparison parameters.

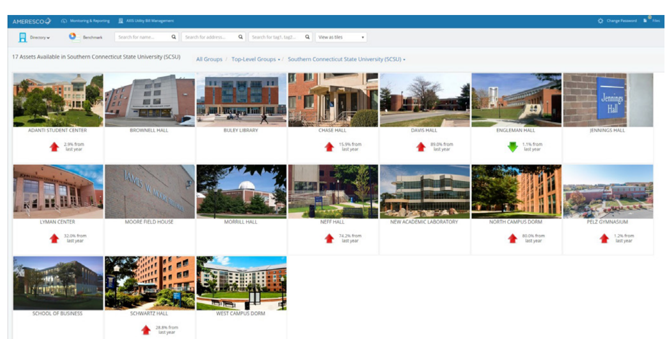


Figure 2.3: Ameresco Building Analytics Dashboard

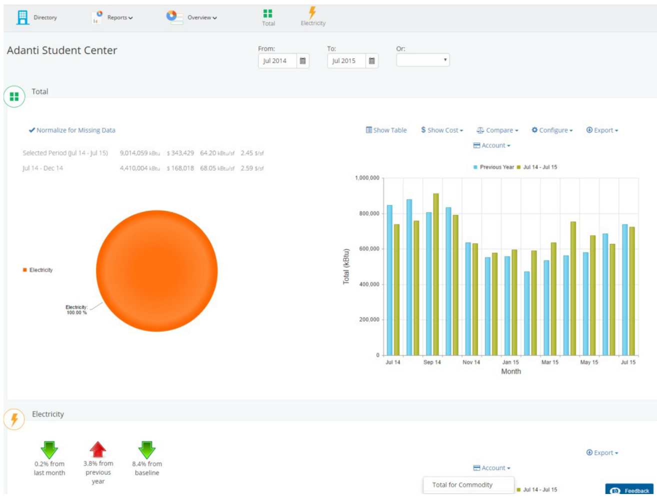


FIGURE 2.4: Building Analytics Available for Adanti Student Center

At current staff levels, time demands related to keeping existing equipment operational prevent Southern from taking full advantage of potential energy savings.

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. Southern should use this template to track energy over time including monitoring weather normalized EUI over time, and associated costs compared to existing budgets.

The following are recommendations for Southern to expand its energy management practices:

- Continue to work with administration to control and administer summer programs and space use
- Continue to take measures to consolidate building use to the most efficient spaces during summer break, and spread awareness of the effect of energy use on campus budgets and in pursuit of increased sustainability.

  a. Involve residence advisors and other campus student leaders to educate the community on the importance of building consolidations
- Advance building recommissioning plans and policies.
- Work with CSCU to develop temperature set point guideline based on seasonal and specific zone indoor air quality (IAQ) conditions
- Expand training and staffing capabilities for management of BAS controls, particularly related to any new technological improvements of the BAS over time. This may include using a third party to supplement their staffing levels, or working with existing staff members to expand training.

2.5 EXISTING BUILDING COMMISSIONING

2.5.1 CURRENT CONDITIONS

Southern has implemented existing building commissioning practices with Seldera, an Ameresco® company. Building Dynamics monitoring based commissioning services for the Adanti Student Center were implemented in January 2014. A snapshot of the project case study indicates the project was highly successful.

Project Overview

- 2,490,455 kWh average annual electricity consumption with a cost of $463,234
- 4–month payback

Building Overview

- 125,000 square feet
- Construction completed in 2006
- Building used 24/7 for different activities: restaurants, computer rooms, gym, radio station, classrooms, offices, ballroom, theater, recreational spaces
- State-of-the art Automated Logic BAS

Project Results

- Operational changes implemented in January 2014
- Consumption reduced by 208,035 kWh (17.3%) or $38,695 from baseline during the first 6 months of the project
- When accounting for weather, consumption has dropped by more than 303,766 kWh (23.5%) or $56,500

FIGURE 2.5: Image from SELDERA Case Study (2014)

Engleman Hall was part of the recommissioning efforts. Examples of findings and recommendations, with respect to air handling unit (AHUs) operations included :

1. AHU-1 operates 24/7 without setbacks for any parameter

2. Hot water valve seems to stay at fixed (fully open or fully closed) position

3. Fan coil units (FCUs) are scheduled to start too early at 4:00 AM for most of them.

> **a.** An Optimum Start / Stop BAS program was recommended

4. Whole building load profiles indicate that a large part of daily maximum electric load is still ON at night (~300 kW out of 420 kW maximum).

> **a.** Consider opportunities to decrease night-time load when ALL FCUs are OFF

5. Chilled Water System operates with negligible chilled water delta T –

> **a.** Maximize use of airside economizer and / or optimizing the chilled water flow to maintain at least 10 degrees delta-T.

6. Interlock Chilled Water Pumps and Condenser Water Pumps operation

7. Verify necessity of running two hot water pumps and two condenser water pumps in parallel

The following observations were made with respect to Primary Systems Performance:

1. Chilled Water System operates 24/7 (alternating two chilled water pumps), even if AHUs are OFF at nights and on most of weekends

2. Both chilled water pumps are equipped with VFDs, but maintain constant speed not modulating flow in accordance with load

3. Hot Water System runs in parallel with chilled water system, operating at least one pump at a time

4. The strategy of complementing lead hot water pump with another (lag) pump is not clear – it looks like a second pump was activated without obvious need, and in parallel with the chilled water system

5. Two Condenser Water Pumps run in parallel most of the time, but at the end of the presented period switched to one pump operations without any visible change on chilled water side. Revise strategy activating second (lag) hot water pump

6. Cooling Tower System switches from one cell to two cells operations without any visible condenser water flow increase

> **a.** Revise a cells start-up controls

7. Presented April-May time interval can be the most beneficial from Water-side economizer operations point of view.

> **b.** Verify the Condenser Water Temperature set-point

Due to the success at Adanti Student Center and Engleman Hall, Southern is planning on implementing the Building Dynamics continuous commissioning program at all campus buildings connected to the existing Automated Logic BAS. The contractor would work to identify building specific BAS issues, and create monitoring strategies for continuous building system optimization. Ameresco estimates the project could yield annual savings up to $350,000.

2.5.2 RECOMMENDATIONS

Buildings with BMSs with measurable points stand to benefit the most from recommissioning. Guidelines for selecting the best candidates for existing building commissioning (EBCx) are available in the Energy Master Plan.

Although State buildings built after 2011 are required to have a commissioning agent new buildings may have not been properly and thoroughly commissioned at numerous 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, recommissioning of existing building systems every 3-5 years is recommended. However, the continuous commissioning practices Southern is implementing is one step better and should be continued, using the BAS to its full potential.

Trending of the data available in the BMS, including all temperatures, flow rates and damper/valve positions will help aid not only future energy benchmarking, but also any recommissioning activities.

2.6 MECHANICAL SYSTEMS

2.6.1 CURRENT CONDITIONS

Existing mechanical system conditions consist of the following:

HTHW AND STEAM

Southern's buildings are served by a central plant, the Energy Center, constructed in 2003. The Energy Center's three boilers support building needs depending on the season. Two 40,000MBH boilers operate in the winter, while a 10,000MBH is used for summer loads. In the colder months, water temperature is maintained at approximately 350°F, while in the summer season, water temperature is reduced to 250°F. Three operations shifts are currently required in the winter, while only two are needed in the summer.

There is an additional 40,000MBH boiler housed in the building that is not installed.

The Energy Center supplies domestic hot water, high temperature hot water (HTHW) for heating to fourteen buildings and steam generation to six buildings. Eleven buildings have a natural gas supply in addition to campus HTHW or steam.

DOMESTIC HOT WATER

Domestic hot water is mainly distributed to buildings from water heaters supplied by the Energy Center's HTHW loop. The West Campus buildings are all supplied in this way. The remaining buildings are supplied by either steam distribution, electric hot water storage heaters or natural gas hot water storage heaters. Steam is generated from HTHW as the source for domestic hot water. As this process requires conversion of HTHW to steam, it is somewhat less efficient than using HTHW directly as the heating source. Buley Library, Davis Hall, and Morrill Hall use electrically heated domestic hot water storage tanks. Natural gas storage heaters are generally used in the North Campus residence halls.

