# COLORADO COLLEGE

# 2014 ENERGY REPORT

Mark J. Ferguson, P.E.
Campus Operations & Plant Manager

Revision 0 September 2014

# Table of Contents

# Executive Summary

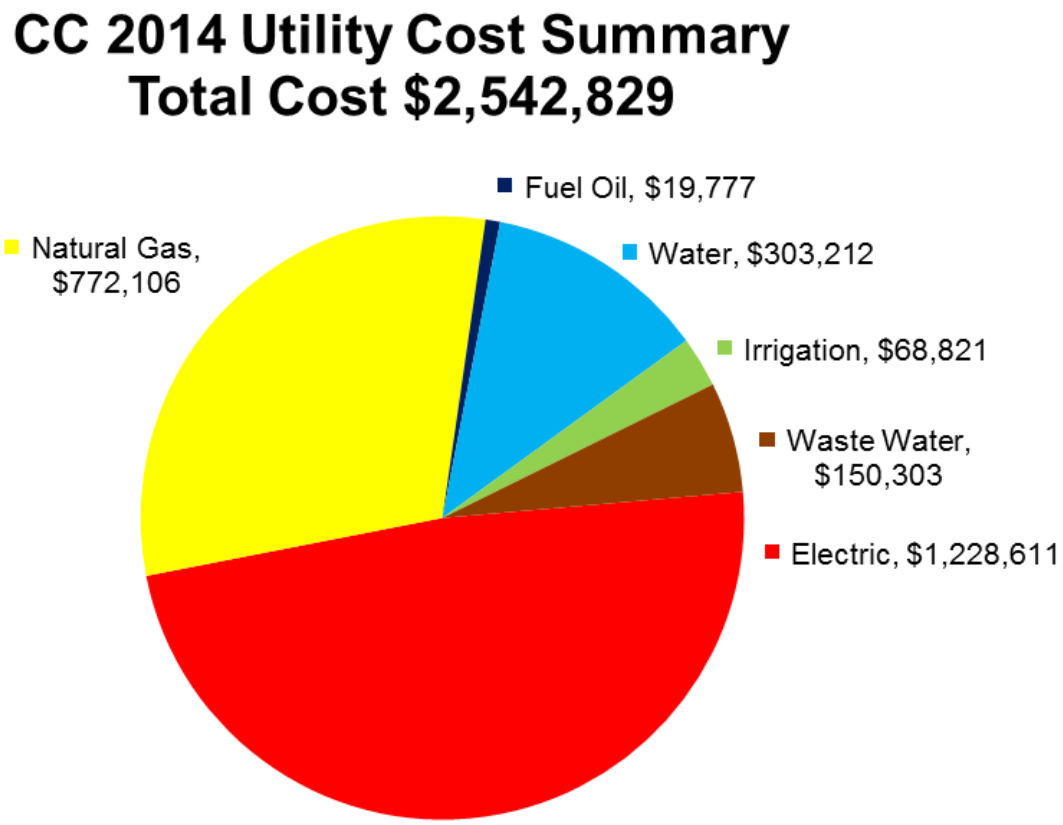
The Facilities Services Department at Colorado College (CC) is committed to taking action to meet the College's 2020 carbon neutrality goal. Utilities management at Colorado College is an area of increased physical plant emphasis. In FY 14, CC experienced slightly increased energy consumption campus wide due to colder than typical weather. Cumulative avoided costs for utilities are estimated to be nearly $2.7M since the 2008 baseline. Some notable accomplishments for 2014 are:

- Increased Renewable Energy Purchases - This year CC increased its purchases of renewable energy. In total this academic year, CC purchased 4.0% of our total energy from renewable sources or 13.4% of our electricity.

- 2014 Sustainability Projects – This year CC completed a large quantity of projects with the purpose of supporting campus energy efficiency goals. Completed projects include the installation of large scale photovoltaic (PV) solar arrays at five campus locations. Another energy efficiency project completed was the renovation of the Spencer Center, making the building an ultra-high performance building. More detail on the Spencer project is included on page 14 of this report.

- 2015 Sustainability Projects – We have an exciting list of project on the horizon for fiscal year 15. These projects include the installation of LED lighting at Honnen Ice Arena and the Schlessman Pool. More detail on this project begins on page 25 of this report.

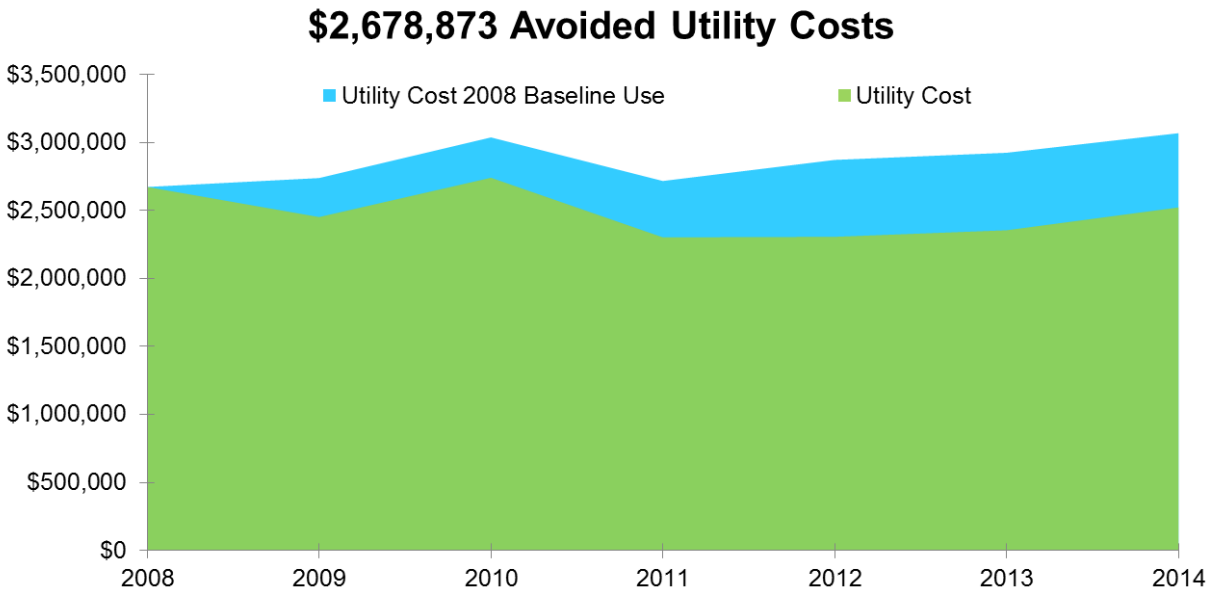
# Utilities Overview




- **For the 2014 academic year, Colorado College's main campus energy related characteristics were:**
  - Approximately 2,064,590 square feet (SF) of space
  - Approximately 95 acres of land
  - 152 Buildings
- **For the 2014 academic year, Colorado College's main campus energy performance statistics were:**
  - Energy use averaged **86.3 kBtu per square foot** (SF)
    - 3.6% increase over previous year
  - Energy costs averaged **$0.98 per SF**
    - 8.9% increase over previous year
  - $MTCO_2$ emissions from energy use averaged **0.0093 $MTCO_2e$ per SF**
    - 2.0% increase over previous year

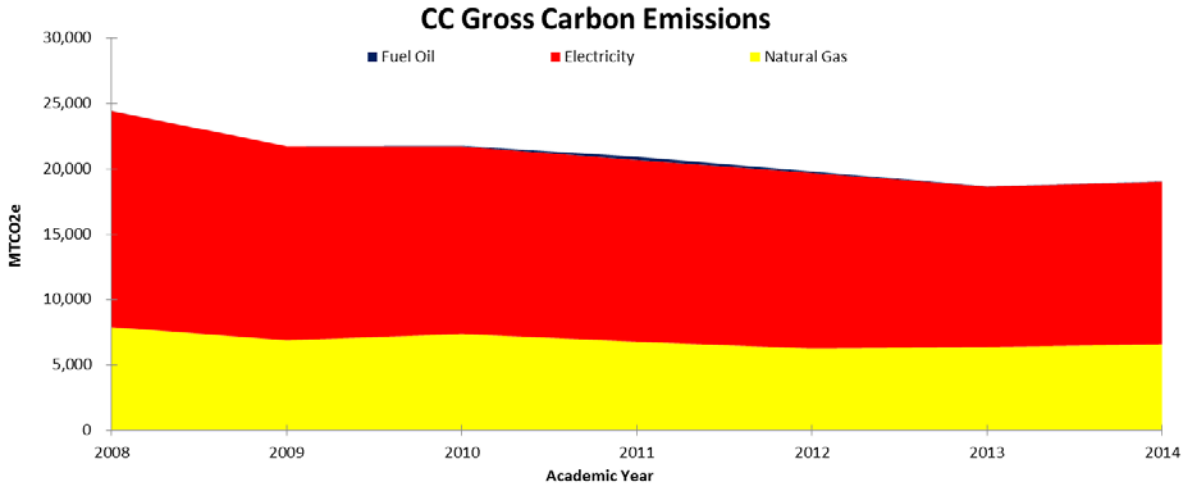
# Avoided Cost

The cumulative campus utility cost avoidance compared to the campus baseline of 2008 is estimated at nearly $2.7M. The avoided cost for the 2014 academic year is estimated at $546K. These numbers reflect combined utility savings, which include avoided electricity, natural gas, water, and waste water costs. Below is a graphical representation of overall avoided utility costs (area in blue).



