ENERGY OFFICE

An Energy Assessment of Cherokee County DSN

Gaffney, SC

South Carolina Office of Regulatory Staff – Energy Office
Conn Fraser, CEAIT

6/19/2018

Contents

Energy Savings Summary

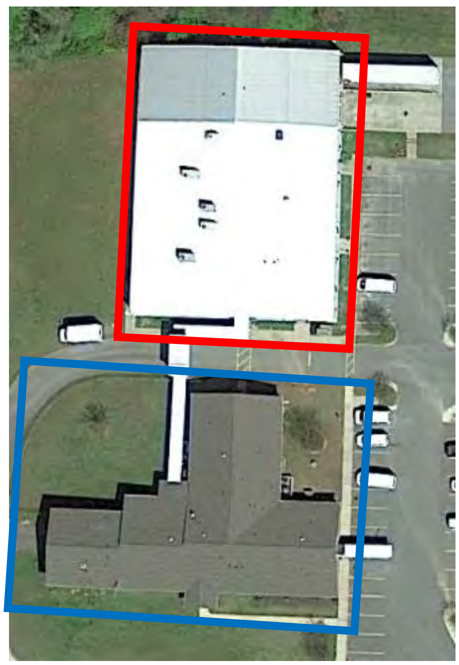
Page #	Energy Conservation Measures (ECM)	Cost[1]	Annual Savings	Simple Payback Period (years)
9	Upgrade Lighting	$7,925	$3,511.74	2.26
9	Purchase New Rooftop A/C Units	$25,500	$2,969.73	8.59
10	Weatherize All Exterior Doors and Windows	$1,145	$310.40	3.69
11	Replace Existing Fiberglass Insulation Batts with Polyisocyanurate in the Workshop	$2,700	$139.61	19.34
11	Install Rigid Insulation under Roof Purlins	$4,275	$400.68	10.67
	Totals:	$41,545	$7,332.16	5.67

[1] All costs are material costs only. No labor is included.

Introduction and Background

On April 17, 2018, the South Carolina Office of Regulatory Staff – Energy Office (Energy Office) performed a walk-through energy assessment of two Cherokee County DSN (CCDSN) buildings in Gaffney, SC. The buildings considered are the Administrative Offices and Workshop.

Principle concerns for CCDSN staff are replacement of Workshop mechanical equipment with more efficient units and repairing the deteriorating building envelope using more climate-resistant materials.



CCDSN Administrative Offices (Blue) and Workshop (Red)
Photo Credit: Google Earth

Building	Area (ft^2)	Energy Use Intensity (kBTU/ft^2)	Energy Cost Intensity ($/ft^2)	Occupancy Patterns
Administrative Offices	5,500	134.02	$0.79	8:00 AM to 5:00 PM
Workshop	8,642	85.3	$1.00	8:00 AM to 5:00 PM; High Occupancy 8:00 AM to 2:00 PM

Envelope

CCDSN's Administrative Offices feature a brick clad exterior with a low-sloped dark colored roof. The insulation currently installed in the roof and walls are unknown to employees at the time.

The Workshop building's envelope is entirely composed of light colored metal with double paned windows. The structure is insulated with approximately 4" batts of fiberglass insulation in both the walls and roof.

Workshop

Administrative Offices

Lighting

Both facilities contain interior fixtures using linear fluorescent and LED tubes, incandescent lamps and metal halide exterior fixtures. The large areas of the Workshop, including the main "activity room" and storage room, are equipped with 8' fluorescent fixtures of both the T12 and T8 variety.

All exit signs observed during the site visit are equipped with incandescent technology.

Mechanical

Space conditioning is primarily achieved through air conditioning units of various vintages. The oldest units are on the Workshop roof and are approximately 20 to 30 years old while others are nearing their useful life of approximately 25 years. The units serving the Administrative Offices building are relatively young and have fewer mechanical issues.

Building Energy Use Summary

The Energy Use Intensity, or EUI, of a building is a metric for roughly comparing the energy use of different facilities that share a similar use (e.g. hotels, schools, offices) regardless of square footage. The Energy Information Administration (EIA) recently released data from the 2012 Commercial Building Energy Consumption Survey (CBECS), a statistical analysis of a portion of commercial buildings found in the U.S. using a wide variety of energy related characteristics.

School	EUI (kBTU/ft^2)
Administrative Office Building	134.02
Workshop	85.3

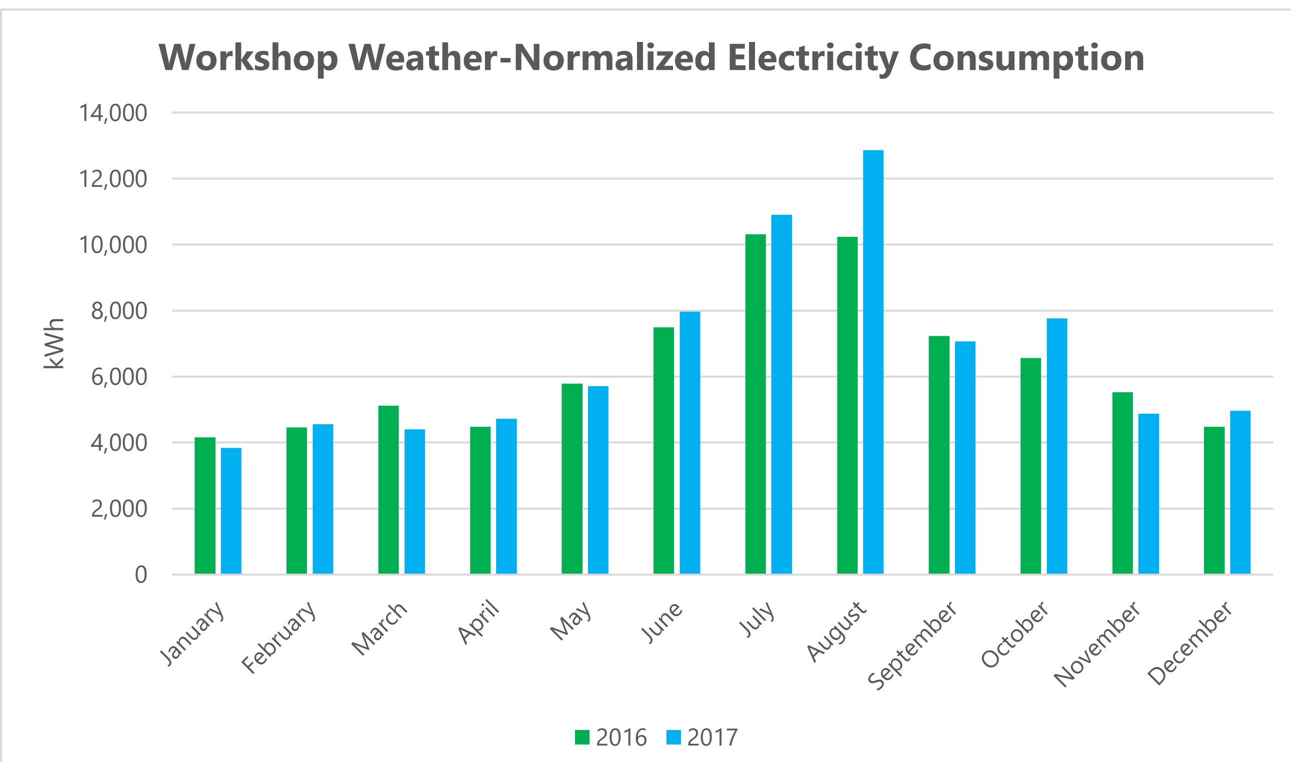
According to the 2012 CBECS, the average EUI of an office building under 80,000 ft^2 in the South Atlantic region of the country and built between 1989 and 1999 is **54.68 kBTU/ft^2.** The average EUI of an assisted living building with the same characteristics is **107.17 kBTU/ft^2.**