Figure 2.6 provides a map of HTHW and steam distribution to Southern's buildings.

CHILLED WATER

Southern does not have a central chilled water system. Instead, cooling is supplied to buildings through various methods including chilled water, direct expansion (DX) and heat pumps. Four residence halls, Wilkinson Hall, Chase Hall, Hickerson Hall and Neff Halls, do not have any cooling systems installed.

The existing building systems table in Table 2.3, provided from a past infrastructure study, summarizes the heating and cooling systems at Southern. Upon review of various sources, it should be noted that there were some discrepancies around available systems. For instance, another source indicated that in addition

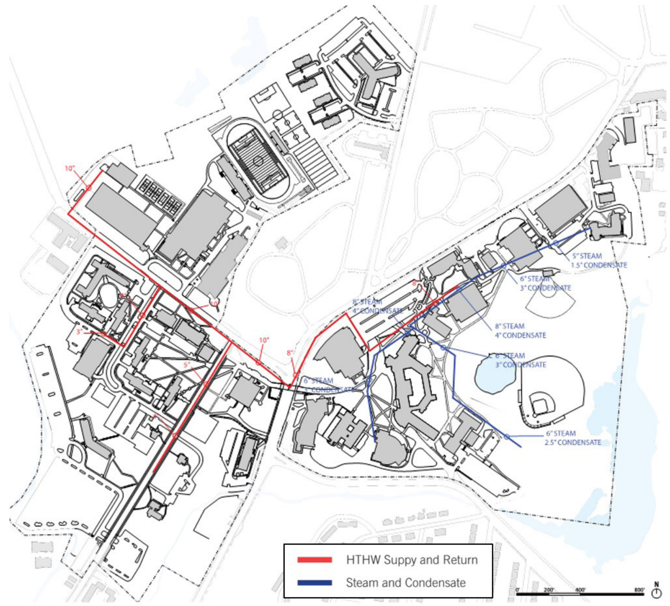


FIGURE 2.6: Southern HTHW and Steam Distribution

to the buildings listed as having no cooling systems, the Nursing Classroom Building, Ethnic Heritage Center, Lang House and Orlando House, all do not have cooling systems.

General observations and notes from talking to staff during the walk-through audit include:

- The central HTHW loop has leaks and the system has a large amount of makeup water. Some sections are being replaced.
- Buildings are not submetered for steam and HTHW, and rooms are not individually controlled or broken into zones.
- Hot water for the Pelz Gymnasium pool is heated using high efficiency Lochinvar water heaters. There were no dehumidification controls used for the pool area.
    - **a.** There are plans to deconstruct or take Pelz Gymnasium offline in the next five years.
- Insulation around hot water piping is not fully adequate at Connecticut Hall.

Bldg #	Name	Heating + DHW			Cooling			Heat Pump	Electrical Service		
		Campus HTHW	Campus Steam	Natural Gas (SCG)	CHW System	DX System	None		UI	East Campus Loop	West Campus Loop
1	Facilities Building/Receiving			■		■			■		
2	Facilities Grounds Garage						■		■		
3	Nursing Building			■		■			■		
4	Davis Hall		■		■					■	
5	Parking Garage - Fitch Street						■		■		
6	Petz Gym		■			■				■	
7	TE-7 Temporary Building 7							■		■	
8	Jennings Hall	■	■	■	■					■	
9	Morrill Hall		■			■				■	
10	TE-8 Temporary Building 8							■		■	
11	Business School	■	■			■				■	
12	Engleman Hall	■	■		■					■	
13	Buley Library	■			■					■	
14	Lyman Performing Arts Center		■		■					■	
15	Earl Hall		■	■	■					■	
16	Michael J. Adamti Student Center		■	■	■					■	
17	Connecticut Hall - Food Services	■		■		■					■
18	Schwartz Hall - Residence Hall			■	■						■
19	Ethnic Heritage Center / Storage			■		■			■		
20	Admissions House			■		■			■		
21	Lang House			■		■			■		
22	Orlando House			■					■		
23	Brownell Hall - Residence Hall	■		■	■						■
24	Farmham Hall - Residence Hall	■		■	■						■
25	Wilkinson Hall - Residence Hall	■		■			■				
26	Chase Hall - Residence Hall	■		■			■				■
27	Parking Garage - West Campus						■				■
28	Hickerson Hall - Residence Hall	■		■			■				■
29	Neff Hall - Residence Hall	■		■			■				■
30	West Campus Residence Complex			■	■						■
31	Granoof Hall - University Polive & Health	■				■					■
32	Office Building One	■				■					■
33	TE-6 Temporary Building 6			■		■					■
34	Energy Center			■		■					■
35	Moore Field House	■		■		■					■
36	Wintergreen Building			■		■			■		
37	Jess Dow Field			■			■				■
38	North Campus Mid Rise			■				■	■		
38A	North Campus Town House A			■		■			■		
38B	North Campus Town House B			■		■			■		
38C	North Campus Town House C			■		■			■		
38D	North Campus Town House D			■		■			■		
	Wintergreen Ave Garage						■				■

TABLE 2.3: Southern Existing Building Systems

Source: SCSU Energy Memorandum by ARUP, February 2015.
Note, the TE-7 building has since been demolished.

2.6.2 RECOMMENDATIONS

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

BOILER SYSTEM

- Implement a steam trap management program. Steam traps may fail open or closed, either wasting thousands of pounds of steam per month, or rendering steam coils inefficient or ineffective.

  a. This EEM often has the most rapid return of investment, even without utility incentives. With the incentives, the cost of the steam trap survey can be 100% covered. The repair of traps can also be substantially covered by the rebate program.

- Add insulation around HTHW valves and fittings. Priority should take place first on the highest temperature piping, from largest to smallest, followed by lower temperatures, such as condensate return. Removable blankets offer sufficient insulation while still allowing access for maintenance.
- Domestic hot water for buildings that use steam can be heated using the condensate return. Building heat will typically require higher temperatures, where domestic hot water (DHW) is usually not much greater than 140 °F. Using a separate heat exchanger for the DHW can extract heat from the condensed steam after it has been used to provide heat for the building.
- If steam is being used as the only means of heating DHW in the summer months, new condensing natural gas boilers designated for DHW should be installed.

- Install condensing economizers on the central heating plant boilers if continuous operation is expected throughout the year. The low grade hot water from the economizer, if not used to preheat makeup water, can be used in new or existing buildings with fin-tube radiators or better, and radiant floor heat where low fluid temperatures can be used.

CHILLER SYSTEM

- While new central plant chilled water systems traditionally offered higher efficiencies than smaller distributed direct expansion (DX) cooling units, advances in technology have made modern DX system equal to or even more efficient than central plant chilled water system. Southern should still consider replacement of numerous smaller units with central plant cooling. Replacement will require an in-depth study of the existing loads and infrastructure. A study to implement a central chilled water system versus replacing DX units should be performed when a majority of the existing equipment is 10-15 years old. Where location or existing layout challenges make connecting to a central chilled water plant unpractical, replacement with new DX units complete with variable speed compressors and advanced controls can provide comparable cooling efficiencies.
- Since chiller efficiencies have dramatically improved over the last twenty years, consider replacing those installed prior to year 2000 in priority of oldest first. Modern chillers compliant with ASRAE 90.1 are up to 50% more efficient than typical chillers 10 to 20 years old. Some chillers identified for replacement due to poor energy efficiency include:

    a. Brownell Hall- Trane 100 Ton unit manufactured in 1982, Model Number CGWA1006RB51CC4B4C311HEB

    b. Schwartz Hall- Trane 110 Ton unit manufactured in 1989, Model Number CGWCD116RDNKL623ABCFGPRT