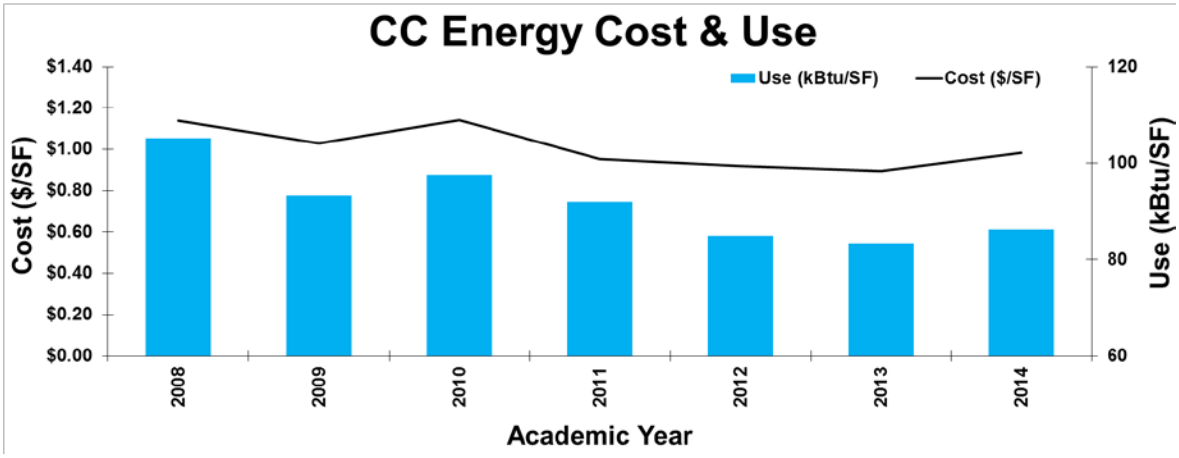
# Our Carbon Footprint

Colorado College's commitment to become carbon neutral stems from the College's signing of the Presidents' Climate Commitment in early 2009. The College's carbon footprint, in 2008, from energy use is estimated at 24,437 metric tons of $CO_2$ ($MTCO_2$). Since 2008, Colorado College has made steady progress toward its carbon neutrality goal. For 2014, the College's carbon emissions from energy use are estimated at 19,038 $MTCO_2$ for a reduction of 22% compared to the 2008 baseline. These measurements include emissions as listed below:



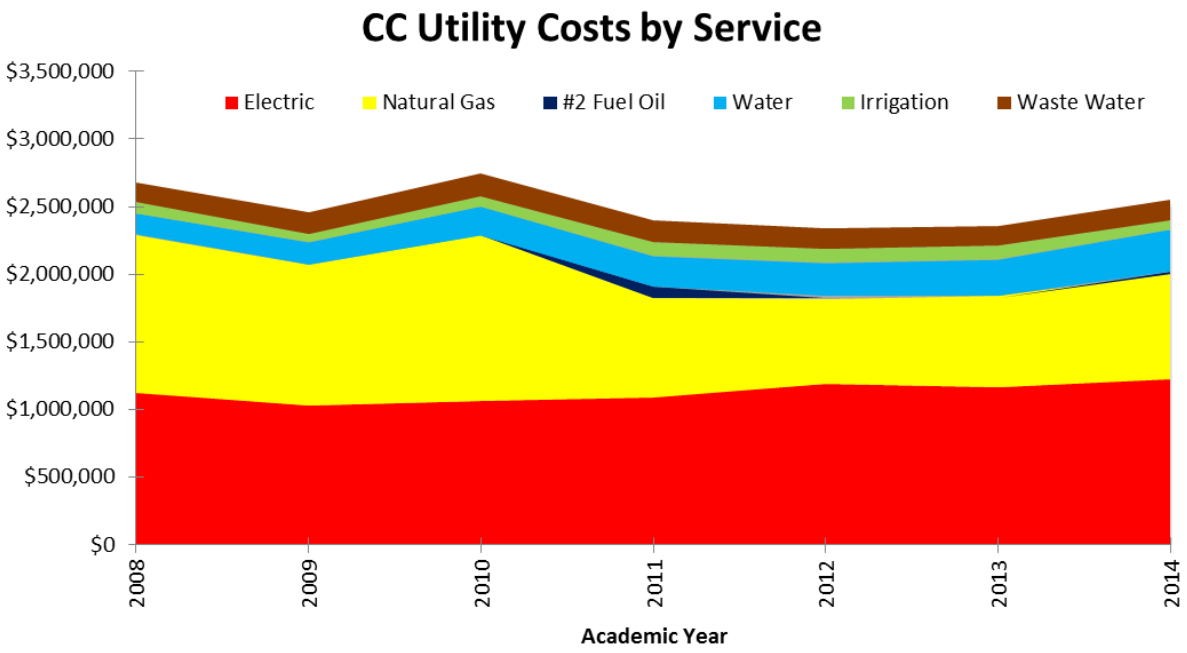
# Benchmarking

Colorado College has been tracking overall campus energy and cost intensity since 2008. For reference, the Association of Physical Plant Administrators (APPA), who represents the largest international association of educational institutions and their facilities departments, list the 2013 average energy intensity at 120 kBtu/SF/Yr. APPA lists the average utilities cost per square foot at $2.15 / SF. The chart below shows CC is well below both figures with an average energy intensity of 86 kBtu/SF/Yr and a utilities cost of $0.98/SF. The chart confirms CC's sustained decline in both energy cost and use.

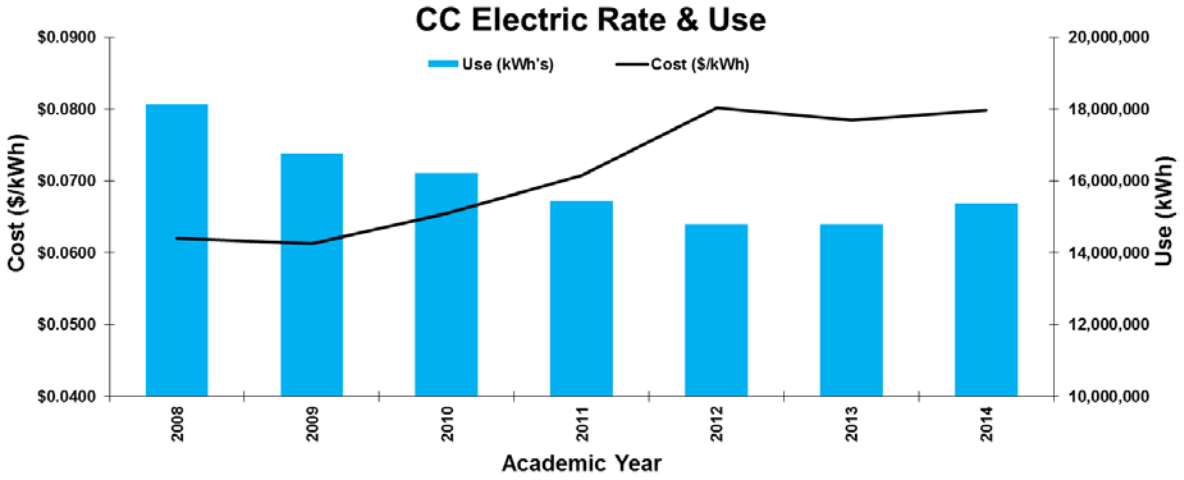


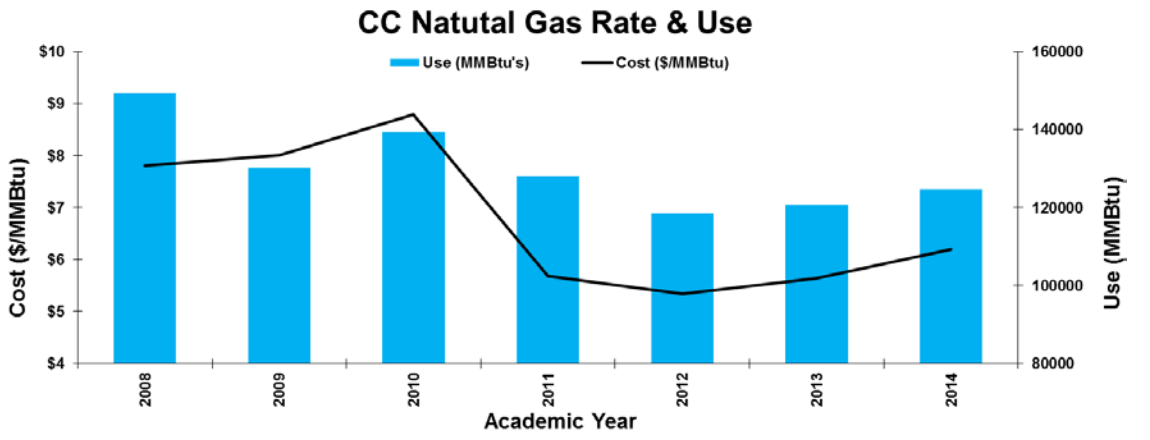

One factor that is unclear is what effect CC's block plan has on our overall energy use intensity. The block is thought to require more educational space because all spaces are used simultaneously. For comparison, the following annual kBtu/SF/Yr numbers were calculated using the most recent ASHEE STARS data available:

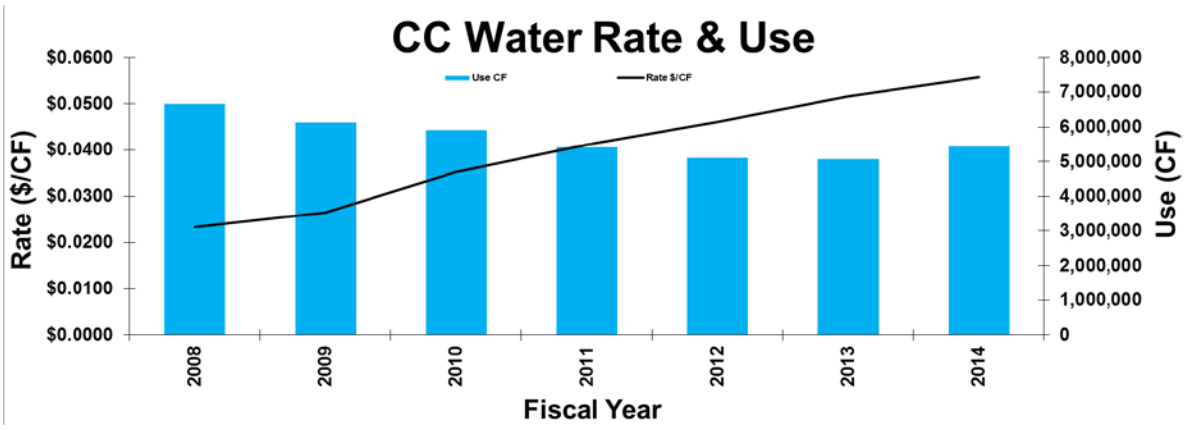
| | | |
|---|---|---|
| • Colby College | 146 kBtu / SF | 2013 data |
| • Colgate University | 171 kBtu / SF | 2013 data |
| • Middlebury College | 137 kBtu / SF | 2014 data |
| • Pomona College | 134 kBtu / SF | 2011 data |
| • University of Denver | 104 kBtu / SF | 2011 data |
| • University of Colorado Boulder | 144 kBtu / SF | 2014 data |
| • Williams College | 148 kBtu / SF | 2011 data |