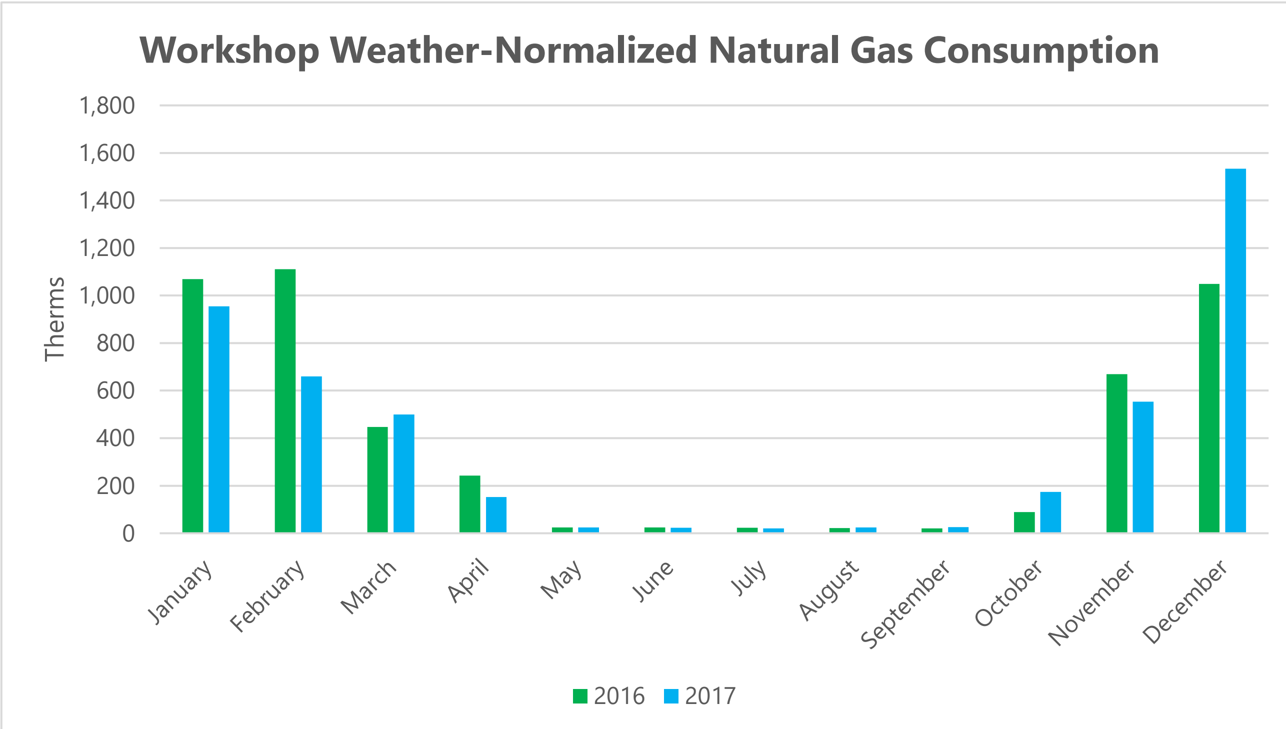
Electricity for both facilities is purchased through the City of Gaffney Public Works and natural gas is purchased through Piedmont Natural Gas.