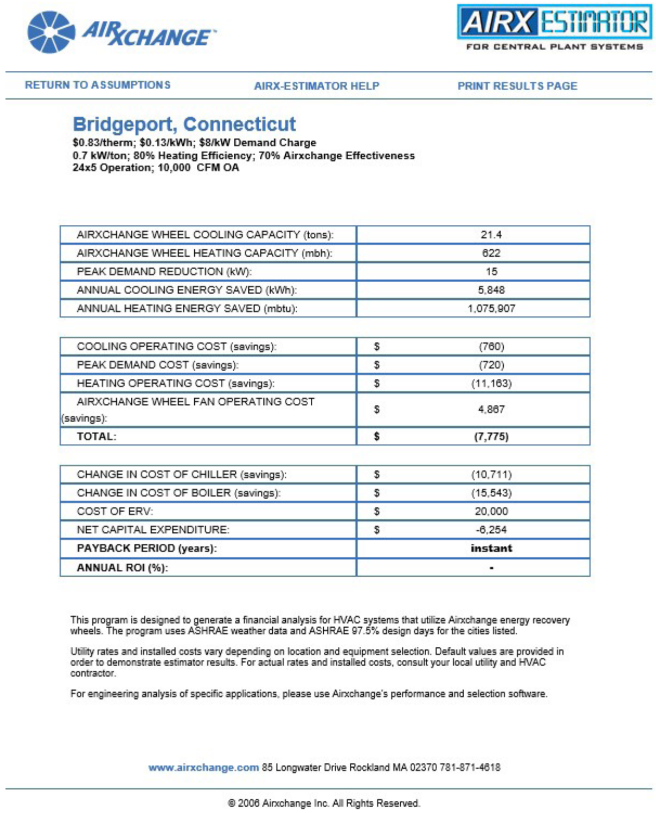
HVAC AIR SIDE

- Add energy recovery units (ERV) for heat recovery in art spaces with high operating hours.

    a. Depending on the existing ductwork configuration, use either a sensible heat wheel or plate heat exchangers (if intake and discharge are near), or run-around coils between more distant intake and discharge duct.

For an initial estimation on savings when pursuing ERV options, only location, occupied building hours, and cubic feet per minute (CFM) of outdoor air are needed. There are many manufacturers of ERVs; Figure 2.7 provides an example estimate based on an assumption of 10,000 CFM.

- Increase HVAC zoning, adding controls for individual rooms to help prevent overheating or overcooling of spaces. Variable refrigerant flow (VRF) systems are one way of providing this flexibility.


AIRXCHANGE

AIRX ESTIMATOR
FOR CENTRAL PLANT SYSTEMS

RETURN TO ASSUMPTIONS | AIRX-ESTIMATOR HELP | PRINT RESULTS PAGE

Bridgeport, Connecticut
$0.83/therm; $0.13/kWh; $8/kW Demand Charge
0.7 kW/ton; 80% Heating Efficiency; 70% Airxchange Effectiveness
24x5 Operation; 10,000 CFM OA

AIRXCHANGE WHEEL COOLING CAPACITY (tons):		21.4
AIRXCHANGE WHEEL HEATING CAPACITY (mbh):		622
PEAK DEMAND REDUCTION (kW):		15
ANNUAL COOLING ENERGY SAVED (kWh):		5,848
ANNUAL HEATING ENERGY SAVED (mbtu):		1,075,907
COOLING OPERATING COST (savings):	$	(760)
PEAK DEMAND COST (savings):	$	(720)
HEATING OPERATING COST (savings):	$	(11,163)
AIRXCHANGE WHEEL FAN OPERATING COST (savings):	$	4,867
TOTAL:	**$**	**(7,775)**
CHANGE IN COST OF CHILLER (savings):	$	(10,711)
CHANGE IN COST OF BOILER (savings):	$	(15,543)
COST OF ERV:	$	20,000
NET CAPITAL EXPENDITURE:	$	-6,254
PAYBACK PERIOD (years):		**instant**
ANNUAL ROI (%):		-

This program is designed to generate a financial analysis for HVAC systems that utilize Airxchange energy recovery wheels. The program uses ASHRAE weather data and ASHRAE 97.5% design days for the cities listed.

Utility rates and installed costs vary depending on location and equipment selection. Default values are provided in order to demonstrate estimator results. For actual rates and installed costs, consult your local utility and HVAC contractor.

For engineering analysis of specific applications, please use Airxchange's performance and selection software.

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FIGURE 2.7: ERV Savings Estimate

FUME HOODS

- Implement a fume hood sash management program to ensure hoods are closed and turned off when not in use.
- Install variable frequency drives (VFDs) on fans for additional control of science laboratory fume hoods.

2.7 LIGHTING

2.7.1 CURRENT CONDITIONS

Southern's Facilities team has completed extensive LED upgrades between 2012 and 2015. As of 2016, Southern has installed LED in all garages, Moore Field House Gymnasium, Pelz Gymnasium, the Energy Center and Adanti Student Center.

Ongoing lighting replacements are in progress for the residence halls: North Campus Residence Hall, Schwartz Hall and Neff Hall. A summary of the replacement projects is included in Appendix B along with other existing projects.

- In addition to completed conversions, Southern has plans for the following projects:
- Converting all fluorescent lighting throughout West Campus to LED
- Finish converting outdoor perimeter building security lighting around residence halls from high pressure sodicum (HPS) to LED
- Finish converting parking lot lighting from HPS to LED in all lots.
- Converting light fixtures from metal halide and incandescent to induction and LED at Moore Field House's pool and bleacher area
- Converting all fluorescent lighting to LED in the main dining area, Barnes and Noble floor space and back storage area of the Adanti Student Center.

The campus also pursued re-lamping for the West Campus Residence Complex with T8s and LEDs. An electrical company provided Southern with a quote of under $49,000 on a materials basis to update over 1,600 fixtures in the residence hall.

The approximate incentives for the lighting projects from UI exceed $100,000.

2.7.2 RECOMMENDATIONS

Southern has already prioritized lighting upgrades and continues to do a superior job in creating low cost, quick savings with relamping efforts. Additionally, the partnership with UI has yielded substantial savings. To complement the upgrades, Southern should consider the following:

- Increasing occupancy based lighting (and ventilation) controls
- Photosensor installation with exterior lighting upgrades
- Creation of an internal policy to promote lighting through motion sensors
- LED replacement specific to Pelz Gymnasium
- Convert 1500-watt metal halide fixtures to LEDs in Dow Field
- Change 250-watt metal halide fixtures in Earl Hall to LED
- Installation of LED fixtures in Davis Hall

2.8 BUILDING ENVELOPE

2.8.1 CURRENT CONDITIONS

In 1981, Connecticut implemented its first energy-related state wide standards for buildings. 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. Southern's buildings construction dates range from 1890 (Orlando House) to the Academic Laboratory and Science Building, constructed in 2015. Twenty-two buildings, or over half of Southern's building assets, were constructed prior to 1981. Earl Hall was one building specifically identified to be in need of building upgrades and window replacements.

FIGURE 2.8: Admissions Building constructed prior to 1981, likely in need of energy improvements

2.8.2 RECOMMENDATIONS

In general, Southern should consider conducting existing building commissioning (EBCx) related to building envelope on buildings built before 1981, or for buildings with obvious deficiencies such as ice dams and drafts. Insulation should exceed the latest building code or ASHRAE 90.1 standard. Southern should insulate wood frame residential buildings constructed prior to 1981 as they are assumed to not have had to abide by stricter building codes. The following sections provide best practices for building envelopes that can be considered by Southern:

- Review and ensure ventilation set points are not excessive per the latest edition of ASHRAE 90.1
- Address air infiltration issues by sealing doors and windows
- Conduct a thermography study using ASTM C1060 or ISO 6781 of buildings built prior to 1980 to identify where there are defects or a lack of insulation.

- Hire a certified consultant to commission the building envelope for new construction using the National Institute of Building Sciences (NIBS) Guideline 3-2012 to include:

  a. Design & construction document review
  b. Laboratory and/or on site performance verification tests
  c. Construction visual QA/QC Inspections
  1. Air, water, water vapor, and thermal barriers

- Include building envelope in recommissioning activities.

2.9 DISTRICT ENERGY / COGENERATION

2.9.1 CURRENT CONDITIONS

While Southern has HTHW distribution at the Energy Center, there is no central chilled water loop or cogeneration system. Southern explored the potential for a fuel cell in 2011 along with the other three Universities, as part of CSCU's fuel cell initiative. No plans were made at the time; however, the campus has interest in revisiting fuel cells.

Southern also commissioned a cogeneration study in 2010 and 2015 by the same firm. Results of the analysis in 2010 identified using a FCE DFC300, 300 kW unit as an option. According to the most recent study, a simple payback near 5 years could be expected before incentives or Renewable Energy Credits (RECs) as shown in Table 2.4. Although not listed in the study summary table, it appears a 1.5 MW Fuel Cell CHP unit was considered.