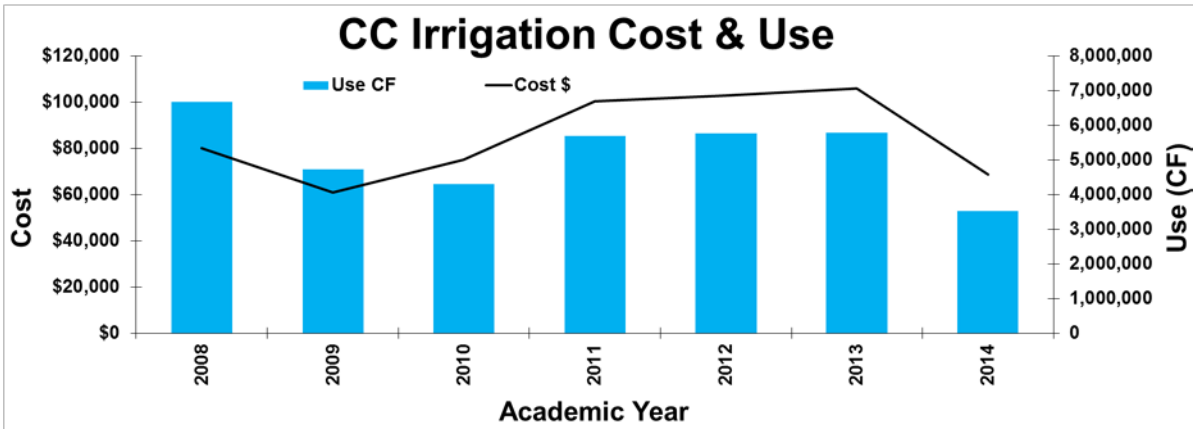


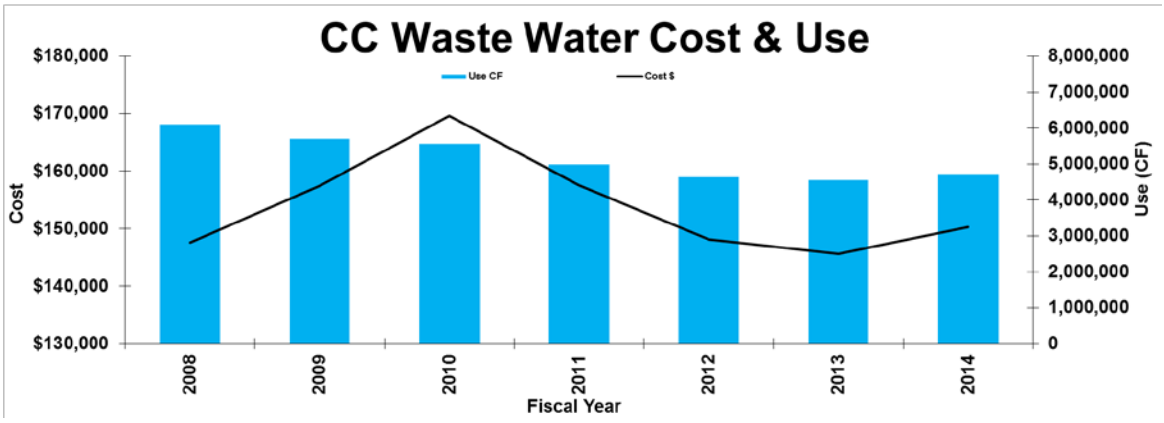

The chart above breaks down expenses by utility commodity. The most notable information is the increase in electricity and water costs despite reduced use. The charts below give more detail on these relationships.