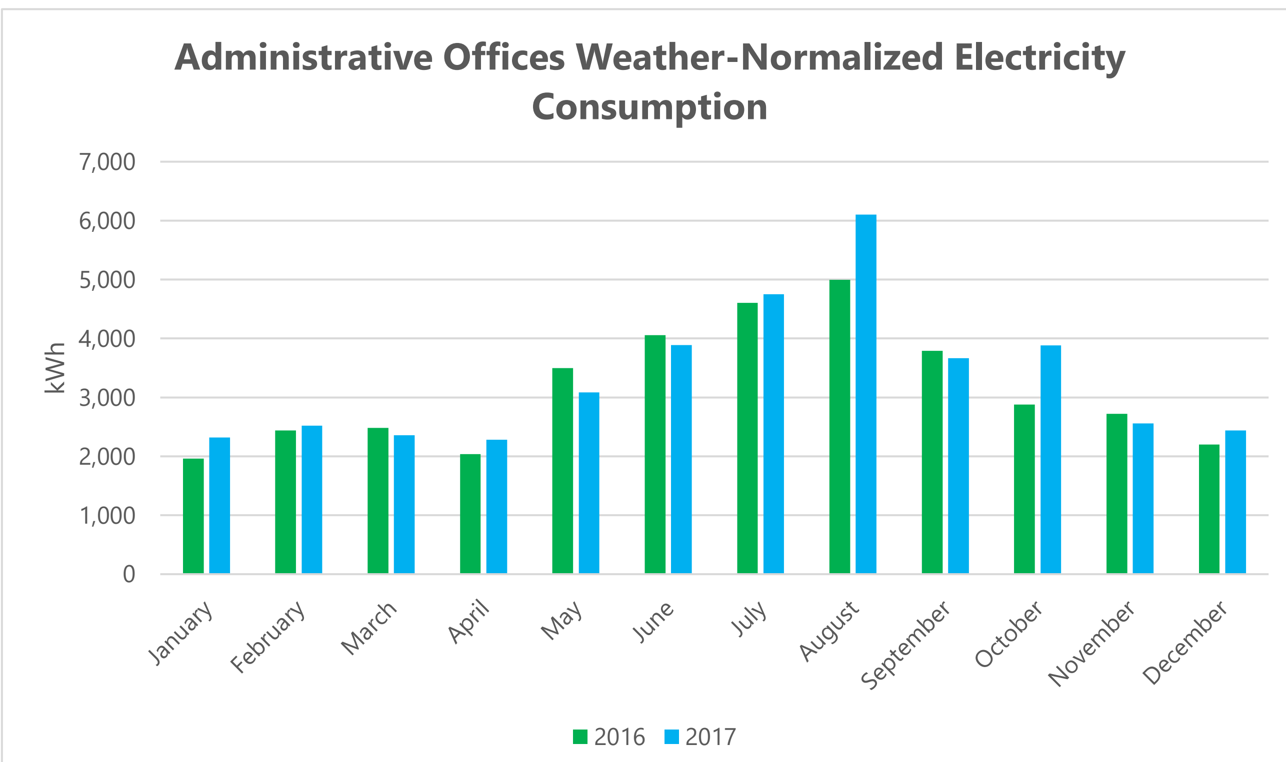
Energy Consumption and Cost Data

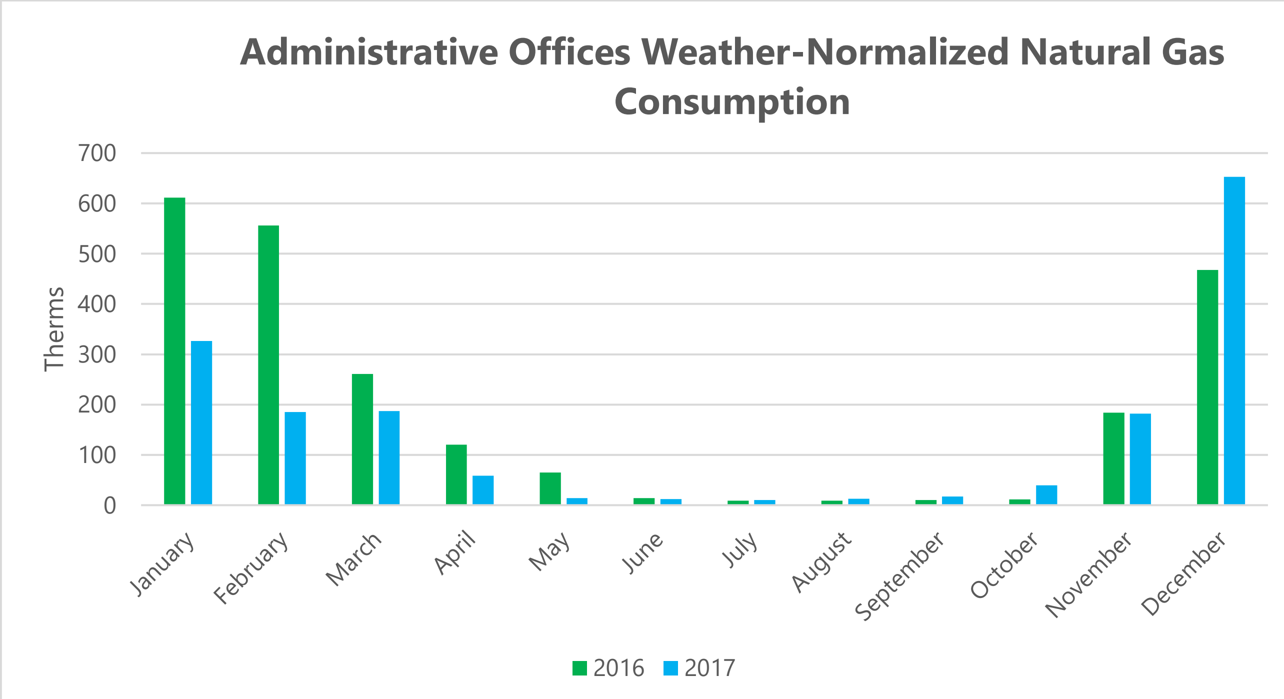
Energy Consumption

	Administrative Offices				Workshop			
	Electricity (kWh)		Natural Gas (Therms)		Electricity (kWh)		Natural Gas (Therms)	
	2016	**2017**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**
Jan	1,960	2,320	612	327	4,160	3,840	1,068.6	954.6
Feb	2,440	2,520	556	185	4,460	4,560	1,110.7	659.3
Mar	2,480	2,360	261	187	5,120	4,400	447.6	499.2
Apr	2,040	2,280	120	59	4,480	4,720	241.9	152.9
May	3,496	3,086	65	14	5,787	5,713	24.0	25.0
Jun	4,059	3,886	14	12	7,493	7,970	24.0	23.0
Jul	4,603	4,749	9	10	10,316	10,905	23.0	21.0
Aug	4,997	6,101	9	13	10,233	12,863	22.0	25.0
Sep	3,790	3,664	10	17	7,225	7,069	21.0	26.0
Oct	2,880	3,880	12	39	6,560	7,760	89.3	173.6
Nov	2,720	2,560	184	182	5,520	4,880	669.2	554.0
Dec	2,200	2,440	468	653	4,480	4,960	1,049.6	1,533.5
Total	**37,665**	**39,846**	**2,319**	**1,698**	**75,834**	**79,640**	**4,791**	**4,647**




Workshop Weather-Normalized Natural Gas Consumption
Therms
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
January
February
March
April
May
June
July
August
September
October
November
December
2016
2017