The information obtained from the previous study did not report on the thermal baseload but rather the electric load. The useable thermal energy generated by a 1.5 MW CHP unit would provide about twice the thermal energy than can be used by the campus for nearly half of the year.

The "Boiler gas displaced by cogen" shown in Table 2.4 indicates the 1.5 MW CHP will need to operate at a significant turndown during portions of the year or dump the excess heat since many packaged CHP unit manufacturers will not let their engines operate at more than 50% turndown. A five-year payback may be optimistic considering the turndown likely required for the 1.5 MW CHP. Before incentives, the return on investment for fuel cells is longer than for internal combustion (IC) engines due to the higher equipment costs associated with fuel cells.

2.9.2 RECOMMENDATIONS

Despite the fact Southern does not have a chilled water distribution loop from the Energy Center, utility data indicates the thermal load alone at the Energy Center could still support operation of a CHP without adding an absorption chiller or additional infrastructure. Instead of a 1.5 MW CHP, as suggested in the study reviewed, Southern is recommended to consider a 600 kW CHP. This smaller application would most likely present a 5 year or less payback, as it would be sized to avoid turndown. CHP recommendations based on thermal and electrical loads include:

BASECASE			33% HIGHER GAS & ELECTRIC		33% LOWER GAS & ELECTRIC	
Boiler gas displaced by cogen	235,480	ccf/year	235,480	ccf/year	235,480	ccf/year
Unit cost of boiler gas	$0.6051	per ccf	$0.8048	per ccf	$0.4054	per ccf
Boiler gas savings	$142,489	per year	$189,510	per year	$95,467	per year
Purchased electricity displaced by cogen	13,193,999	kWh/year	13,193,999	kWh/year	13,193,999	kWh/year
One half of historical purchased electricity	11,613,000	kWh/year	11,613,000	kWh/year	11,613,000	kWh/year
Unit cost of purchased electricity	$0.1310	per kWh	$0.1742	per kWh	$0.0878	per kWh
Net metering electrical savings for up to 1/2 of total annual usage at $0.1310/kWh	$1,521,303	per year	$2,023,333	per year	$1,019,273	per year
Net metering electrical savings for remainder of displaced electricity at $0.0786/kWh	$124,266	per year	$124,266	per year	$124,266	per year
Total electrical savings	$1,645,569	per year	$2,147,599	per year	$1,143,540	per year
Cogen gas consumption	1,228,317	ccf/year	1,228,317	ccf/year	1,228,317	ccf/year
Unit cost of cogen gas	$0.5301	per ccf	$0.7298	per ccf	$0.3304	per ccf
Added cost of gas due to cogen	$651,116	per year	$896,390	per year	$405,842;	per year
Cogen system maintenance cost at $.025/kWh	$329,850	per year	$329,850	per year	$329,850	per year
Net annual savings due to cogen	$807,092	per year	$1,110,869	per year	$503,315	per year
Estimated cogen implementation cost	$4,000,000		$4,000,000		$4,000,000	
Cogen grant at $450/kW I	$900,000		$900,000		$900,000	
Value of RECs at $26/MWH	$343,044	per year	$343,044	per year	$343,044	per year
Payback w/o grant or RECs	5.0	years	3.6	years	7.9	years
Payback w/ grant & w/o RECs	3.8	years	2.8	years	6.2	years
Payback w/ grant & RECs	2.7	years	2.1	years	3.7	years

TABLE 2.4: CHP Cost and Saving Analysis per 2015 Study

Thermal

The existing infrastructure Southern provides could potentially support an internal combustion (IC) CHP installation if installed at the Energy Center and connected to the HTHW loop. The existing hot water and steam loop would allow the CHP to run near peak load throughout the year, despite not having a chilled water loop to increase load over the summer months.

The monthly FY 14 natural gas energy use data for the Energy Center indicates at least 20,000 Therms are used throughout the summer months. The daily average would be near 27 Therm/hr and could support an internal combustion CHP of 600 kW. A thermal storage buffer tank would likely be necessary to balance out the load throughout the day.

An alternate location for a potential CHP is on the steam distribution loop using a back pressure turbine. A back pressure turbine is suggested for study as it is well suited where boilers are oversized and capable of generating steam in excess of 100 psi. Since details on the steam system are unknown, no analysis for this option has been performed. A negative consideration to factor is the increased electrical load due to pumping more HTHW through the water to steam heat exchanger.

Electrical

The 15-minute interval data for the West Substation indicates a 500-1000 kW CHP could connect behind-the-meter without any need to connect to the East Substation network, as would be necessary for any larger CHP units. Alternatively, virtual net metering could be explored; CHP systems are classified as a Class III renewable energy in Connecticut and are therefore eligible for virtual net metering, if it meets a minimum 50% overall efficiency. Virtual net metering would allow up to five electrical services to benefit from the excess generation on one service. In theory, excess generation at the West Substation could offset use at the East Substation even though they are not physically connected. UI would need to be consulted to confirm eligibility and specifics.

Results

For consideration other than the 2015 cogeneration study, a 600 kW CHP may be well suited for Southern. Generally, about 25 kW of electricity can be generated by an internal combustion CHP for every therm of useful heat generated. Assuming an existing boiler efficiency of 83%, a 600 kW CHP may be adequate.

A 600 kW CHP could be base-loaded throughout the year and would maximize runtime and efficiency. Additionally, the generator would not need to be physically connected to the East Substation network since the load profile on the West Substation appears to have the load to handle the CHP nearly the entire year. A 5 year or less simple payback is likely based on utility costs used by the 2015 study, monthly UI data, and an installed IC CHP cost of $3,250/kW of capacity.

With any installation of a cogeneration unit, Southern should pursue RECs and additional benefits through the utility offered natural gas LDC distributed generation rebate rider.

The addition of a CHP system with the LDC rebate should significantly lower the total Energy Center natural gas bill. The total gas usage will increase, as energy is needed to generate electricity, but the significantly lower rate on fuel is expected to reduce the overall bill.

2.10 DEMAND RESPONSE

2.10.1 CURRENT CONDITIONS

Southern has been exploring opportunities to reduce demand charges on campus, starting with understanding when historically peak demands have occurred.

Based on provided calendar year 2014 fifteen-minute data, the West and East Substations have a base load of at least 500 kW and 1000 kW, respectively for most of the year (Figure 2.9 and Figure 2.10)

The East Substation peaks into the two and even three megawatt demand region during peak cooling hours in the summer. Southern's Energy Reports indicate peak demand dates for available meters, which happened to both be the Wednesday before Labor Day in both 2014 and 2015. Figure 2.11 provides the Energy Reports summary page, with the large West Campus Electric Meter showing the most obvious peak towards the end of the day on the September 9th.

The East Campus account is not available in Energy Reports. Southern has also received recommendations to install a real-time meter on the campus' largest account, attributed to the East Campus Loop, to more actively respond to peaking demands.

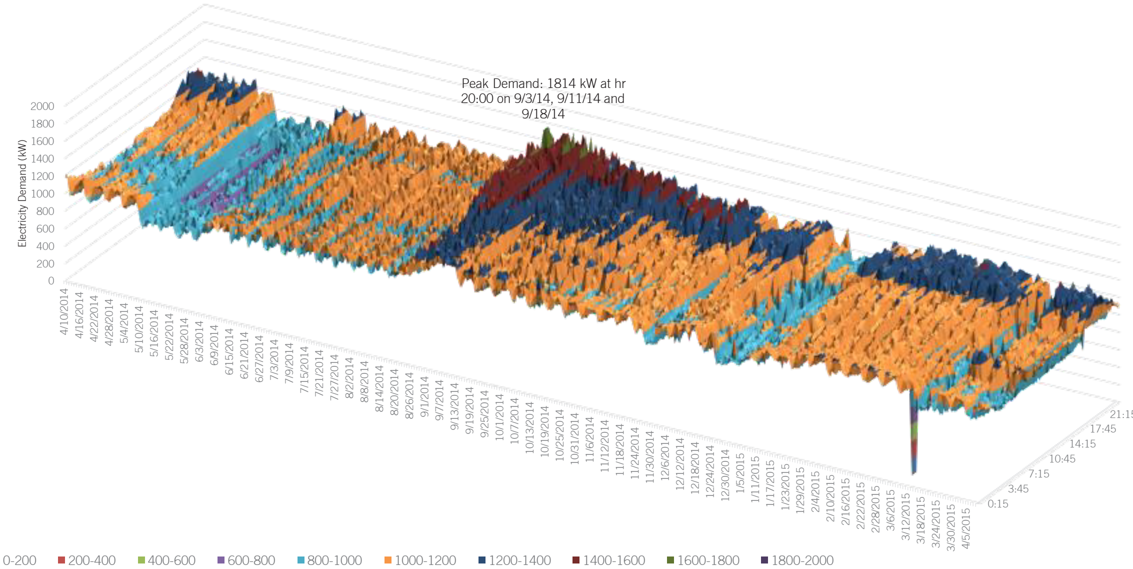

FIGURE 2.9: West Substation Load Data (kW)

