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Cost-Effectiveness of ASHRAE Standard 90.1-2013 for the State of South Carolina

December 2015

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U.S. DEPARTMENT OF
ENERGY

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Acronyms and Abbreviations

ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
BECP	Building Energy Codes Program
BTO	Building Technologies Office
DOE	U.S. Department of Energy
EIA	Energy Information Administration
FEMP	Federal Energy Management Program
HVAC	Heating, Ventilating, and Air-Conditioning
LCC	Life-Cycle Cost
NIST	National Institute of Standards and Technology
PNNL	Pacific Northwest National Laboratory
UPV	Uniform Present Value
SWH	Service Water Heating

Highlights

Moving to the ASHRAE Standard 90.1-2013 (ASHRAE 2013) edition from Standard 90.1-2010 (ASHRAE 2010) is cost-effective for the State of South Carolina. The table below shows the state-wide economic impact of upgrading to Standard 90.1-2013 in terms of the annual energy cost savings in dollars per square foot, additional construction cost per square foot required by the upgrade, and life-cycle cost (LCC) per square foot. These results are weighted averages for all building types in all climate zones in the state, based on weightings shown in Table 4. The methodology used for this analysis is consistent with the methodology used in the national cost-effectiveness analysis[1]. Additional results and details on the methodology are presented in the following sections.

Average Savings, Construction Cost and LCC (Weighted by Climate Zone and Building Type)	
Annual Cost Savings, $/ft^2	$0.130
Added Construction Cost, $/ft^2	($0.973)
Publicly-owned scenario LCC Savings, $/ft^2	$3.11
Privately-owned scenario LCC Savings, $/ft^2	$2.38

The report provides analysis of two LCC scenarios:

- **Scenario 1**, representing publicly-owned buildings, considers initial costs, energy costs, maintenance costs, and replacement costs—without borrowing or taxes.
- **Scenario 2**, representing privately-owned buildings, adds borrowing costs and tax impacts.

Figure 1 compares annual energy cost savings, first cost for the upgrade, and net annualized LCC savings. The net annualized LCC savings per square foot is the annual energy savings plus the annualized value of first cost savings under scenario 1. Figure 2 shows overall state weighted net LCC results for both scenarios. When net LCC is positive, the updated code edition is considered cost-effective.
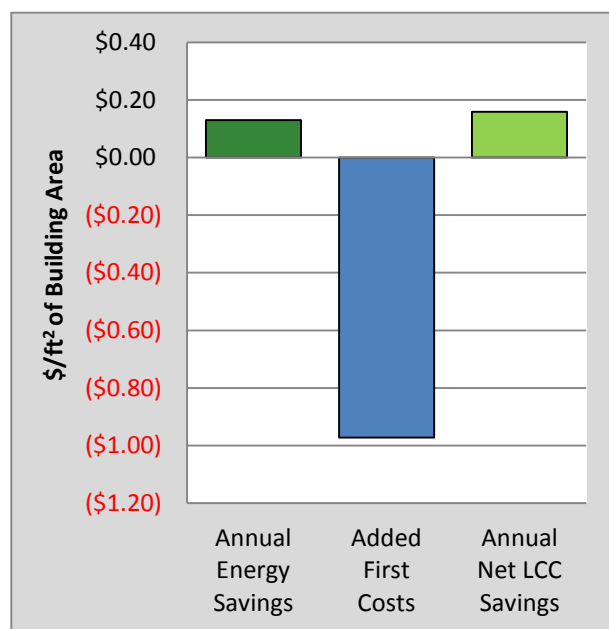

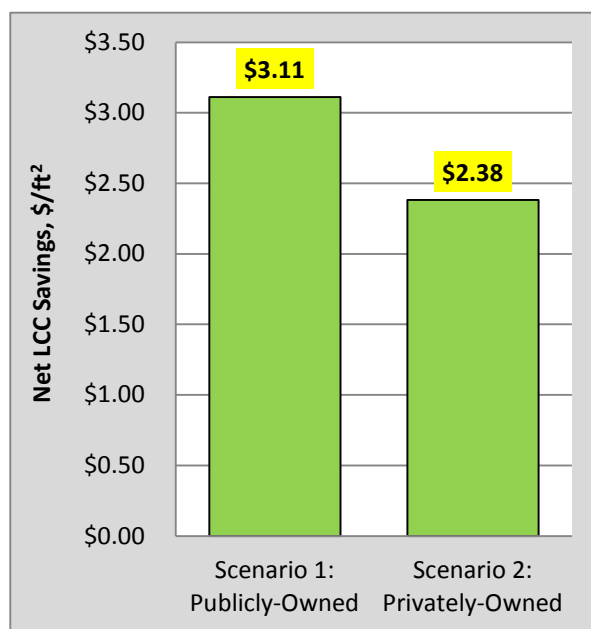**Figure 1**. State-wide Weighted Costs and Savings

Figure 2. Overall Net Life-Cycle Cost Savings

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[1] National cost-effectiveness report: https://www.energycodes.gov/development/commercial/cost_effectiveness.