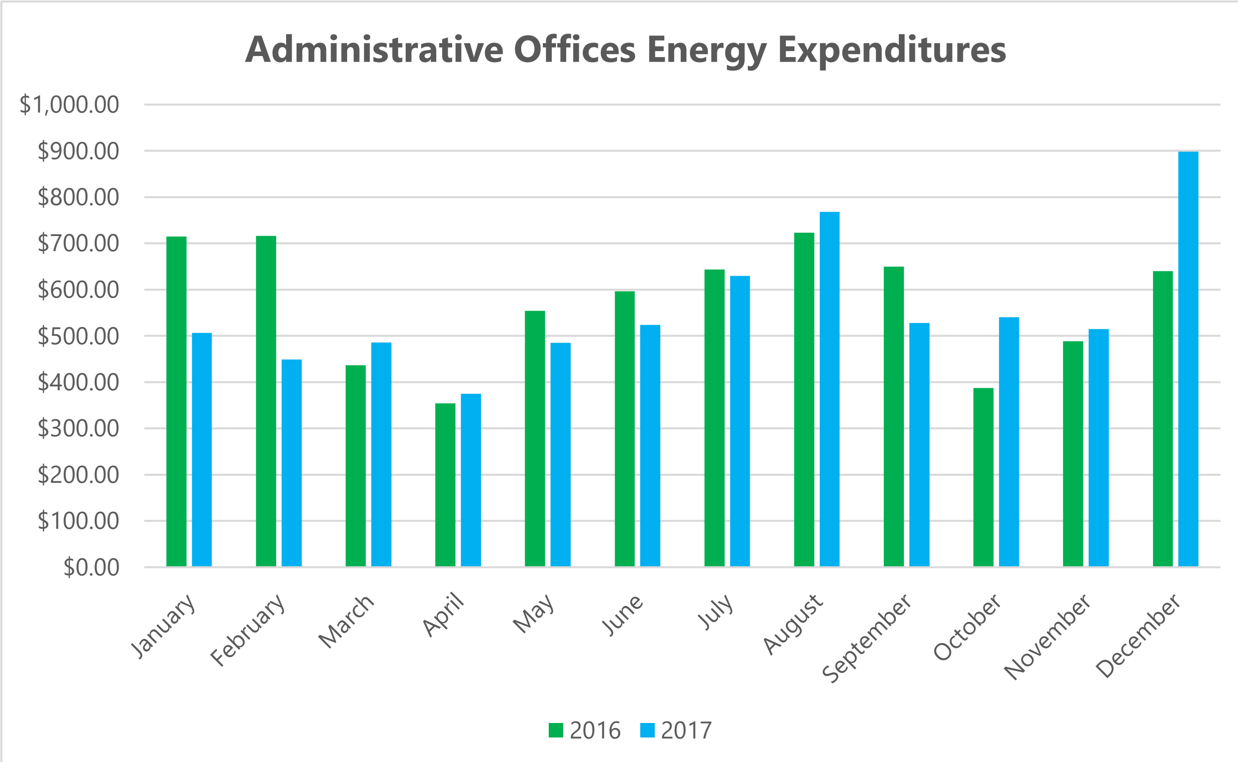

Administrative Offices Weather-Normalized Electricity Consumption
kWh
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
January
February
March
April
May
June
July
August
September
October
November
December
2016
2017

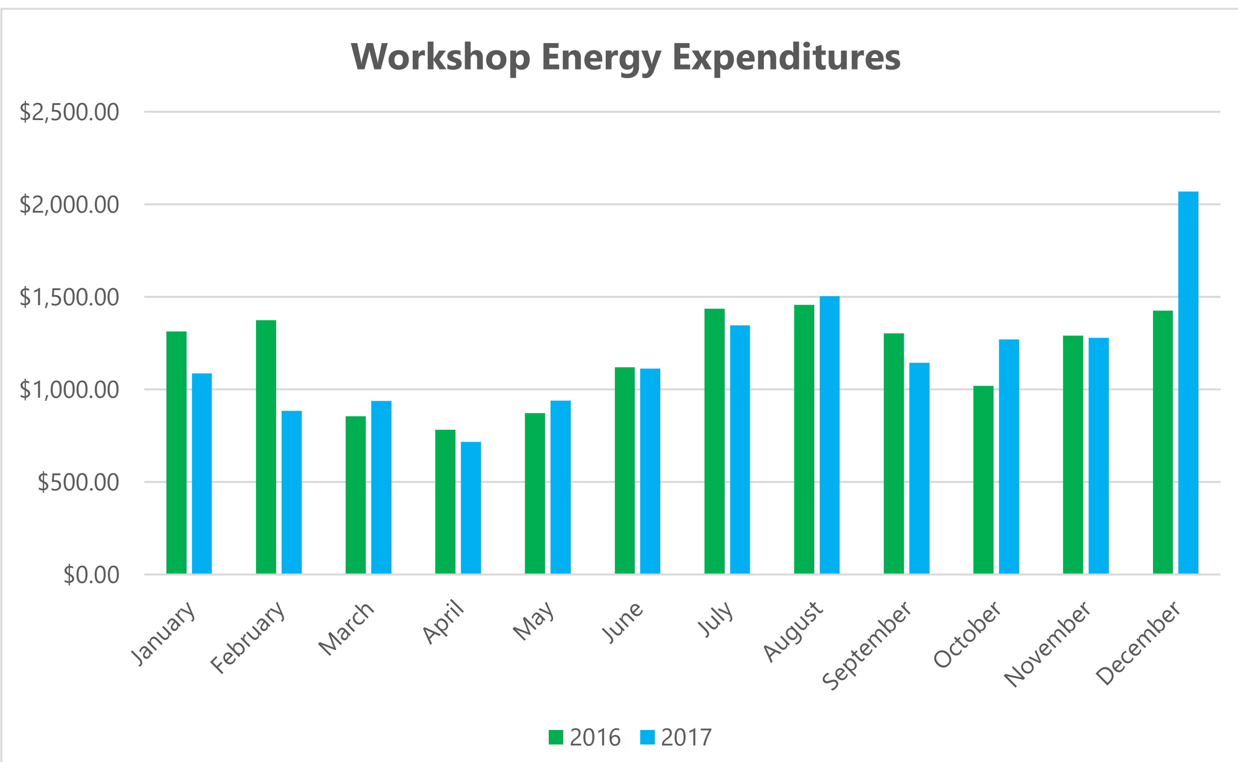


Energy Cost

Building	Energy Cost Intensity ($/ft^2)
Administrative Offices	$0.79
Workshop	$1.00