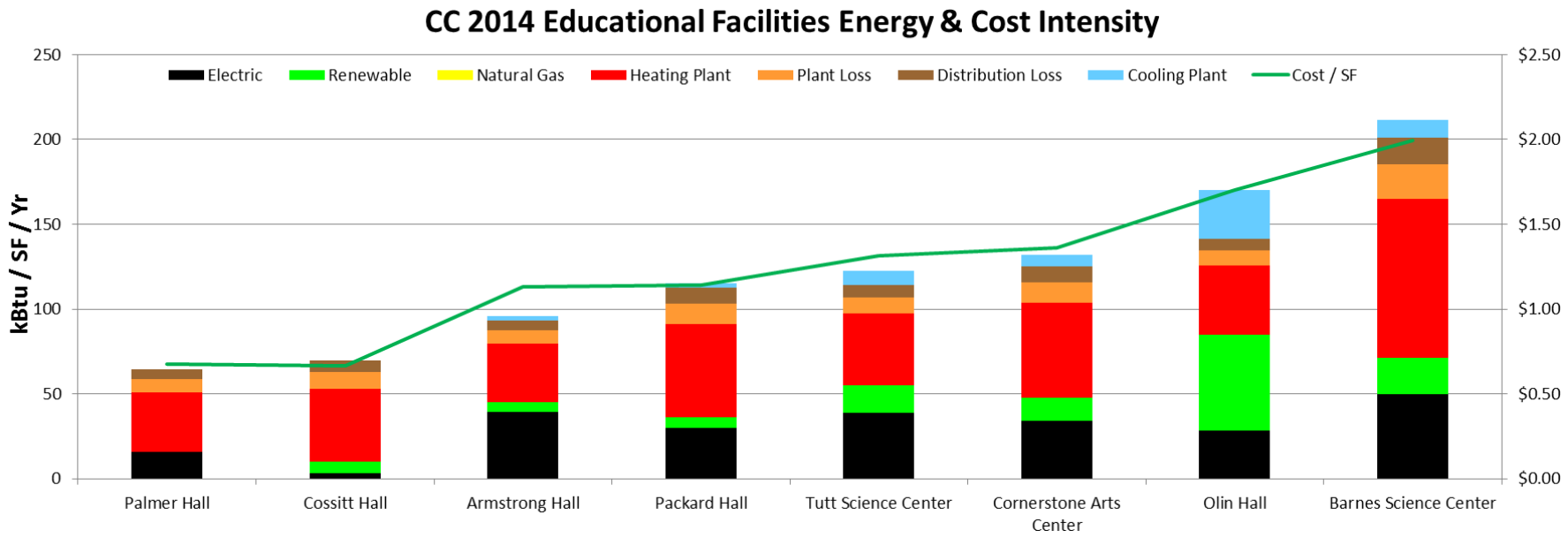


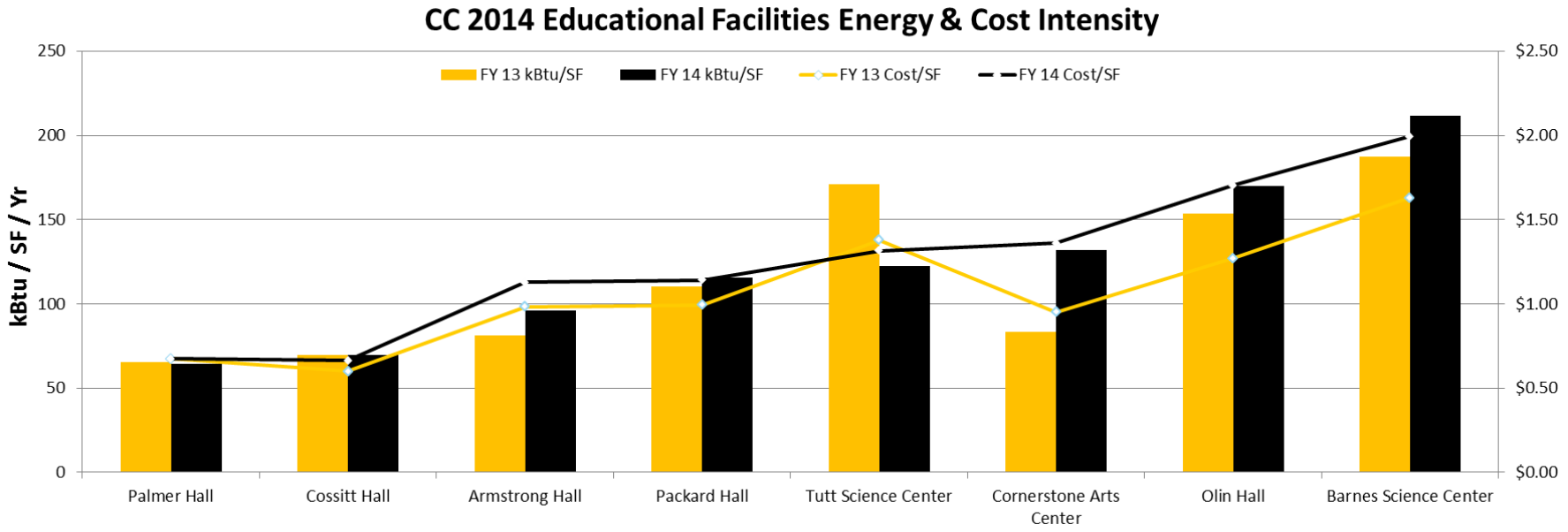



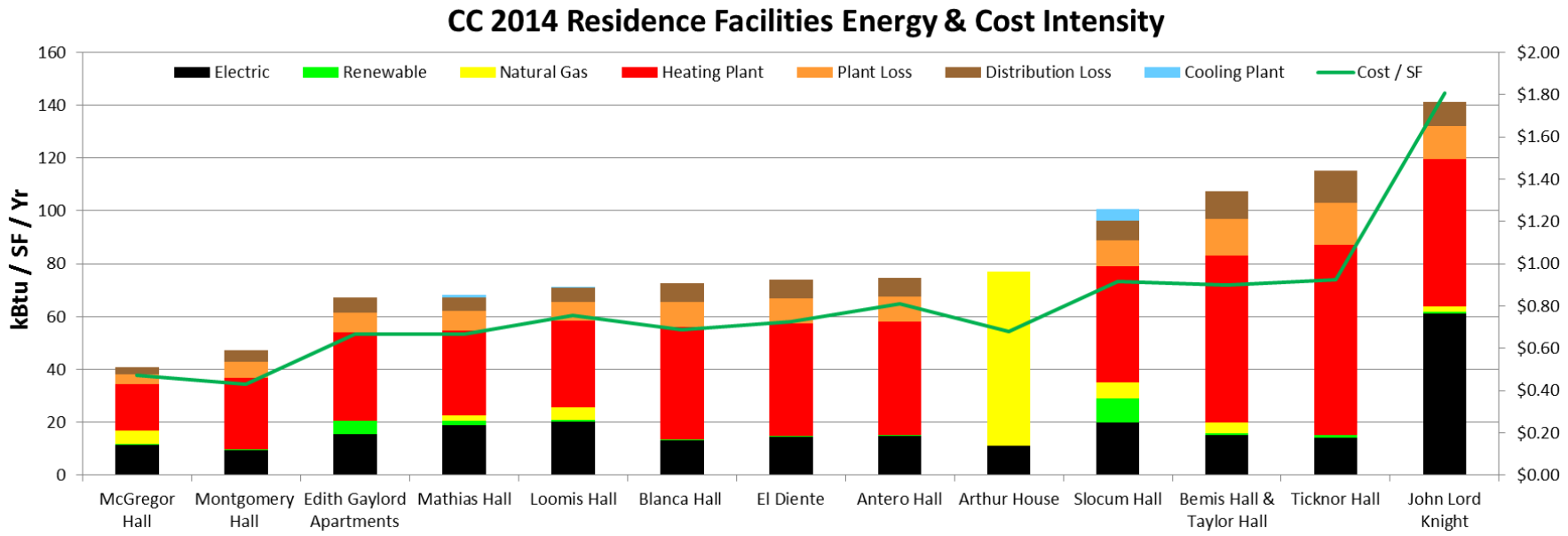

This is the second year for energy benchmarking at the building level. Three years ago, thermal metering was installed. Thermal metering has enabled CC to measure the amount of heating and cooling energy flowing from the central plant to respective buildings. The following charts are the result of building level thermal and electrical metering.