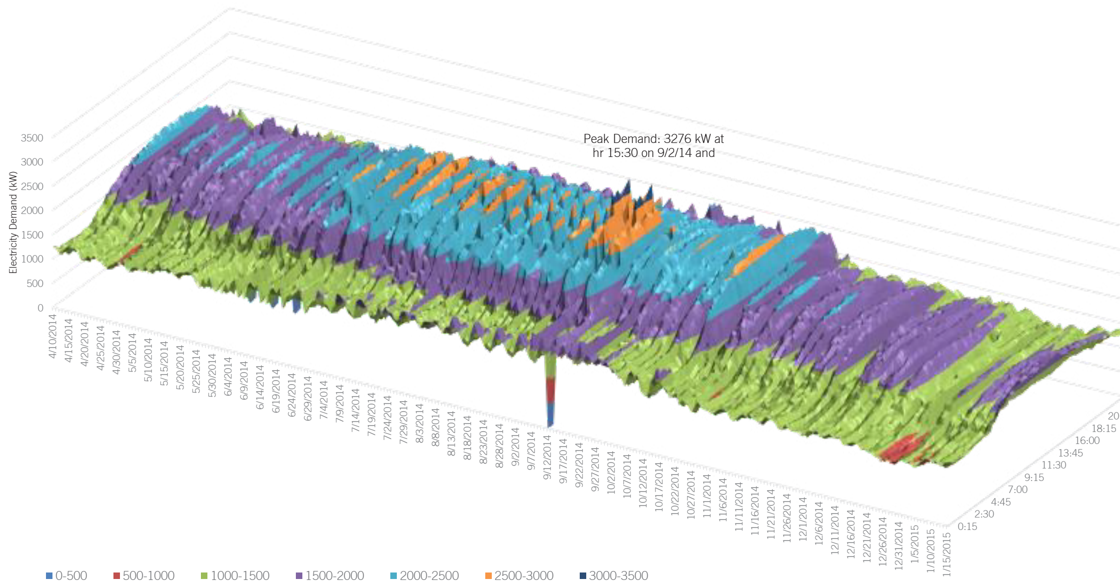

FIGURE 2.10: East Substation Load Data (kW)

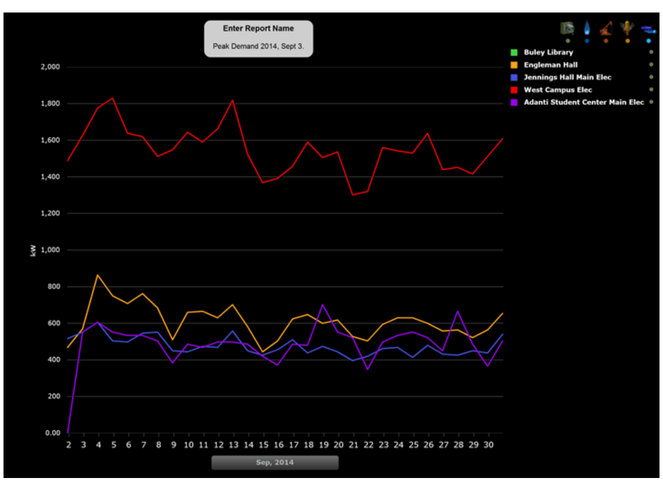

FIGURE 2.11: 2015 Peak Day in Southern Energy Reports

2.10.2 RECOMMENDATIONS

As demonstrated by the load data, there is opportunity for peak shaving during cooling hours in the summer. To further Southern's current demand response efforts, the addition of on-site generation can help to offset electricity use need during peak hours. As suggested in the cogeneration section, cogeneration has multiple benefits including aiding in demand response. If Southern intends to purchase additional generators to be used for demand response as well as emergency generation, Southern should purchase Tier IV compliant generators. As part of EPA's regulations, in order to participate in real time demand response, generators must meet EPA's Tier IV emissions requirements.

In addition to managing peak days on campus, Southern should manage demand on the days in which the regional electric grid is at its peak. Each end-user has an Installed Capacity (ICAP) tag, which represents the end-user's share of New England's requirement for generation capacity. The ICAP tag determines a portion of a customer's electric supply costs for the following year and it is set by the customer's load in the peak hour during the regional electric grid's highest usage. In the past, peak day has generally occurred between July and September. The 2015 peak day was July 29th from 4-5PM. Knowing when the peak days are projected to occur provides a significant opportunity to manipulate supply costs. Capacity savings for 2017-2018 are estimated at $9.86/kW-month. For instance, if peak load was reduced by 200 kW on peak day alone, the campus could see supply savings of $23,665.

Predicting electric grid peak days can be difficult, although in the past they tend to occur on hot and high humidity days. In order to prepare for events, Southern can monitor ISO-NE's predicted loads, available on their website, or have a third-party demand response group provide warning in advance.

Strategically, Southern should work with administration and residence advisors to provide materials to students and faculty about times to reduce electricity consumption. Easily implemented efforts to suggest could include turning off lights and powering down AC units. Framing demand response as an effort to promote sustainability by reducing the need for energy-intensive peaking plants may be aid in increasing buy-in.

2.11 RENEWABLE ENERGY

2.11.1 CURRENT CONDITIONS

Southern received favorable responses to its 2016 solar PV request for proposal (RFP) featuring a cumulative 1 MW of ground-mount, parking canopy and roof mount solar PV. Renewable energy was proposed at three locations during the April RFP Process. The contract will be in the form of a PPA. Wintergreen Parking Garage is included in the base bid for approximately 100-150 kW AC roof mounted PV solar system. The other base bid includes an area of 72,000 feet at Parking Lot #9 for an anticipated 400-500 kW ground mount system.

A supplemental bid is for the parking lot main section at approximately 95,000-sf for up to a 650-750 kW AC fixed parking solar PV canopy. The campus also has solar PV existing on Brownell Hall.

2.11.2 RECOMMENDATIONS

There are several other potential opportunities for rooftop solar PV on campus depending on roof age, plans for renovations, and availability of space not encumbered by mechanical equipment. In general, there are opportunities for small sites of less than 200 kW. For ground-mount solar, most of the available land is either tree covered or used for recreational purposes. However, a suitable ground-mount installation may be adjacent to the Wintergreen Parking Garage and tennis courts. Tree removal may provide additional opportunities for ground-mount. The campus should continue to consider additional parking lot canopies.

Table 2.5 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.

Strategically, and to aid climate action plan goals, the campus should attempt to implement solar on campus before the 2019 federal investment tax credit expires, unless there is an extension. As practice, 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 also be incorporated into future capital planning building design.

Other suggestions include:

- Optimize available incentives including:
    - **a.** Strategically plan for small, medium, and large ZRECs and LRECS for best savings
    - **b.** Site plan based on meter size, associated limits on installed KW and other legal restrictions
- Pursue Off-site Solar
    - **a.** Consider purchasing renewable energy offsite, as part of system wide electricity procurement.
    - **b.** If an offsite PPA is pursued, the campus should look for a longer than 10-year price guarantee.

Southern should continue to work closely with CSCU when pursuing renewable energy options. With the rapid improvement of energy storage technology, Southern may want to consider solar islanding in the future, whereby solar energy can be stored during the day and released at times of peak load to reduce energy costs. The campus may want to also consider a microgid, where financially advantageous and feasible. Connecticut currently has a microgrid grant program to support critical facilities .