	Administrative Offices				Workshop			
	Electricity		Natural Gas		Electricity		Natural Gas	
	2016	**2017**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**
Jan	$246.28	$299.17	$468.29	$207.10	$494.66	$528.84	$818.49	$557.46
Feb	$300.48	$338.36	$415.91	$110.94	$548.86	$555.11	$825.72	$329.32
Mar	$304.99	$319.97	$131.28	$165.88	$636.27	$536.73	$218.32	$402.16
Apr	$255.32	$317.02	$98.83	$58.00	$599.29	$605.38	$182.23	$111.08
May	$484.60	$449.44	$69.74	$35.75	$831.43	$894.38	$40.73	$45.17
Jun	$562.73	$489.61	$33.66	$34.03	$1,079.61	$1,068.55	$40.73	$43.44
Jul	$613.29	$597.44	$30.13	$32.33	$1,396.16	$1,305.14	$40.03	$41.74
Aug	$691.42	$733.39	$31.93	$34.89	$1,417.19	$1,458.16	$39.32	$45.17
Sep	$617.88	$489.61	$32.18	$38.32	$1,264.76	$1,097.27	$38.63	$46.02
Oct	$355.91	$480.24	$31.38	$59.94	$933.68	$1,088.27	$84.86	$181.82
Nov	$337.53	$325.53	$150.87	$189.40	$805.96	$750.74	$484.94	$527.45
Dec	$285.42	$321.07	$354.58	$576.95	$660.58	$746.31	$766.06	$1,322.49
Total	**$5,055.85**	**$5,160.85**	**$1,848.78**	**$1,543.53**	**$10,668.45**	**$10,634.88**	**$3,580.06**	**$3,653.32**


Administrative Offices Energy Expenditures
$1,000.00
$900.00
$800.00
$700.00
$600.00
$500.00
$400.00
$300.00
$200.00
$100.00
$0.00
January
February
March
April
May
June
July
August
September
October
November
December
2016
2017


Workshop Energy Expenditures
$2,500.00
$2,000.00
$1,500.00
$1,000.00
$500.00
$0.00
January
February
March
April
May
June
July
August
September
October
November
December
2016
2017

Energy Conservation Measures (ECM)

Upgrade Lighting

Currently the CCDSN maintenance staff members are gradually switching existing lighting to LED technology as the lamps fail. This ECM recommends immediately replacing all lights with either LED retrofit kits or LED fixtures, see the Appendix for details on whether retrofitting or installation of a new fixture is recommended.

This ECM assumes all lighting will be replaced with "wattage equivalent" lighting, meaning that both the existing lights and LED lights will produce the same amount of light.

Expected Material Cost	Expected Annual Savings	Expected Simple Payback Period (SPP)
$7,925	$3,511.74	2.26 Years

Expected Annual Energy Savings (kWh)	Expected Lifetime of Measure	Expected Lifetime Energy Savings (kWh)
26,264.47	10 Years	262,644.7

Purchase New Rooftop A/C Units

The rooftop air conditioning units on the Workshop are at or well past their useful life. This ECM recommends replacing each unit with a similarly sized high efficiency unit of at least 15 SEER. SEER, or seasonal energy efficiency ratio, is a quantification of the amount of heat removed per watt-hour of electricity consumed and can serve as a comparative metric when deciding between various A/C units.

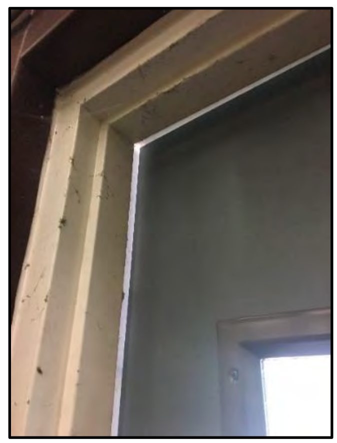
When discussing the project with prospective vendors it is good practice to request a load calculation for the structure. A load calculation is an intensive look at how much cooling is optimal for the facility and relies on information regarding occupancy, and building orientation.

These calculations are sometimes done using modeling software and are beyond the scope of this energy assessment.

Expected Material Cost of (4) 15 SEER Units	Expected Annual Savings	Expected Simple Payback Period (SPP)
$25,500	$2,969.73	8.59 Years

Expected Annual Energy Savings (kWh)	Expected Lifetime of Measure	Expected Lifetime Energy Savings (kWh)
24,747.79	25 Years	618,694.75

Weatherize All Exterior Doors and Windows



Ensuring a continuous building envelope is necessary to keep filtered and conditioned air inside the building. An added benefit is maintaining the thermal comfort of occupants.

Weatherization is the process of increasing a building's resistance to cold weather by adding door sweeps, weather stripping, and caulk to windows and other spaces along the building envelope susceptible to infiltration.

Knowing the exact amount of weather stripping needed would require careful inspection of each piece of the building envelope. However, based on a previous energy assessment performed on a facility with similar window and door quantities $0.05/ft^2 of floor area is a reasonable cost estimate.

Reported energy savings assume that infiltration is found to be responsible for 13% of heating cost and 3% of cooling cost in U.S. commercial buildings[2]. By weather stripping doors and windows these energy costs can be reduced by a third[3].

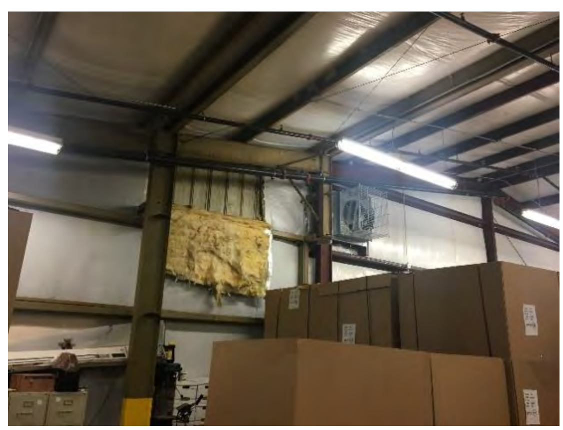
Methods and types of weather stripping can be found in resources such as the US Department of Energy's website.[4]

Expected Cost of Weatherizing	**Expected Annual Savings**	**Expected Simple Payback Period (SPP)**
$1,145.10	$310.40	3.69 Years

Expected Annual Energy Savings (kBTU)	**Expected Life Time Of Measure**	**Expected Lifetime Energy Savings (kWh)**
8,318	15 Years	124,770

Replace Existing Fiberglass Insulation Batts with Polyisocyanurate in the Workshop

The current insulation in the walls of the Workshop is in various stages of deterioration. In addition to this, newer materials have come to market that insulate much more effectively.