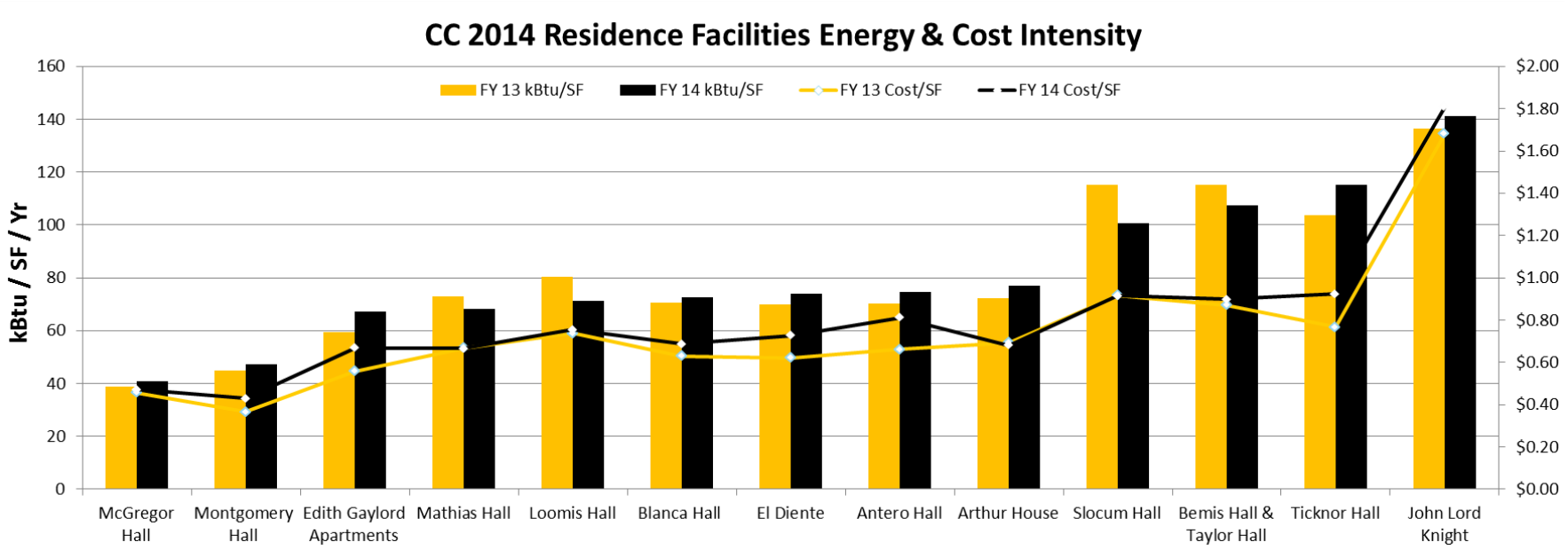
# Benchmarking Educational Facilities



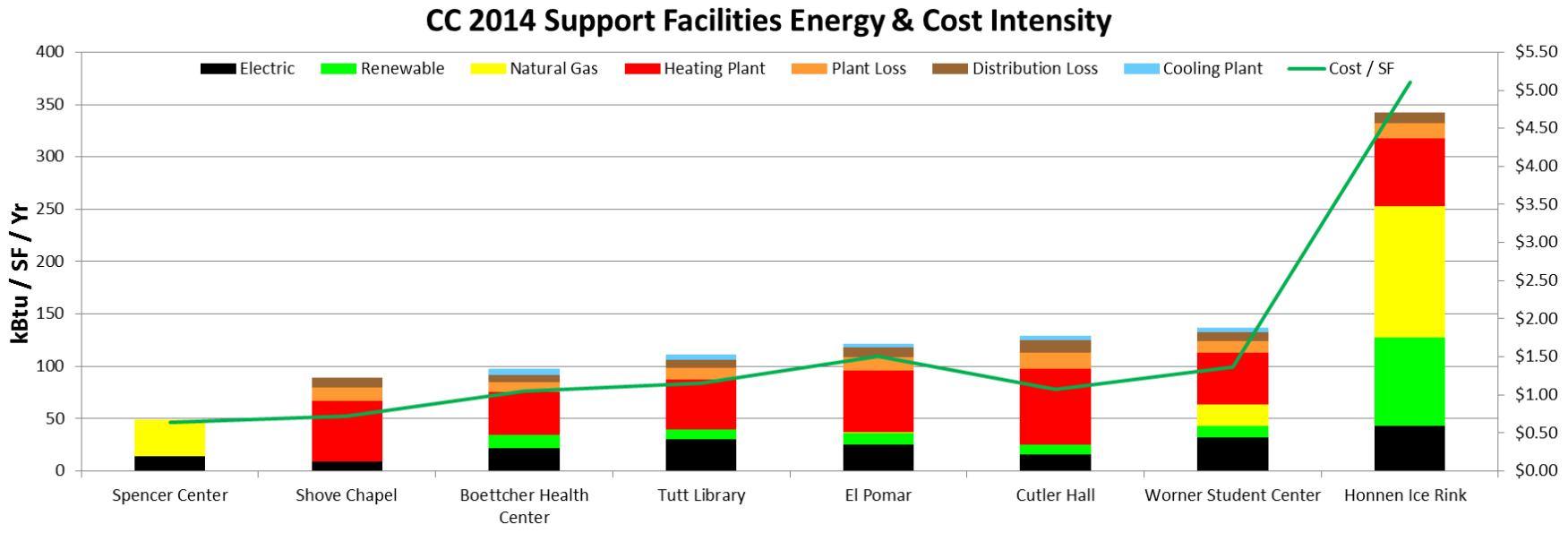



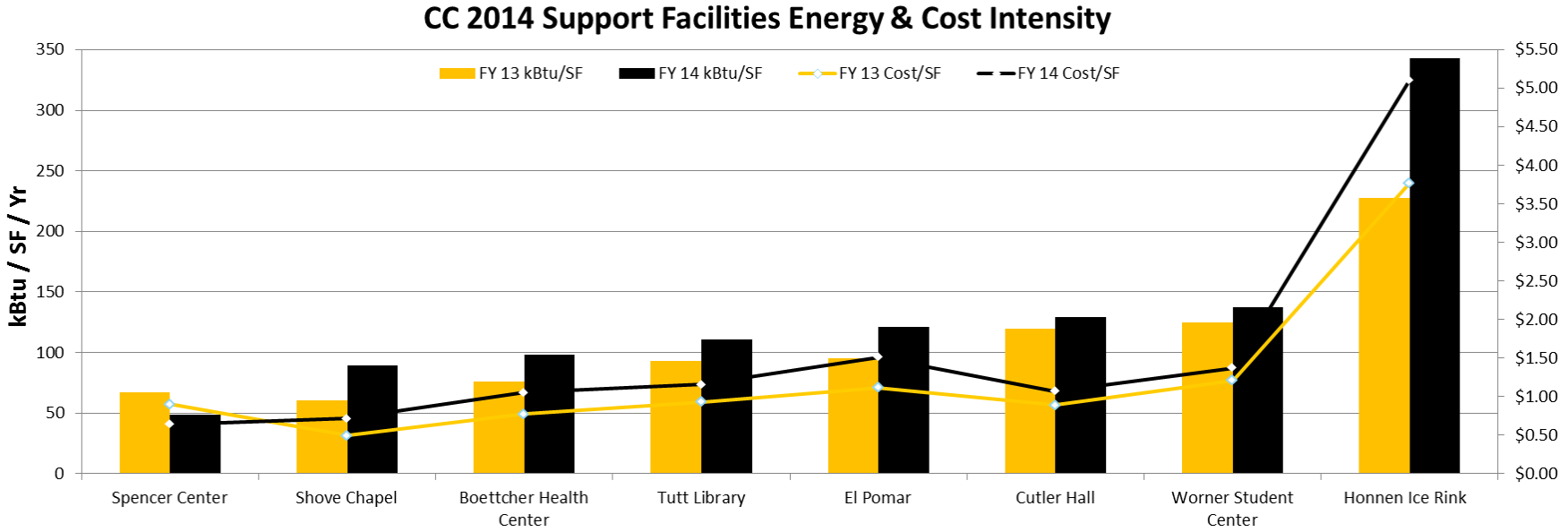
# Benchmarking Residential Facilities



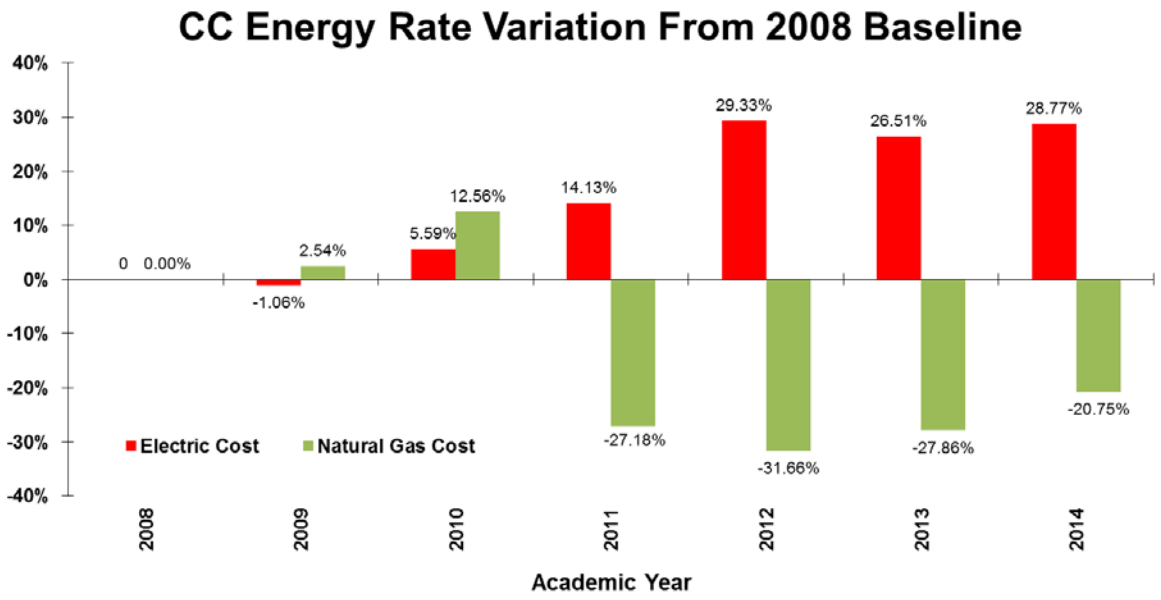
# Benchmarking Support Facilities

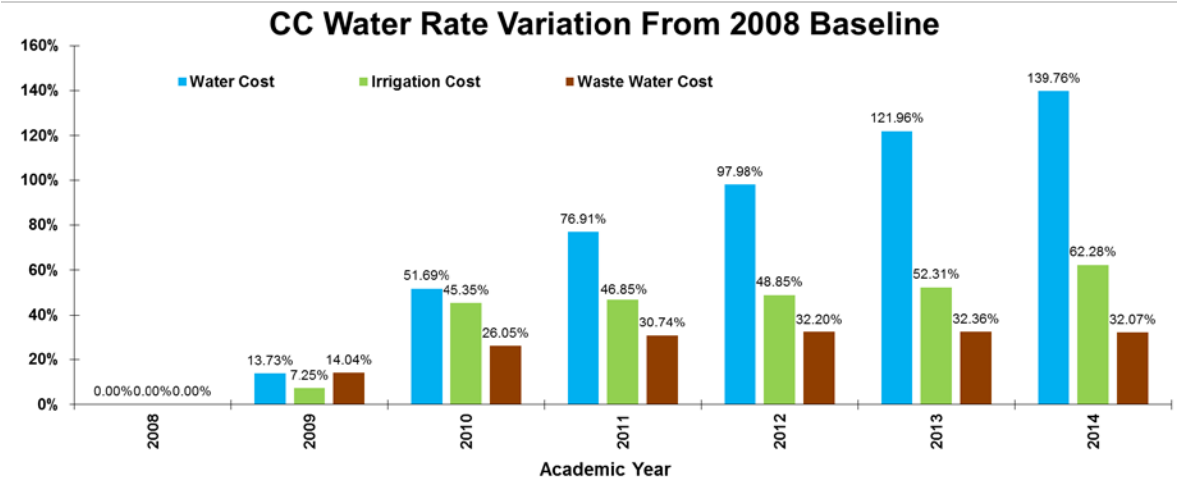


# Utility Rates

CC has made significant improvements in reducing utility consumption since 2008. Despite these improvements, total costs are relatively unchanged due to annual increases in utility rates. The charts below show the variation in commodity rates per unit experienced by CC since 2008. Electricity and water rate increases have seen larger than expected upward pressure. Natural gas costs have declined due to market conditions and moving to an interruptible rate in late 2014.

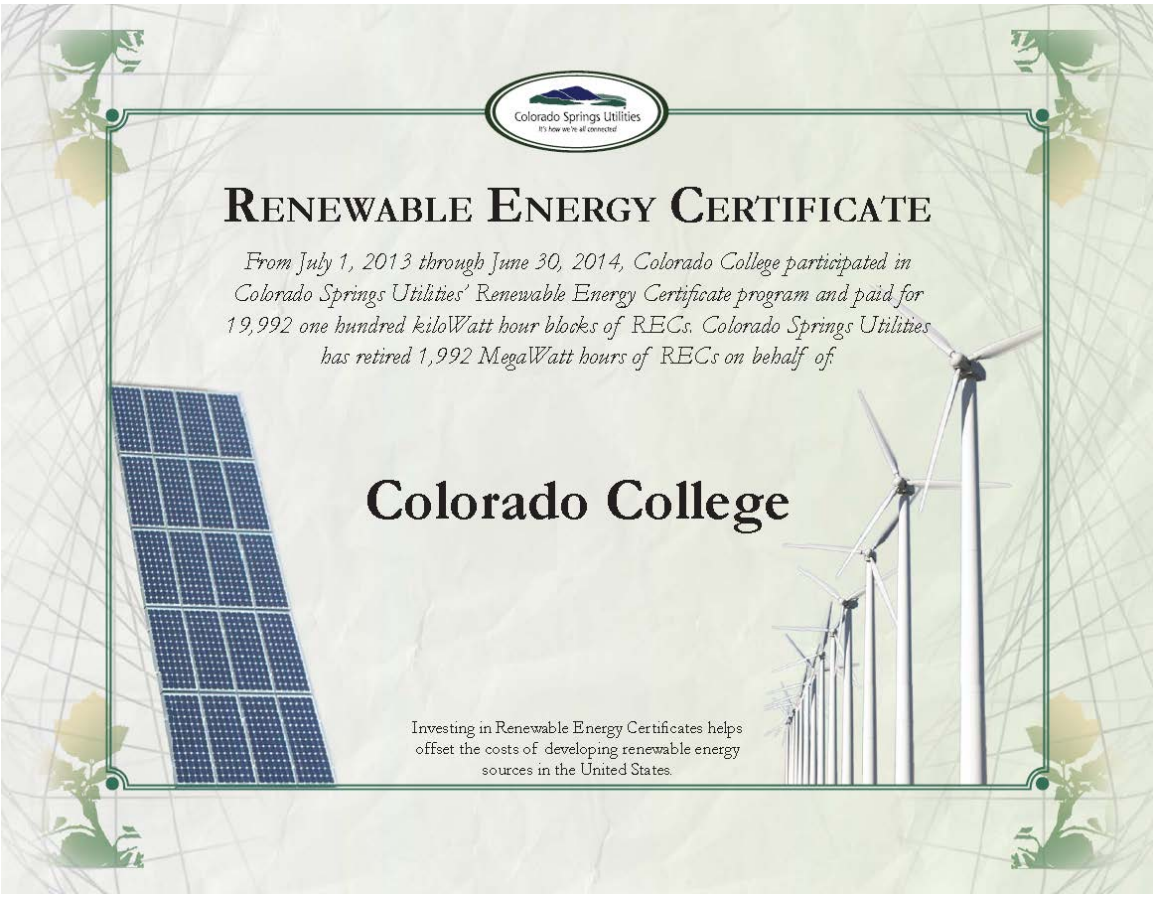


# Increased Renewable Purchases

This year, CC increased its purchases of renewable energy. In total this academic year, we purchased 4.0% of our total energy from renewable sources or 13.4% of our electricity. The bulk of our renewables was provided by wind purchased from Colorado Springs Utilities (CSU). The College entered into a two year wind contract beginning September of 2012 for 1000 MWh's of wind per year. In April 2013, we doubled our purchase to 2000 MWh's / year. The contract ends on December 31st, 2014. We are optimistic CSU will make more wind power available but it does not appear likely.

All wind power is applied to the College's Central Plant which serves most large buildings on campus with high temperature heating water and chilled water. Below is the renewable energy certificate provided by CSU for the wind purchase.