Building Name	Address	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 PRIORITY PROJECTS									
Buley Library	377 Fitch	1968	249,412	7,913	2015	EPDM	36-47	47-61	
Chase Hall	Wintergreen	1967	59,266	9,500		AHDERED. EPDM	22-29	29-37	
Energy Center	21 Wintergreen	2003	16,580	5,714		Metal	26-34	34-44	
Engleman Hall	501 Crescent	1953	224,599	21,242		ADHERED EPDM	98-127	127-164	
Fitch Street Parking Garage	525 Fitch Lot 1GA	2000	193,605	64,535		NA	237-310	310-398	Solar canopy
Lyman Center for the Performing Arts	501 Crescent	1967	53,058	42,000	1994	EPDM	97-126	126-162	
Moore Field House	11 Wintergreen	1976	145,992	42,602	2013	BITUMEN/G RAVE	157-204	204-262	
Neff Hall	112 Wintergreen	1969	48,150	8,100		EPDM	19-24	24-31	
Nursing Building	555 Fitch	2005	5,000	3,500		SHINGLES	13-17	17-22	
School of Business	324 Fitch	1958	100,293	12,500		BITUMEN MD.	29-38	38-48	
West Campus Parking Garage	108 Wintergreen	2004	148,098	25,395		NA	93-122	122-156	Solar canopy
Earl Hall	501 Crescent	1960	46,027	32,000		EPDM	74-96	96-123	Some shading
Land area adjacent to Tennis Courts and Wintergreen Parking Garage							423-552	552-709	Ground-mount
Subtotal							1324-1726	1726-2217	
LOWER PRIORITY PROJECTS									
Hickerson Hall	100 Wintergreen	1967	59,266	8,000	1994	EPDM	22-29	29-37	Could be good candidate but roof condition is said to be poor
North Campus Res. Hall Complex: Mid-Rise	180 Pinerock Ave	1985	152,517	25,600	2012	MOD. BUR	94-123	123-158	Structural analysis needed
North Campus Res. Hall Complex: Town House A	182 Pinerock	1991	9,165	1,354			42529	42592	Could reduce shading, small array
North Campus Res. Hall Complex: Town House B	184 Pinerock	1991	9,165	2,430			42689	15-19	Could reduce shading, small array
North Campus Res. Hall Complex: Town House C	186 Pinerock	1991	9,165	1,354			42529	42592	Could reduce shading, small array
North Campus Res. Hall Complex: Town House D	188 Pinerock	1991	9,165	2,430			42689	15-19	Could reduce shading, small array
Subtotal							150-198	198-253	
Total							1474-1924	1924-2470	

TABLE 2.5: Southern 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 calculated if a solar PV study was performed.
[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.

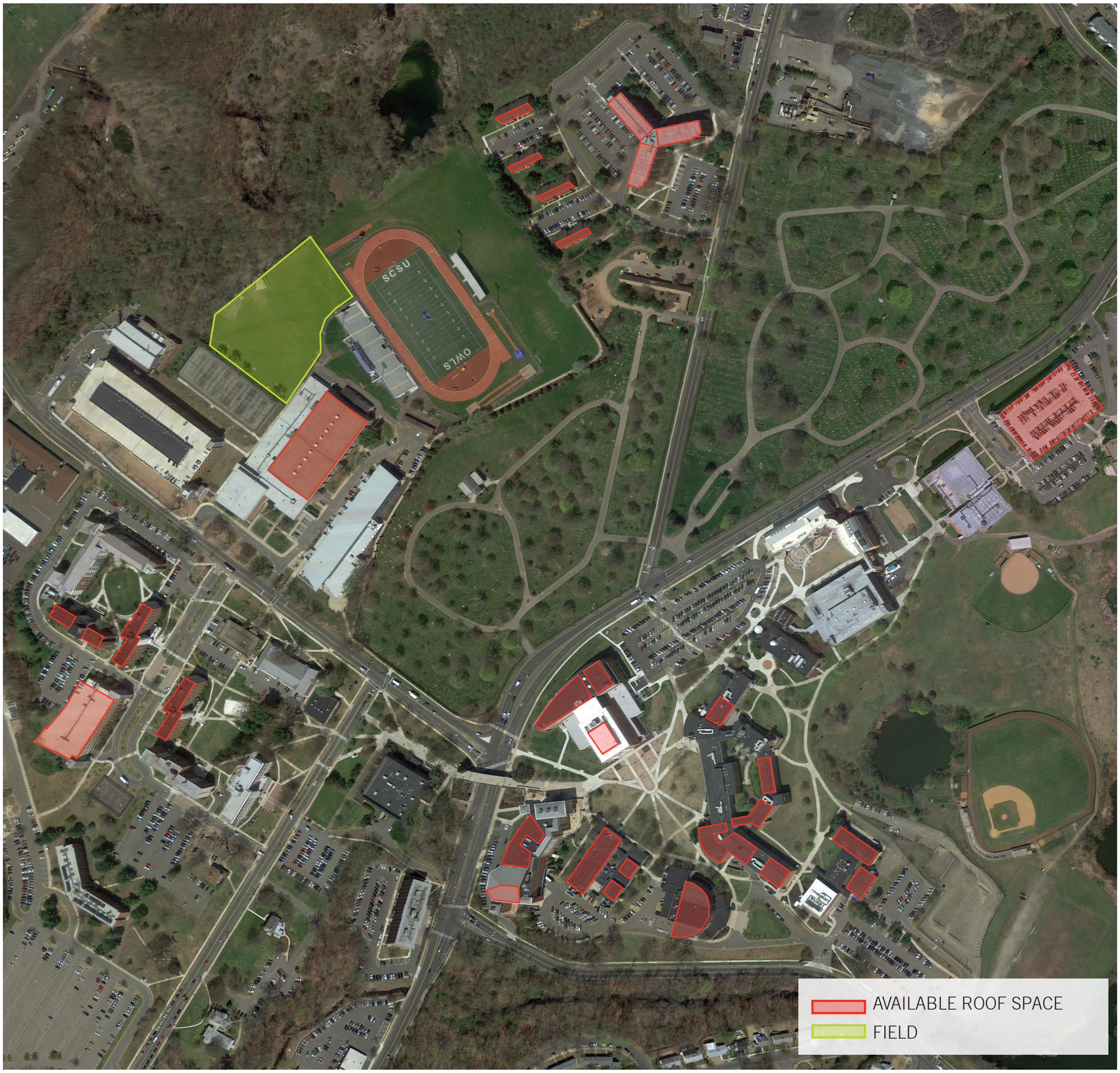

FIGURE 2.12: Southern Campus Solar Potential

2.12 CAPITAL PLANNING

2.12.1 CURRENT CONDITIONS

The dedicated Facilities staff oversees planning, design, construction and maintenance of Southern campus facilities. The University Master Plan, the 2020 Program, the Climate Action Plan, and the University's Strategic Plan all help shape Facilities' long-term responsibilities, inclusive of preparing for new construction projects and renovations to existing infrastructure. Facilities has regular meetings regarding large capital planning projects. The campus also has numerous deferred maintenance projects, that if addressed would also reduce energy intensity. According to Southern, deferred maintenance projects in order of priority, include:

- Lyman Center for the Performing Arts: Mechanical systems upgrade/ AHU replacement
- Moore Field House: replace all 7 AC units and upgrade pool lighting
- Davis Hall: Mechanical systems upgrade/ replacement
- Pelz Gymnasium: Mechanical and electrical systems upgrade, with a return on investment of 1-2 years. The Gymnasion is recommended for demolition
- Recommendations from a return on physical assets benchmarking study including mechanical systems upgrade and piping for AC / electrical systems upgrade
- North campus mechanical upgrade with wireless BAS controls
- Earl Hall: Building envelope, window replacement
- Upgrade Jess Dow field lighting when financially advantageous

FIGURE 2.13: Lyman Center per 2006 Master Plan

To accomplish its energy infrastructure goals, Southern 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.

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

2.12.2 RECOMMENDATIONS

As Southern plans for energy upgrades, collaboration with UI in the planning stages may be beneficial. In general, Southern should continue to collaborate with UI for all major building renovations and all new construction, as well as mechanical, electrical and plumbing equipment upgrades. Additionally, milestone bid reviews for renovations or new construction should include review and comments by a dedicated energy manager from CSCU and a Commissioning Agent.