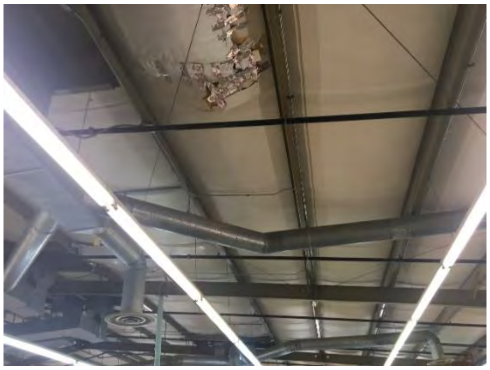
This ECM recommends replacing the fiberglass wall insulation, which has an R-value of approximately 3.2 ft^2·°F·h/BTU per inch of material, with material featuring at least an R-value of 6 ft^2·°F·h/BTU per inch. Rigid Polyisocyanurate is an eligible candidate for this as it has an R-value of 7.1 ft^2·°F·h/BTU per inch.

[2] Doty, Steve. Commercial energy auditing reference handbook. The Fairmont Press, Inc., 2011.

[3] Doty, Steve, and Wayne C. Turner. Energy management handbook. CRC Press, 2013.

[4] https://www.energy.gov/energysaver/weatherize/air-sealing-your-home/weatherstripping

The insulation being used on the roof is being compressed by the purlins, creating a “short circuit.” When solar radiation hits the roof it travels through the compressed insulation and into the conditioned space through the purlins. For example, with 6 inches of fiberglass insulation installed over the purlins of the roof, the normal R-value of approximately 19 ft^2·°F·h/BTU is reduced to 10 ft^2·°F·h/BTU assuming 6′ O.C. purlin spacing[5].



This ECM recommends installing foil-faced rigid insulation on the bottoms of structural roof members. This will ensure that there are no thermal “short circuits,” while adding additional thermal resistance to the roof in both the heating and cooling season.

This is an economical solution that improves heat transfer resistance for the roof. Otherwise, capital and labor-intensive work could be done to completely replace the existing fiberglass insulation.

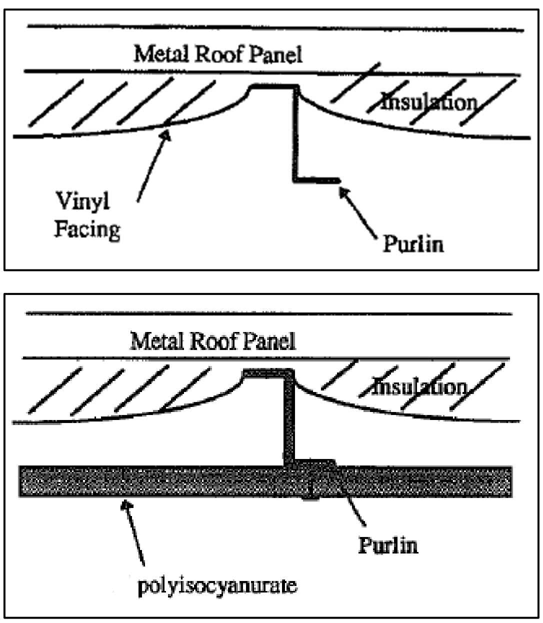
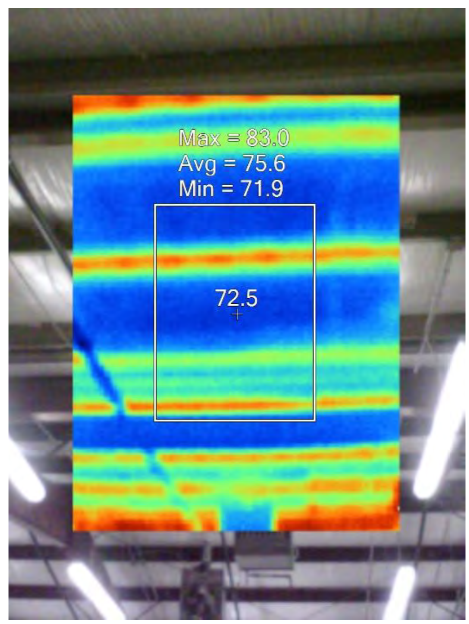


Image Source: Energy Management Handbook



Top Left: Current insulation situation, fiberglass insulation is installed above roof structural members and compressed.
Right: Infrared thermograph of the Workshop demonstrating the high temperature (red/yellow) of roof structural members due to increased heat transfer through the roof and compressed insulation. Note: Due to the positioning of the IR sensor on the camera, the colors within the center portion are slightly shifted downwards.
Bottom Left: Proposed insulation design with polyisocyanurate or comparable rigid insulation installed underneath structural members, providing additional heat transfer resistance.

[5] Doty, Steve, and Wayne C. Turner. Energy management handbook. CRC Press, 2013.

While this ECM has a relatively long payback, these savings calculations do not take into consideration the harder to quantify impacts of thermal comfort and second-order effects of a more efficient structure. These include: indoor environmental comfort for at-risk occupants, decreased maintenance of equipment that has been working harder due to high space temperatures, and slower deterioration of building materials exposed to high space temperatures.

Replace Wall Insulation with at least R-6 material

Expected Cost	Expected Annual Savings	Expected Simple Payback Period (SPP)
$2,700	$139.61	19.34 Years

Expected Annual Energy Savings (kBTU)	Expected Lifetime of Measure	Expected Lifetime Energy Savings (kBTU)
8,979	10 Years	89,790

Install Rigid Insulation under Roof Purlins

Expected Cost	Expected Annual Savings	Expected Simple Payback Period (SPP)
$4,275	$400.68	10.67 Years

Expected Annual Energy Savings (kBTU)	Expected Lifetime of Measure	Expected Lifetime Energy Savings (kBTU)
17,031	10 Years	170,310