# 2014 Facilities Sustainability Projects

## Cornerstone Arts Center Rooftop Solar Photovoltaic (PV)

Project Status: Complete September 2014

Project Highlights:

- $MTCO_2$ Emissions Reduction = 4807 $MTCO_2$ @ 40 Years
- Annual Energy Generation (year 1): 164,600 kWh/Year
  - **Approximately 26% of building electric consumption**
- PV System Power Ratings: 108.0 kWp DC / (100 kW AC)
- PV Modules: 360 x 300Wpanels
- Ballasted Mounting System (no roof penetrations)
- Kiosk to illustrate real-time performance and environmental benefit

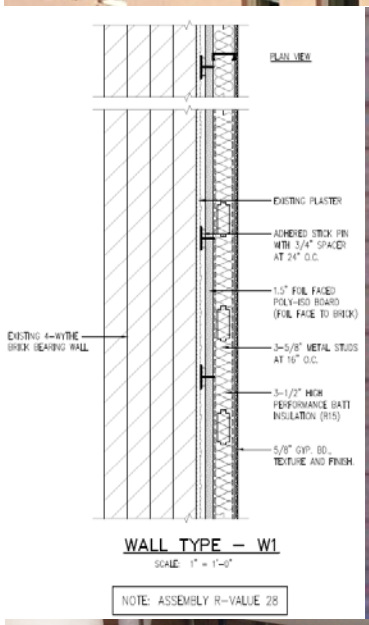
# Spencer Center Renovation

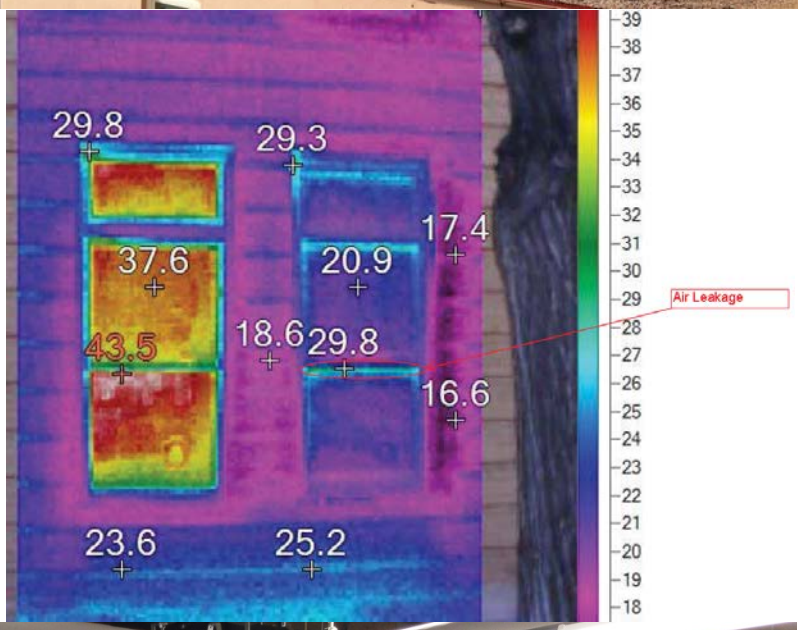
Project Status: Complete September 2014

Project Description: Support the renovation of the Spencer Center with planning, design, construction, and commissioning expertise to achieve a 10 to 20 kBtu/SF/Yr. energy performance target. This project delivered a high performance building without sacrificing occupant comfort or aesthetics. The Spencer Center, which is more than 100 years old, utilizes a water source variable refrigerant flow (VRF) heating, ventilating, and air conditioning (HVAC) system. The VFR system utilizes variable speed heat pumps and a sophisticated series of heat exchangers to efficiently move heating and cooling (refrigerant) around the building. The HVAC system utilizes the existing campus chilled water system as a heat sink and high efficiency boilers to optimize system efficiency.

Project Highlights:

- Energy performance target of 10 to 20 kBtu/SF/Yr
- High performance building envelope
  - R27 wall assembly
  - Energy Star windows (rebate received is nearly $5,851)
- 18 kW PV array on roof (rebate received is $22,899)
- Water source variable refrigerant flow (VRF) heating and cooling system
  - Utilizes campus chilled water loop as free ground loop
  - Energy recovery ventilators
  - VRF system provides building domestic hot water
- LED lighting with occupancy sensors
- In-house building commissioning


PLAN VIEW
EXISTING PLASTER
ADHERED STICK PIN WITH 3/4" SPACER AT 24" O.C.
1.5" FOIL FACED POLY-ISO BOARD (FOIL FACE TO BRICK)
EXISTING 4-WYTHE BRICK BEARING WALL
3-5/8" METAL STUDS AT 16" O.C.
3-1/2" HIGH PERFORMANCE BATT INSULATION (R15)
5/8" GYP. BD., TEXTURE AND FINISH
WALL TYPE – W1
SCALE: 1" = 1'-0"
NOTE: ASSEMBLY R-VALUE 28


29.8
29.3
17.4
37.6
20.9
43.5
18.6
29.8
16.6
23.6
25.2
Air Leakage
39
38
37
36
35
34
33
32
31
30
29
28
27
26
25
24
23
22
21
20
19
18


VRF SUPPLY
VRF RETURN

## Packard Hall Art Upgrades

Project Status: Complete September 2014

Project Highlights:

- Improved indoor air quality in art studios and print making
  - Improved exhaust and separated solvents and acids
- Added air conditioning to art studios
  - Energy recover ventilator
- New lighting
  - Occupancy Sensors

## Worner Solar Thermal

Project Status: Complete September 2014

Project Highlights:

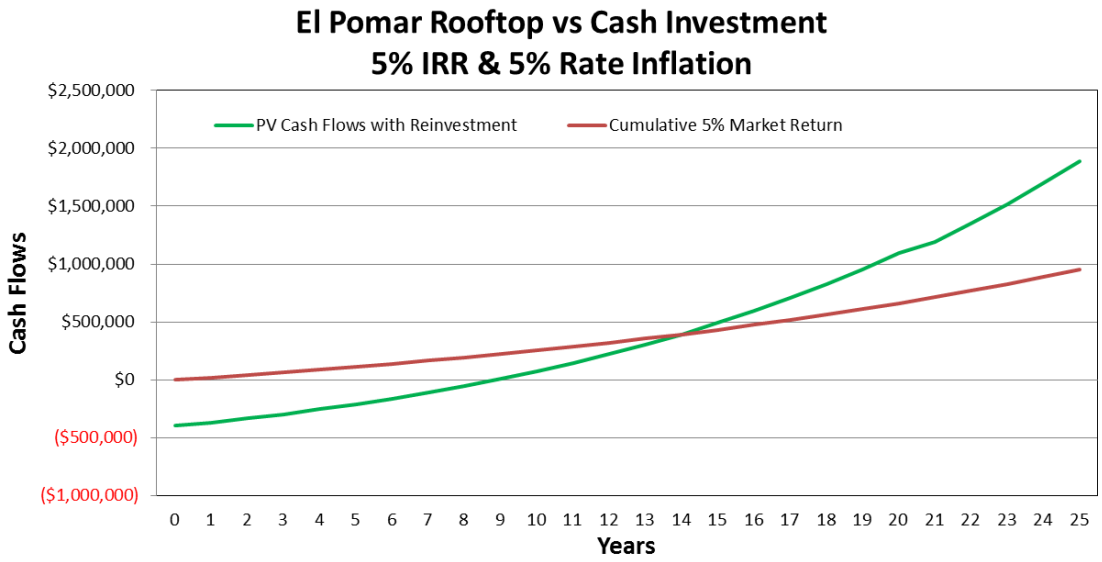
- $MTCO_2$ Emissions Reduction = 1479 $MTCO_2$ @ 25 Years
- Solar thermal system to support campus cooking operations
- **135,000 kBtu/Yr**
  - **approximately 10% of building hot water use**
- $15,000 Utility Rebate
- Ballasted Mounting System (no roof penetrations)

# El Pomar Sports Center Rooftop Solar Photovoltaic (PV)

Project Status: Complete September 2014

Project Highlights:

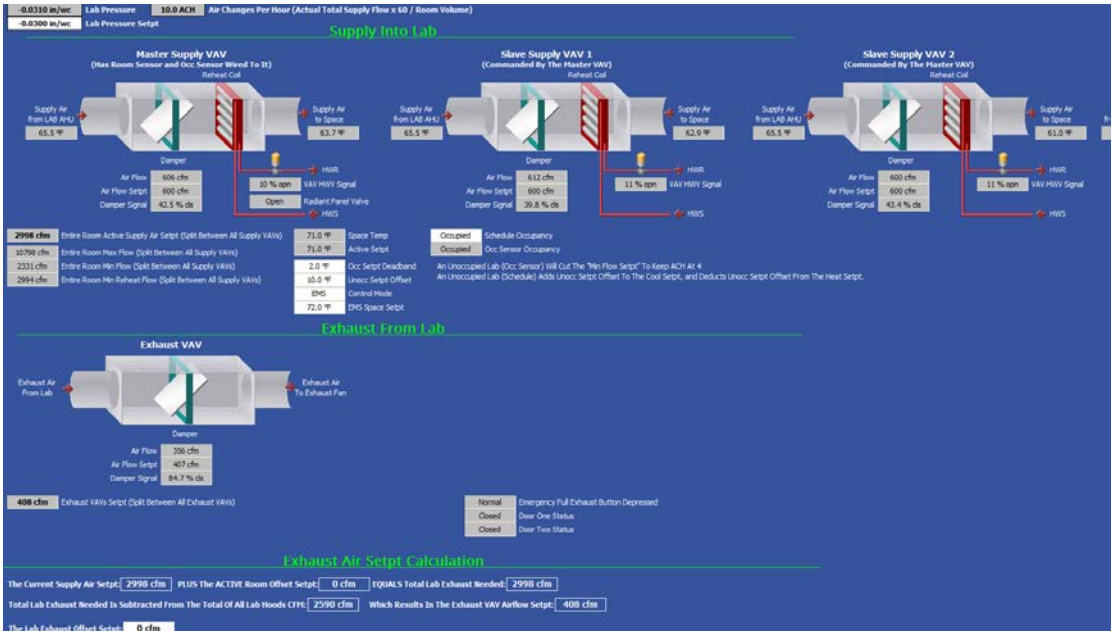
- $MTCO_2$ emissions reduction = 7170 $MTCO_2$ @ 40 years
- Annual energy generation (year 1): 278,000 kWh/Yr
  - **Approximately 39% of building electric consumption**
- PV system power ratings: 182.4 kWp DC / (160 kW AC)
- PV modules: 608 x 300W panels
- Ballasted mounting system (no roof penetrations)
- Kiosk to illustrate real-time performance and environmental benefit
- Outperforming original estimates
  - Simple payback in less than 9 years
  - Becomes cash positive in 14 years assuming 5% IRR & 5% utility rate inflation