While budgets are allocated to expansion projects, ideally capital funding would be allocated to address energy related deferred maintenance at the campus. The capital funding to support deferred maintenance energy projects would lead to lasting yearly savings and a decreased operating budget.

2.13 COLLABORATION / PARTNERSHIP

2.13.1 CURRENT CONDITIONS

UI has provided support to Southern to accomplish significant energy projects. Since 2000, UI has provided Southern with a total of $468,914 in electricity incentives alone. The utility was involved with providing incentives for a total of 47 lighting, cooling and heating projects. UI estimates over 2.5 million net kwh savings from the projects.

Southern's Facilities team has also had success working with administration in a concerted effort to improve campus scheduling and shut downs in summer months. The collaboration is expected to decrease kW demand, helping to save on peak charges and shave electricity spending.

2.13.2 RECOMMENDATIONS

Southern should continue to have regular meetings with UI, preferably on a monthly basis. Administratively, supplying the utility with a list of all capital projects, deferred maintenance and the suggested EEMs in this report would help to align existing incentives and potentially maximize rebates through bundling of projects. Involving the utility in the early stages of planning is important to understand the latest equipment that may receive additional incentives.

Incentives structures range and vary by program, but UI has offered incentives of up to 80% of project costs in the past. Southern should coordinate with UI to maximize available incentive structures through:

- Enhanced rebates
- Bundled rebates
- Performance design rebates

The Energy Master Plan provides a list of available incentives programs in Chapter 4.

2.14 SUMMARY OF RECOMMENDED ENERGY EFFICIENCY OPPORTUNITUES

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 2.6. 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. Currently, Southern 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%. UI 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 UI will be required to determine rebate amounts for each opportunity. 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	Associated Building if Applicable	App. Cost (Before Rebate)	Payback w/rebate (Years)	Priority
SCSU-1	Implement a steam trap maintenance program.	East Campus	$15 / trap surveyed + repair costs	<1 - 2	1
SCSU-2	Continue recommissioning (in progress).	All	$0.50 - $3.50 /sf ($60k for continuous Cx)[1]	Varies	1
SCSU-3	Optimize BAS with Continuous Cx practices.	All	$20k/ 100k sf / year	Varies	
SCSU-4	Consolidate course offerings to certain buildings to reduce energy consumption at times of lower occupancy (in progress).	All	Varies	Varies	
SCSU-5	Explore use of BAS for capacity charge and demand response management.	All	Administration Time	2016-2017 estimated savings of $9.86/kW-month	
SCSU-6	Implement fume hood sash management as a part of a fume hood sash management campaign with goal to instill an energy efficient culture.	Various	Minimal	Varies	1
SCSU-7	Install variable speed drive for control of fume hoods in Science Labs. Also explore adding heat recovery coils if used frequently.	All	Varies	2 - 5	1
SCSU-8	Install variable speed drives. Fund with UI rebate program (in progress).	All	Varies	2 - 5	1
SCSU-9	Investigate roof-top solar PV opportunities, specifically with new construction or roof renovations, in addition to pending PPA for the Lot 9 PV array. Also investigate ground mount and additional solar canopies.	All	PPA	PPA	1
SCSU-10	Enable trending of energy data through BAS for future benchmarking and EEM savings estimates. Store at least 2-years' worth of data in 15-minute increments.	All	Varies	Varies	1
SCSU-11	Convert 1500-watt metal halide fixtures to LEDs.	Jess Dow Field	Varies	Varies	1
SCSU-12	Creation of an internal policy to promote lighting through motion sensors.	All	Administration time	Minimal	1
SCSU-13	Replace existing lighting with LED.	Pelz Gymnasium	Varies	2 - 6	1
SCSU-14	Change 250-watt metal halide fixtures in LED.	Earl Hall	Varies	2 - 6	1
SCSU-15	Replace existing fixtures with LED in lecture spaces.	Davis Hall	Varies	2 - 6	1
SCSU-16	Increase occupancy based lighting (and ventilation) controls.	Campus	Varies	Varies	2
SCSU-17	Focus energy efficiency projects on buildings with a high EUI and a high total energy consumption.	All	Varies	Varies	2
SCSU-18	Lower temperature and use natural gas infrared heaters with infrared thermostats in maintenance shops and garages.	Maintenance/Facilities Garage	Varies	3 - 6	2
SCSU-19	Add insulation around HTHW valves and fittings.	Connecticut Hall	Varies	1 - 2	2

SCSU-20	Explore or conduct a further study for a 600 kW Internal Combustion CHP engine at the Energy Center, near 600 kW. The system should be sized for year-round operation, and may possibly include a thermal buffer tank. The campus should also explore capturing additional benefits from CHP like reduced natural gas pricing with the LDC waiver. [1]	Energy Center	Varies, $3k - $4k per installed kW capacity	Varies	2
SCSU-21	Upgrade mechanical systems upgrade, including an AHU replacement	Lyman Center for the Performing Arts, Davis Hall	Varies	Varies	2
SCSU-22	Replace all 7 AC units with more efficient models.	Moore Field House	Varies	Varies	2
SCSU-23	Complete a mechanical and electrical systems upgrade, dependent on Master Plan and fate of the building.	Pelz Gymnasium	Varies	Varies	2
SCSU-24	Straightlines: Complete an electrical systems upgrade and a mechanical systems upgrade and piping for AC	Campus	Varies	Varies	2
SCSU-25	North campus mechanical upgrade w/ wireless BAS controls.	North Campus	Varies	Varies	2
SCSU-26	Add ventilation heat recovery for art spaces with high operating hours.	Various	$2 per CFM of capacity	Varies	3
SCSU-27	Connect new buildings to west campus loop (previously recommended).	Future	Varies	Varies	3
SCSU-28	Preheat DHW using condensate return from steam loop.	East Campus	Varies	Varies	3
SCSU-29	Explore ~150 kW backpressure turbine after steam generator on East Steam Loop and connect extra 40 MMBtu Boiler at Energy Center.	East Steam Loop	Varies	Varies	3
SCSU-30	Install Heat Recovery Ventilator (HRV) for pool ventilation and dehumidification, if pool continues to be used (Pelz Gymnasium may be taken offline).	Pelz Gymnasium	$2 per CFM of capacity	Varies	3
SCSU-31	Install condensing economizer on central heating plant boilers and supply low temperature hot water to nearby or new buildings.	Energy Center	$350,000, N.I. demand side modifications	9-10 based on UC Davis and JAX studies	3
SCSU-32	Increase HVAC zoning and/or add individual room controls to BAS.	Various	Varies	Varies	3
SCSU-33	Replace older cooling equipment, especially those greater than twenty years old. Consider replacing DX units with new variable speed compressor units or installing a central water cooled chiller plant when infrastructure permits.	Various	Varies	Varies	3
SCSU-34	Upgrade building envelope including window replacements	Earl Hall	Varies	Varies	3

TABLE 2.6: Southern Energy Efficiency Measures

Footnote: 1)A 2010 study identified a 300 kW fuel cell installed near the Energy Center would have total installed cost of $2.7M and annual savings of $119,718 (2010 CSUS Fuel Cell Evaluation Report)

ENERGY NEEDS

3.1 FUTURE DEVELOPMENT

Overall energy use may be impacted by campus expansions and renovations. In April 2015, Southern opened its $31 million, 98,000 square foot renovated wing of the Buley Library. Also completed in 2015 is Southern's new $49 million, 103,608 square foot Academic Laboratory and Science Building. CSCU 2020 includes construction of a Health and Human Services (HHS) instructional building at Southern, and centralizing departments and providing upgraded clinical facilities to support growing programs in Nursing. Southern plans to locate the HHS adjacent to Pelz Gym. The building is in Phase 1 of the project, with CSCU pursuing funding for Phase 2 which entails further expansion for the planned HHS building and demolition of Pelz Gymnasium.

According to the 2015 Master Plan Update, and based on 10-year enrollment projections, Southern's campus is in need of an additional 294,000 Assignable Square Feet (ASF). Including the aforementioned HHS, the Master Plan also suggests:

- Jennings Hall and Morrill Hall Renovation to include undergraduate biology labs,
- Construction of a 110,000 GSF School of Education Building,
- Construction of 80,000 GSF School of Business,
- West Campus new residence halls, and
- Numerous other space use and campus beautification recommendations.