Appendix

Upgrade Lighting

	Approximate # of Fixtures	Estimated Fixture Wattage (W)	Estimated Total W	Suggested Action	Proposed W	Total W	Estimated kW Reduction	Estimated Annual Runtime	kWh Reduction	Cost Savings	Action Material Cost	Action SPP
4' 2 lamp T8 Fluorescent	29	59	1,682	LED Retrofit	26	741	0.94	2,880	2709	$325.04	$855	2.63
4' 2 Lamp T12	4	72	288	LED Retrofit	26	104	0.18	2,880	530	$63.59	$120	1.89
4' 4 Lamp T8	21	112	2,352	LED Retrofit	52	1,092	1.26	2,880	3629	$435.46	$1,260	2.89
4' 3 Lamp T8	1	89	89	LED Retrofit	39	39	0.05	2,880	144	$17.28	$45	2.60
4' 1 Lamp T8	1	32	32	LED Retrofit	13	13	0.02	2,880	55	$6.57	$15	2.28
8' 2 Lamp T8	30	109	3,270	LED Retrofit	80	2,400	0.87	2,880	2506	$300.67	$1,200	3.99
8' 2 Lamp T12	55	123	6,765	LED Retrofit	80	4,400	2.37	2,880	6811	$817.34	$2,200	2.69
Incandescent	10	40	400	LED Retrofit	10	100	0.30	2,880	864	$103.68	$150	1.45
Compact Fluorescent Lamp	3	13	39	LED Retrofit	10	30	0.01	2,880	26	$3.11	$45	14.47
Parabolic Aluminized Reflector (PAR) Lamp	9	60	540	LED Retrofit	19	171	0.37	4,314	1592	$191.02	$135	0.71
High Pressure Sodium	6	250	1,500	LED Fixture Replacement	100	600	0.90	4,314	3883	$465.91	$1,200	2.58
Exterior Wall Pack	4	250	1,000	LED Fixture Replacement	50	200	0.80	4,314	3451	$414.14	$400	0.97
Incandescent Exit Sign	10	40	400	LED Fixture Replacement	5	50	0.35	8,760	3066	$367.92	$300	0.82
									29264	$3,511.74	$7,925	2.26

Purchase New Rooftop A/C Units

7.5 Ton	
Heating Power Difference	
HSPF Old	0
HSPF New	0
Capacity (BTU per Hour)	90,000
dW Winter	
Cooling Power Difference	
SEER Old	9
SEER New	15
Capacity (BTU per Hour)	90,000
dW Summer	4,000
Hour Calculation[6]	
Winter dT50	24.4
Summer dT50	41.8
Heating Hours	784.92
Cooling Hours	2,812.25
Savings Calculation	
Heating Savings	
Cooling Savings	$1,349.88
Annual Savings	$1,349.88
Material Cost	$10,000
# of Units	1
Total Cost	$10,000
Total Savings	$1,349.88
SPP	7.41

2 Ton	
Heating Power Difference	
HSPF Old	0
HSPF New	0
Capacity (BTU per Hour)	24,000
dW Winter	
Cooling Power Difference	
SEER Old	9
SEER New	15
Capacity (BTU per Hour)	24,000
dW Summer	1,066.67
Hour Calculation	
Winter dT50	24.4
Summer dT50	41.8
Heating Hours	784.92
Cooling Hours	2,812.25
Savings Calculation	
Heating Savings	
Cooling Savings	$359.97
Annual Savings	$359.97
Material Cost	$3,000
# of Units	1
Total Cost	$3,000
Total Savings	$359.97
SPP	8.33

3 Ton	
Heating Power Difference	
HSPF Old	0
HSPF New	0
Capacity (BTU per Hour)	36,000
dW Winter	
Cooling Power Difference	
SEER Old	9
SEER New	15
Capacity (BTU per Hour)	36,000
dW Summer	1,600
Hour Calculation	
Winter dT50	24.4
Summer dT50	41.8
Heating Hours	784.92
Cooling Hours	2,812.25
Savings Calculation	
Heating Savings	
Cooling Savings	$539.95
Annual Savings	$539.95
Material Cost	$5,500.00
# of Units	1
Total Cost	$5,500.00
Total Savings	$539.95
SPP	10.19

4 Ton	
Heating Power Difference	
HSPF Old	0
HSPF New	0
Capacity (BTU per Hour)	48,000
dW Winter	
Cooling Power Difference	
SEER Old	9
SEER New	15
Capacity (BTU per Hour)	48,000
dW Summer	2,133.33
Hour Calculation	
Winter dT50	24.4
Summer dT50	41.8
Heating Hours	784.92
Cooling Hours	2,812.25
Savings Calculation	
Heating Savings	
Cooling Savings	$719.94
Annual Savings	$719.94
Material Cost	$7,000.00
# of Units	1
Total Cost	$7,000.00
Total Savings	$719.94
SPP	9.72

Total Project Cost	**$25,500**
Total Project Savings	$2,969.73
Project SPP	8.59

[6] Greenville-Spartanburg CDD50

Weatherize All Exterior Doors and Windows

Workshop

	Energy Consumption[7]	Energy Cost[8]	Infiltration Cost	Cost Savings
January	991	$990.60	$128.78	$42.50
February	864	$863.97	$112.32	$37.06
March	452	$452.38	$58.81	$19.41
April	176	$176.41	$22.93	$7.57
May	1,750	$209.98	$6.30	$2.08
June	3,732	$447.78	$13.43	$4.43
July	6,610	$793.21	$23.80	$7.85
August	7,548	$905.79	$27.17	$8.97
September	3,147	$377.67	$11.33	$3.74
October	110	$110.47	$14.36	$4.74
November	591	$590.60	$76.78	$25.34
December	1,271	$1,270.55	$165.17	$54.51

Administrative Offices

	Energy Consumption[7]	Energy Cost[8]	Infiltration Cost	Cost Savings
January	460	$459.64	$59.75	$19.72
February	361	$360.87	$46.91	$15.48
March	215	$214.56	$27.89	$9.20
April	80	$79.93	$10.39	$3.43
May	1,171	$140.57	$4.22	$1.39
June	1,852	$222.28	$6.67	$2.20
July	2,556	$306.70	$9.20	$3.04
August	3,429	$411.44	$12.34	$4.07
September	1,607	$192.84	$5.79	$1.91
October	16	$16.00	$2.08	$0.69
November	173	$173.45	$22.55	$7.44
December	551	$550.94	$71.62	$23.64

Cost to Weatherize Both Facilities $1,145.10 **Savings for Both Facilities** $310.40 **SPP** 3.69

Replace Existing Fiberglass Insulation Batts with Polyisocyanurate in the Workshop