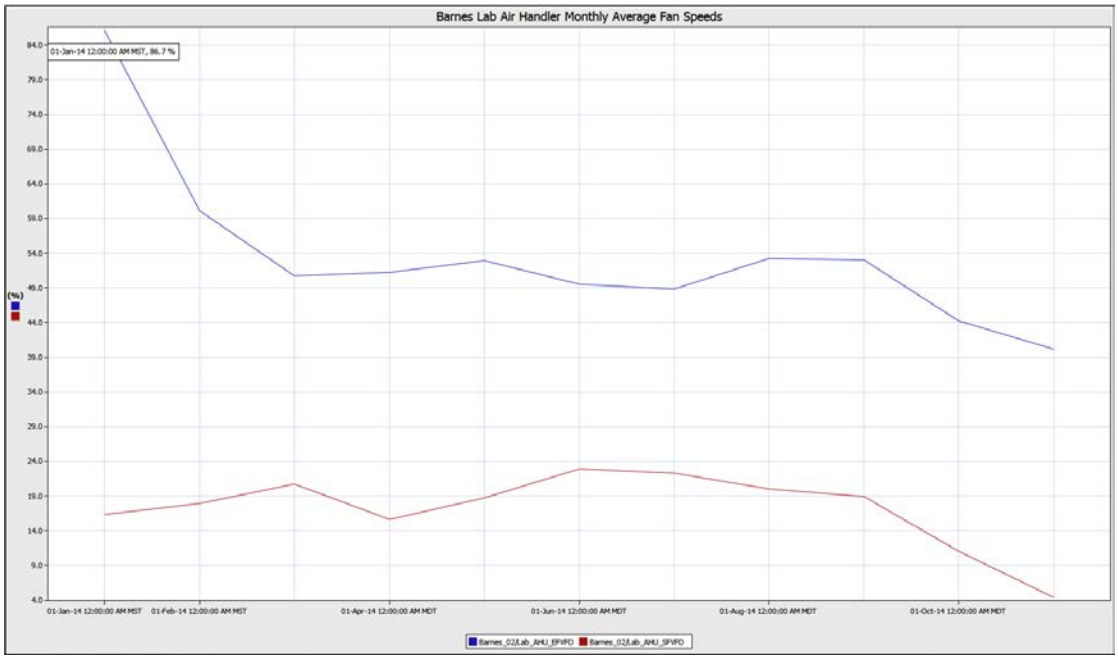

# Barnes Fume Hood Project

Project Status: Phase 2 Complete July 2014

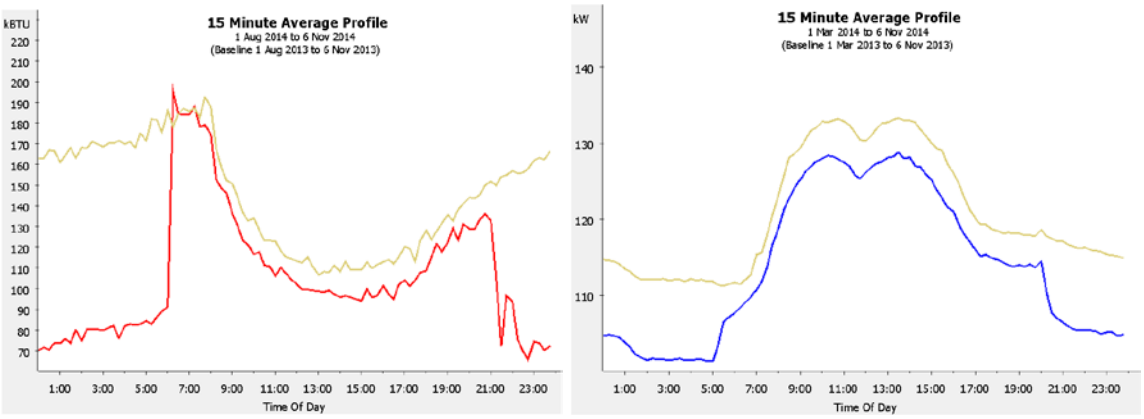
Project Description: This year, Facilities Services has improved energy performance in Barnes by replacing the pneumatic controls on the supply air, room exhaust, and radiant zone valves with direct digital controls (DDC). The new controls allow the College to apply more sophisticated logic to each lab and reduce air changes during unoccupied hours. The system will also allow the College to operate the room exhaust and fume hood exhaust as a coordinated system to insure proper lab ventilation without over ventilating. The graphic below shows the new controls system modulating to maintaining 10 air changes per hour in Lab 325 while it is occupied.




This graphic below illustrates improved operation and energy savings of the buildings lab air handling unit. It shows monthly average fan speeds as the project progressed.



The demonstrated energy efficiency improvement in the Barnes Labs is captured in the trends below. The area between the red or blue line (this year) and the yellow line (last year) represents the energy savings. The savings are expected to increase significantly as temperatures get colder. The chart on the left is the average daily profile for high temperature hot water supplied to Barnes. The chart on the right is the average daily profile for electricity supplied to Barnes.




## Campus Combined Heat and Power Feasibility Study

Project Status: Complete July 2014
Project Description: In support of Phase 3 of the Carbon Neutrality Action Plan recommendations, Facilities Services contracted a design study to determine the best alternative for integrating a combined heat and power system on campus. We looked at all options and presented our findings to the Campus Sustainability Council. Based on feedback, we moved into schematic design on a micro grid which will be used for small peak shaving and emergency backup to critical campus facilities.

## Campus Housing Wireless Thermostats

Project Status: Complete June 2014
Project Description: This project installed 10 wireless thermostats in houses on campus to gain experience with the technology. Three different manufacturers were used. The goal is to empower residents with the tools to better manage their energy consumption.

## Olin Power Factor Correction

Project Status: Complete February 2014
Project Description: The electrical loads at Olin Hall require more current to achieve the same amount of useful work as other facilities. The result is an increase in the amount of energy lost in the distribution system. This project corrected the facilities power factor saving that energy and reducing monthly building electricity costs. The payback is just over 3 years.

## Net-Zero Synergy House

Project Status: Complete October 2014

Project Description: The Synergy house at 1018 N. Weber houses students who are among the most committed to sustainability on campus. This project is designed to give students a prototype net-zero building to study and discuss as we move closer to carbon neutrality.

Project Highlights:

- Web based thermostat
- High efficiency heat pumps for space and domestic water heating
- 4.3 kW DC PV system with web monitoring

## Net Zero the Dean's House

Project Status: Complete June 2014

Project Highlights:

- Web based thermostat
- New LED lighting
- 10.7 kW PV system with web monitoring
  - New array offsets 100% of the house electricity use.

## Armstrong Auditorium $CO_2$ Sensor

Project Status: Complete February 2014
Project Description: This project added demand control ventilation to Armstrong's auditorium. Demand control ventilation uses $CO_2$ sensors to measure the amount of CO2 in the space and modulate the outside air damper to maintain optimal air quality levels. It saves energy by reducing the amount of outside air the system is required to condition when air quality is good.

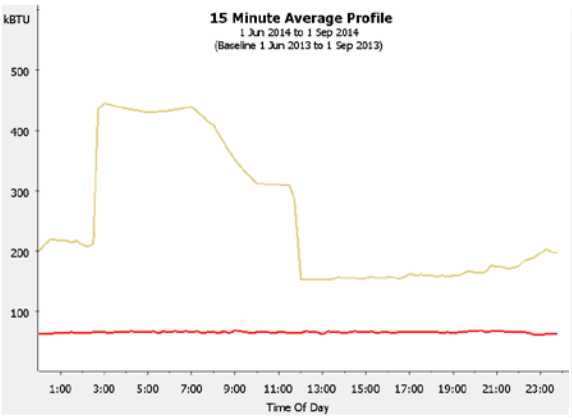
## Packard Auditorium HVAC Controls Upgrade

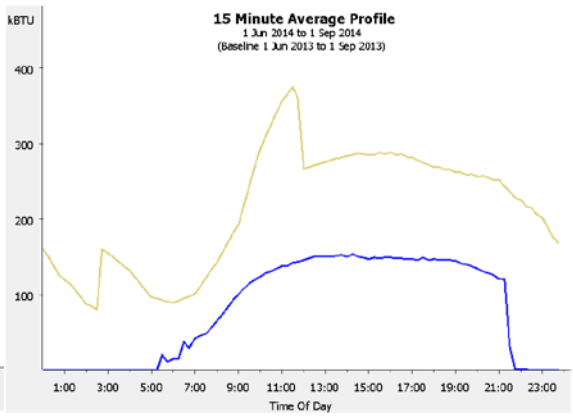
Project Status: Complete December 2013
Project Description: This project replaced outdated pneumatic controls that operated 24/7 with new direct digital controls (DDC) on the HVAC system serving the Packard Auditorium. This controls upgrade added a demand control ventilation sequence of operation to the auditorium. This enables us to maintain excellent indoor air quality and save energy.