Southern is also considering removing several energy inefficient buildings from its current assets. The buildings under consideration include:

- Old Student Center
- Temporary buildings- TE 6 and 8 when no longer needed
- Office Building 1 and Granoff Hall

FIGURE 3.1: Energy Center per 2015 Master Plan Update

Southern had an infrastructure-specific study conducted in concurrence with its updated Master Plan. Based on the findings, commissioning the unused 40,000MBH boiler in the Energy Center would support all heating and DHW needs in a campus expansion. The addition of the boiler would both be of no significant capital cost to the campus, and also support 100% redundancy for the Energy Center. It was also recommended to continue to evaluate cooling options on a building by building basis. Additional recommendations include:

- Eliminate individual natural gas use for the eleven buildings that have both HTHW/steam and a UIL account. Instead, buildings can use HTHW for heating and DHW needs to increase boiler efficiency
- Re-evaluate building systems for the buildings that use steam for heating and DHW
- Connect new buildings to the East Campus or West Campus electrical loops, rather than being supplied directly from UI.

Focus on energy optimization should especially be placed on future buildings that are generally more intensive such as academic buildings with laboratories and dining halls. In general, Southern should take the opportunity to complete energy efficiency upgrades during building renovations.

3.2 ENERGY RESILIENCY RECOMMENDATIONS

As the campus grows it is important to be able to support the electric needs in case of power outages and unreliable energy situations. Southern has 11 generator assets on campus, ranging from 17 kW to 1.5 MW. The largest generator provides 100% redundant power to the West Campus Loop, while an 800 kW Kohler generator supplies full power to the Facilities Building. Most of the smaller capacity generators serve individual buildings for purposes of providing lighting and elevator use.

For increased power reliability, Southern may want to consider employing a microgrid, especially if the campus pursues fuel cells or combined heat and power. Connecticut's Department of Energy & Environmental Protection (DEEP) offers $10 million in funding for round three grants.

In 2015, Southern partook in the CSCU multi-campus hazard mitigation planning initiative which identified energy resiliency opportunities that are also applicable for the Energy Master Plan. The following presents recommendations from the hazard mitigation plan for improving the energy reliability and resiliency of the campus.

- Study and evaluate solutions for redundant power on campus, including cogeneration and implement engineered solutions.
- Increase generator capacity, particularly for the East Campus Loop
- Add transient surge suppression to block large voltage spikes in Adanti Student Center.
- Install and maintain surge protection on critical electronic equipment.
- Improve building envelopes
- Develop a debris management plan.
- Bury power lines to provide uninterrupted power after severe winds
- Add building insulation to prevent burst pipes and other winter-related impacts.

CONCLUSION / NEXT STEPS

Southern has an advanced energy program and access to varied forms of energy data. Southern's program is inclusive of recommissioning efforts and includes deliberate shut downs coordinated with administration to save energy. Southern's continued efforts are largely guided by climate action goals, a desire to keep sustainability in the forefront of campus actions and to reduce costs. As evident by the relatively low EUI, Southern is doing an excellent job managing energy use with the existing systems.

Improvements for Southern relate to enhancing existing practices to bolster utility incentives, and seeking alternative forms of energy that will provide cost and energy savings. Top priority initiatives include:

- Alternative Energy: Explore an Internal Combustion CHP engine at the Energy Center. A unit sized for year-round operation is suggested, near 600 kW, with the final size and feasibility based on further study.
- Renewable Energy: Explore additional PPAs for on-site solar, as well as off-site, where economically advantageous.
- Utility Incentives/ Develop Plan for EEMs: Maximize incentive funding for EEMs by working with UI, and combining multiple energy saving opportunities in what is known as a "Comprehensive Project." Further analysis and collaboration with UI is required to determine rebate amounts for each opportunity.

A summary of further projects and priorities for the campus are listed in Table 2.6. While Southern has the second lowest energy use intensity of the four CSCU Universities, there are remaining substantial energy optimization opportunities that will aid in decreasing energy use and increasing energy reliability and sustainability.

4.1 CONTACT INFORMATION FOR KEY STAKEHOLDERS

Collecting all the necessary information for this planning effort required a collaborative effort. Listed 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: WESTERN DATA, METHODOLOGY, ASSUMPTIONS AND NOTES

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

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

Electricity: UI Summary Report (FY13,14,15) and BAS Data (FY13,14)

- Total campus consumption is taken from the UI report.
- BAS data in the form of the east-west pivot, residence halls sheet, and academic buildings sheet were used to break out building level numbers for buildings under the east and west loops.
- No information was found for the Nursing Building, which was noted as having a UI account.

Natural Gas: UI Report (FY13,14,15)

APPENDIX B: SUMMARY OF PAST ENERGY PROJECTS

Energy Conservation

2015

1- Entire campus-Converted 750 HPS Granville outdoor light pole fixtures to LED-20% energy savings
2- Entire campus-Converted all elevator lighting from fluorescent to LED
3- Schwartz Hall-Converted all hallway, stairwell, and room lighting from fluorescent to LED
4- North Campus-Converted all hallway, stairwell, bedroom and foyer lighting from fluorescent to LED
5- Brownell Hall-Converted hallway lighting in dorm rooms from fluorescent to LED
6- West Campus garage-Converted all stairwell lighting from fluorescent to LED
   Replaced all HPS ramp light fixtures with LED fixtures
7- West Campus garage-Replaced 150 HPS ramp lighting with LED lighting
   Replaced all HPS ramp light fixtures with LED fixtures
8- Fitch St. garage-Replaced all stairwell HPS lights with LED lights
9- Pelz Gym-replace all perimeter HPS wall pack light fixtures with new LED light fixtures
10- Moore Field House-Replaced 1000 watt metal halide main gym lights with t-8 fluorescent light fixtures
11- Pelz Gym-Replaced 400 watt metal halide light fixtures with t-8 fluorescent light fixtures
    Pelz Pool-Replaced 400 watt metal halide light fixtures at with induction light fixtures
12- North Campus parking lot and Condos- Converted all outdoor parking lot lights and condominium wall pack light fixtures from HPS to LED
13- Parking Lot #12- Replaced all HSP pole lights with new LED light fixtures
14- Lyman Auditorium-Replaced all perimeter building wall pack HPS light fixtures with LED light fixtures.

15- Schwartz Hall parking lot and Lot #10-Replaced all parking lot light HPS light fixtures with new LED light fixtures.

16- Schwartz Hall-Converted all outdoor perimeter HPS security lighting to LED

17- Conn Hall- Replaced all outdoor HPS perimeter security and wall pack light fixtures with LED light fixtures.

18- Conn Hall-Replace 120 watt incandescent lamps throughout entire dining room area with 28watt LED lamps.

19- En A120 and C112 lecture halls, replaced 120 watt incandescent ceiling lamps throughout lecture halls with 28 watt LED lamps.

20- Barnes and Noble Bookstore-replaced all track lights with LED lights

21- Guard shacks throughout campus-replaced all incandescent outside accent soffit lights with LED lamps.

Res Life energy efficiency 2015

In reference to energy efficiency projects, residence life has completed the following:

- Low flow showerheads have now been installed in all 6 first/second year residence halls.
- All refrigerators and dishwashers are replaced using energy star rated units.
- Residence Life has worked with our laundry contractor to install only front loading, energy star rated units in the residence halls.
- LED lighting has been installed in all hallway and room fixtures in Schwartz Hall and North Campus.
- LED lighting has been installed in all Brownell room common areas.
- Motion sensors have been installed in all common area kitchen units and most study spaces as well as the Farnham Programming space.
- All 1500 lamps in the residence halls have been equipped with CFL bulbs
- We just completed an RFP process for 911 energy star rated small refrigerator/microwave combination units which are energy star/CRE Free.

  I wanted to mention a few other items to highlight which are not related to "energy" but might be useful ...
- Residence hall rooms now painted with zero VOC paint which is GreenGuard® Indoor Air Quality Certified and GreenGuard® Certified for Children and Schools.
- Recycling stations exist in all residence halls for batteries, fluorescent lights and cellular phones.
- For the Fall of 2015 we have moved to an online/paperless room selection process.