Fiberglass Thickness	4	inches	**Total Workshop wall area estimate assuming 15' high**	6,000	Ft^2
Fiberglass R-Factor	3.2	per inch	**Workshop Roof Area**	9,500	Ft^2
Total Fiberglass R-Factor	12.8		**Polyisocyanurate insulation cost**	$0.45	Per ft^2
Polyisocyanurate R-Factor	7.1	per inch			
Total Polyisocyanurate R-Factor at 4”	28.4		**R-value with compressed insulation**	10.9	
			R-value with rigid insulation outside of purlin	19.9	

[7] 2 Year Average Weather-Normalized, May through September Electricity (kWh), other months Natural Gas (Therms)

[8] $.12/kWh and $1.00/ Therm

Replace Wall Insulation with at least R-6 per inch material

Calculating Avoided Energy Transfer from Conduction

	Avoided Transfer	Avoided Consumption[9]	Avoided Costs[10]
January	1,842,673	2,303,341	$23.03
February	1,409,845	1,762,306	$17.62
March	1,004,928	111,659	$13.40
April	385,554	42,839	$5.14
May	360,630	40,070	$4.81
June	732,975	81,442	$9.77
July	955,955	106,217	$12.75
Aug	831,462	92,385	$11.09
September	461,769	51,308	$6.16
October	380,868	42,319	$5.08
November	973,155	1,216,443	$12.16
December	1,488,300	1,860,375	$18.60
			$139.61

Table 9-8. Roof insulation installed compressed over the purlin.[6]

Unbridged R-Value	*Nominal Thickness (Inches)*	*R-Value 2′ O.C.*	*R-Value 3′ O.C.*	*R-Value 4′ O.C.*	*R-Value 5′ O.C.*	*R-Value 6′ O.C.*
10	3	5.4	6.5	7.2	7.7	8.1
13	4	5.7	7.1	8.0	8.7	9.3
16	5-1/2	5.9	7.4	8.6	9.5	10.2
19	6	6.0	7.7	9.0	10.0	10.9

Estimated Cost Assuming	$2,700.00
Estimated Savings	$139.61
SPP	19.34

[9] Assuming 80% Efficient Natural Gas and 9 EER
[10] Assuming $1/therm and $.12/kWh

Install Rigid Insulation under Roof Structural Members

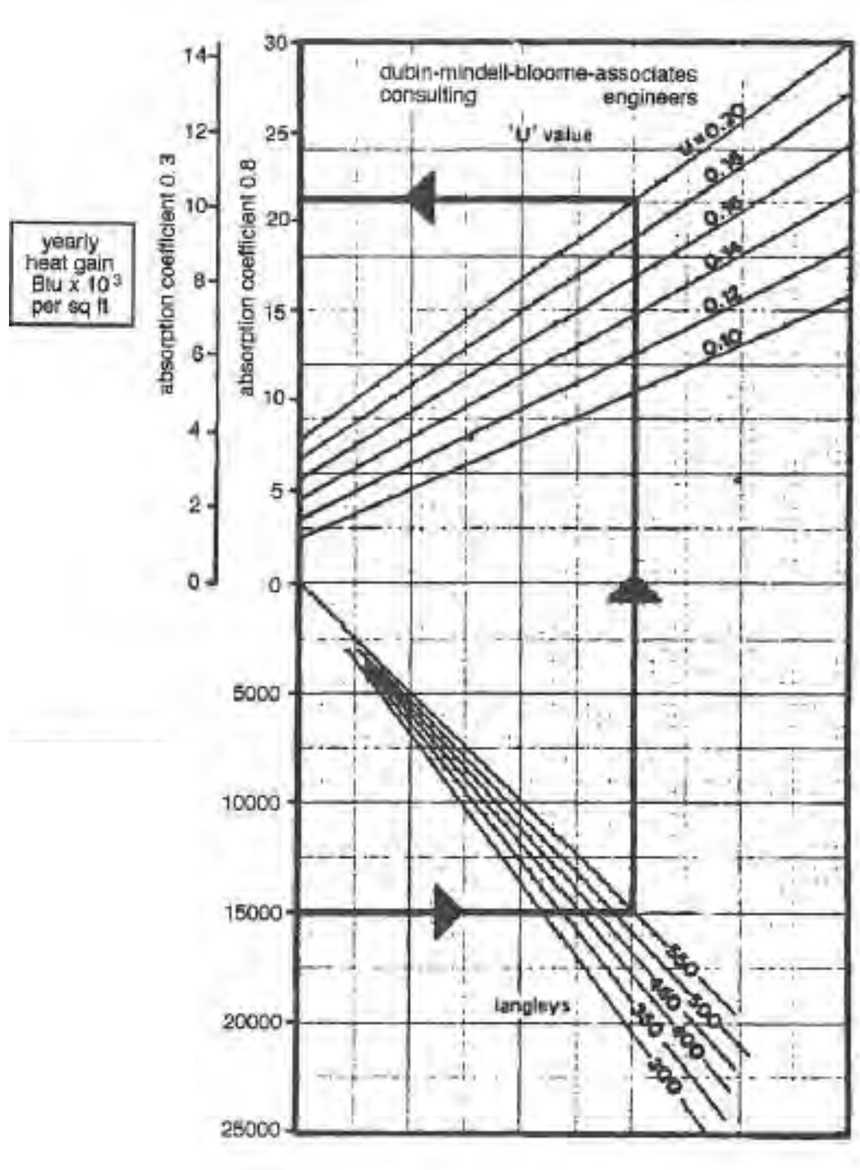
Calculating Avoided Energy Transfer from Conduction

	Avoided Heat Transfer[11]	Assuming 80% Efficient Natural Gas	Cost Avoided
January	2,820,897	3,526,121	$35.26
February	2,158,293	2,697,866	$26.98
November	1,489,776	1,862,220	$18.62
December	2,278,397	2,847,996	$28.48
			$109.34

Calculating Avoided Energy Transfer from Radiation

Langleys[12]	390	
Initial U-Factor	0.092	
Proposed U-Factor	0.050	
Dry-bulb degree hours above 78	5,173.1	
Initial Annual Heat Transfer	5	kBTU per ft^2
Proposed Annual Heat Transfer	2.7	kBTU per ft^2
Avoided Heat Transfer	21,850,000	BTU avoided
Assuming 9 EER	2,427.78	kWh
At $0.12/kWh	$291.33	per Year

Total Energy Savings	$400.68
Estimated Cost	$4,275.00
SPP (Years)	10.67



[11] Calculated using hourly weather data from Greenville, SC

[12] Source: Energy Auditing Handbook

ENERGY.SC.GOV