## Monthly Building Automation Review

Project Status: Ongoing
Project Description: This project is a periodic review with stakeholders to review building performance through the building automation system and make adjustments as needed. This periodic review is used to commission new projects and retro-commission buildings that are not performing as well as expected. Below is an example of adjustments made to Tutt Science resulting in improved energy efficiency and operational performance. Facilities Services Controls Specialist created a schedule keeping the radiant heating system off during the summer. The resulting elimination of systems conflicts amongst the heating and cooling infrastructure is represented by the red and blue lines below. The area between the red or blue line and the yellow line represents energy savings. The smooth system response confirms optimal system performance.
Project Highlights:

- 29% energy reduction at Tutt Science in FY14 compared to FY13



## Slocum Renovation

Project Status: Complete August 2013

Project Description: This project was a renovation of the Slocum Hall student residence. The project included some significant sustainability improvements. The most notable improvement was in occupant comfort as a result of replacing the steam heating system with a hot water radiant heating system.

Project Highlights:

- 12% energy reduction at Slocum Hall in FY14 compared to FY13
  - Energy recovery ventilators
  - Added air conditioning to common spaces
- Improved Indoor Air Quality
- Improved Occupant Comfort

## Large Scale Solar Project

Project Status: Cancelled

Project Description: In support of Phase 2 of the Carbon Neutrality Action Plan recommendations, Facilities Services spent a great deal of time during FY14 to make a large scale solar project a reality. In the end we were not able to come to terms with Colorado Springs Utilities on the construction of an off campus PV system. We continue to work with Colorado Springs Utilities to find a renewable energy solution to achieve our carbon neutrality goals.

# 2015 Facilities Sustainability Projects

## Firm Natural Gas Transportation

Project Status: Complete October 14

Project Description: The firm natural gas transportation project is a change in the way we buy natural gas at our central plant. Currently we are on an interruptible rate meaning Colorado Springs Utilities can stop natural gas delivery to us at any time. When this happens, we switch to our back-up fuel #2 fuel oil. This project moves us from interruptible service to firm service meaning our service cannot be interrupted. As part of this project the College has contracted to purchase natural gas from **C**ontinuum Energy.

Project Highlights:

- Improve central plant reliability
- Ability to lock pricing

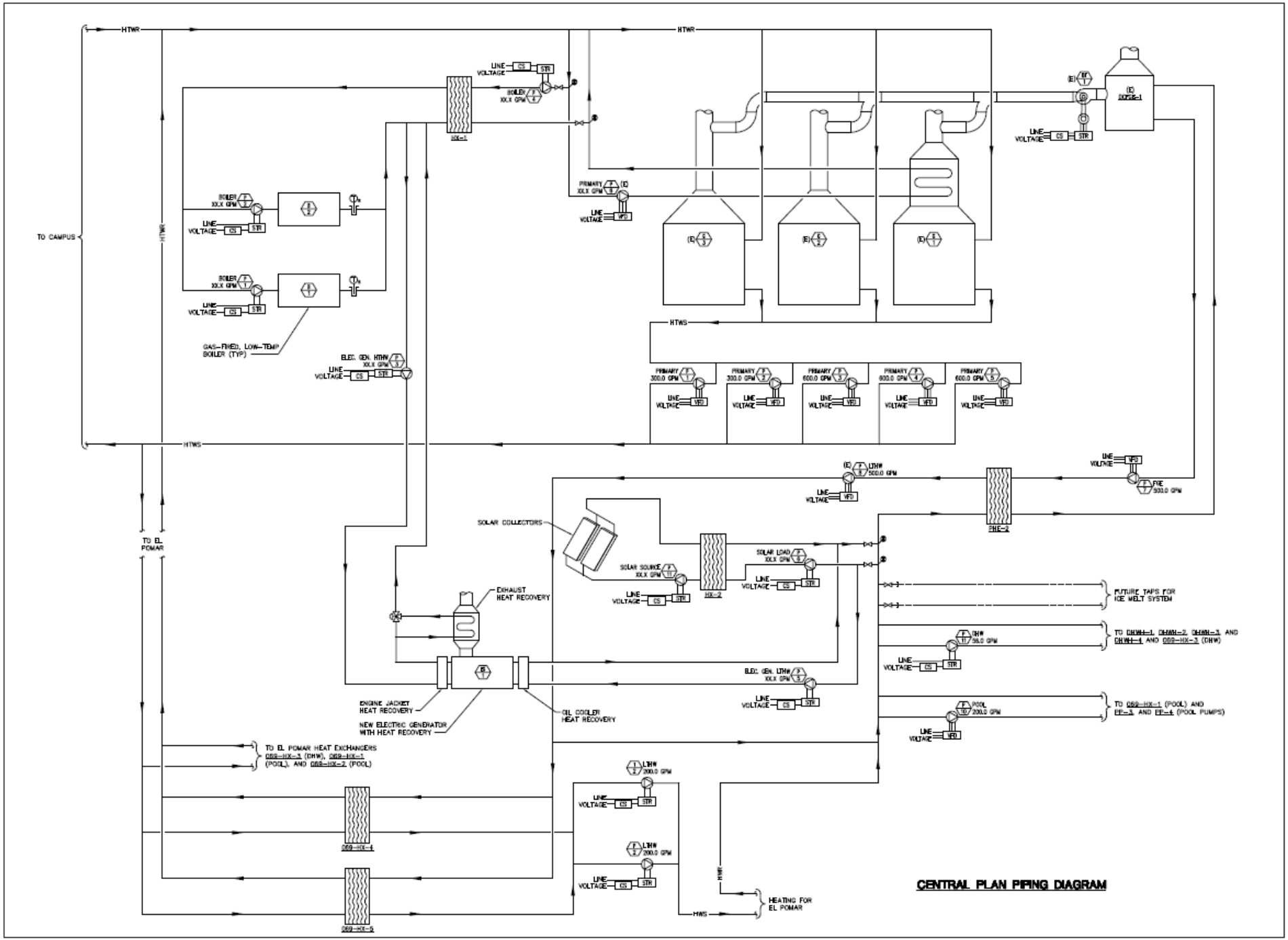
## Campus Micro-Grid

Project Status: Development

Project Description: This project would create a campus micro grid to reduce carbon emissions by combining heat and power processes, reduce energy costs by peak shaving, and provide infrastructure to critical infrastructure to support emergency operations. Currently during a power outage, we can operate the central plant, but we do not have power to circulate water through the buildings connected to the high temperature hot water distribution system. This project would construct a 400kW combined heat and power system at the central plant. The system would run off of natural gas and provide emergency power to the Worner Center to support cooking operations and El Pomar for use as an emergency shelter. The system would achieve carbon savings and payback by operating in parallel to with the utility grid during summer peak demand periods. This would reduce demand at the central plant, also known as, peak shaving. A preliminary central piping plan diagram is given on the next page.

Project Highlights:

- Estimated Cost $2,000,000
- Estimated carbon savings = 500 to 1500 $MTCO_2$ / Year
- Provides emergency power for Worner Center and El Pomar
- Estimated cost savings = $50,000 to $100,000 first year


HTWR
HTWS
TO CAMPUS
TO EL POMAR
HX-1
HX-2
GAS-FIRED, LOW-TEMP BOILER (TYP)
SOLAR COLLECTORS
EXHAUST HEAT RECOVERY
ENGINE JACKET HEAT RECOVERY
NEW ELECTRIC GENERATOR WITH HEAT RECOVERY
OIL COOLER HEAT RECOVERY
FUTURE TAPS FOR ICE MELT SYSTEM
TO DHWH-1, DHWH-2, DHWH-3, AND DHWH-4 AND DSG-HX-3 (DHW)
TO DSG-HX-1 (POOL) AND PP-3, AND PP-4 (POOL PUMPS)
TO EL POMAR HEAT EXCHANGERS DSG-HX-3 (DHW), DSG-HX-1 (POOL), AND DSG-HX-2 (POOL)
DSG-HX-4
DSG-HX-5
HEATING FOR EL POMAR
CENTRAL PLAN PIPING DIAGRAM

## Real-Time Energy Dashboards

Project Status: Construction

Project Description: This project is to create dashboards internal to our building automation system. These dashboards will provide building technicians real-time feedback on building operations. Getting this information in real-time will help technicians understand and manage building energy use. A dashboard created for electrical use at Armstrong Hall can be referenced below.

Project Highlights:

- Project Cost = $2500


## Honnen LED Lighting

Project Status: Design

Project Description: Replace metal halide lighting in Honnen Ice Arena with more efficient LED lighting.

Project Highlights:

- Estimated energy reduction = 75%
- Estimated Simple Payback = 3 Years
- Estimated carbon savings = 100 $MTCO_2$ / Yr

## Schlessman LED Lighting

Project Status: Design

Project Description: Replace metal halide lighting in the Schlessman Pool with more efficient LED lighting.

Project Highlights:

- Estimated energy reduction = 82%
- Estimated Simple Payback = 2 Years
- Estimated carbon savings = 40 $MTCO_2$ / Yr

## Central Plant Controls Upgrade

Project Status: Construction

Project Description: The central plant controls upgrade project will complete the automation of the central plant heating operation. The controls work includes adding system logic to allow for the modulation of the high temperature hot water system expansion tank and distribution system pumps. These controls will enable the central plant to adjust system temperature more frequently to help optimize central heating plant efficiency. The project will also add alarms for safety allowing the plant to be controlled remotely and left unmanned allowing central plant operators time to perform maintenance activities on the distribution system during the summer.

Project Highlights:

- Improves central plant efficiency
- Improves distribution system maintenance

## Worner Steam Generator

Project Status: Planning

Project Description: The Worner steam generator project will add a steam generator to the Worner Center to support cooking operations and allow the temperature of the high temperature hot water loop to be lowered during the summer. Currently the campus high temperature hot water loop temperature during the summer is driven by the need for steam to support cooking operations at Worner Center. By removing this constraint, the centralized system will be able to run at a lower temperature. This will save energy by decreasing system losses in the campus distribution system.

Project Highlights:

- Improves campus high temperature hot water system efficiency during the summer