Cost-Effectiveness Results for
ASHRAE Standard 90.1-2013 in South Carolina

This section summarizes the cost-effectiveness analysis results. Life-Cycle Cost (LCC) savings is the primary measure DOE uses to assess the economic impact of building energy codes. Savings are computed for two scenarios:

- **Scenario 1 (publicly-owned)** includes costs for initial equipment and construction, energy, maintenance and replacement and does not include loans or taxes.

- **Scenario 2 (privately-owned)** includes the same costs as scenario 1, plus the initial investment is financed through a loan amortized over 30 years with corresponding federal and state corporate income tax deductions for interest and depreciation.

Both scenarios include the residual value of equipment with remaining useful life at the end of the 30 years. Totals for building types, climate zones, and the state overall are averages based on Table 4 weightings. Factors such as inflation and discount rates are different between the two scenarios, as described in the Cost-Effectiveness Methodology section.

LCC is affected by many variables, including the applicability of individual measures in the code, measure costs, measure lives, replacement costs, state cost adjustment, energy prices, and so on. The LCC could be negative for a building type in a climate zone based on the interaction of these variables, but the code is considered cost-effective as long as the weighted state-wide LCC is positive.

Table 1 shows that the value today of the total LCC savings over 30 years for buildings in scenario 1 averages $3.11 per square foot for Standard 90.1-2013.

Table 1. LCC Savings for South Carolina, Scenario 1 ($/ft^2)

Climate Zone	Small Office	Large Office	Stand-Alone Retail	Primary School	Small Hotel	Mid-Rise Apartment	All Building Types
3A	$2.57	$24.83	$3.34	$1.41	$1.93	$0.92	$3.11
State Average	$2.57	$24.83	$3.34	$1.41	$1.93	$0.92	**$3.11**

Table 2 shows that the LCC savings over 30 years averages $2.38 per square foot for scenario 2.

Table 2. LCC Savings for South Carolina, Scenario 2 ($/ft^2)

Climate Zone	Small Office	Large Office	Stand-Alone Retail	Primary School	Small Hotel	Mid-Rise Apartment	All Building Types
3A	$2.20	$15.63	$2.49	$1.50	$1.73	$0.90	$2.38
State Average	$2.20	$15.63	$2.49	$1.50	$1.73	$0.90	**$2.38**

Energy Cost Savings

Table 3 shows that the primary benefit of Standard 90.1-2013—annual energy cost savings—averages $0.130 per square foot for both scenarios.

Table 3. Annual Energy Cost Savings for South Carolina ($/ft^2)

Climate Zone	Small Office	Large Office	Stand-Alone Retail	Primary School	Small Hotel	Mid-Rise Apartment	All Building Types
3A	$0.111	$0.038	$0.174	$0.146	$0.111	$0.063	$0.130
State Average	$0.111	$0.038	$0.174	$0.146	$0.111	$0.063	**$0.130**

Construction Weighting of Results

Energy and economic impacts were determined and reported separately for each building type and climate zone. Cost-effectiveness results are also reported as averages for all prototypes and climate zones in the state. To determine these averages, results were combined across the different building types and climate zones using weighting factors shown in Table 4. These weighting factors are based on the floor area of new construction and major renovations for the six analyzed building prototypes in state-specific climate zones. The weighting factors were developed from construction start data from 2003 to 2007 based on an approach developed by Jarnagin and Bandyopadhyay (McGraw Hill Construction 2007, Jarnagin and Bandyopadhyay 2010).

Table 4. Construction Weights by Building Type

Climate Zone	Small Office	Large Office	Stand-Alone Retail	Primary School	Small Hotel	Mid-Rise Apartment	All Building Types
3A	15.5%	3.4%	42.7%	13.5%	3.4%	21.6%	100.0%
State Average	15.5%	3.4%	42.7%	13.5%	3.4%	21.6%	100.0%

Incremental Construction Cost

Cost estimates were developed for the differences between Standard 90.1-2010 and Standard 90.1-2013 as implemented in the six prototype models. Costs for the initial construction include material, labor, commissioning, construction equipment, overhead and profit. These costs were developed using a commercial cost estimation firm, engineering design consultants and RS Means 2012 and 2014 cost data (RS Means 2012a,b,c, 2014a,b,c; Hart et al. 2015). The costs were developed at the national level and then adjusted for local conditions using a state construction cost index (Means 2014c). Table 5 shows incremental initial cost for individual building types in state-specific climate zones and weighted average costs by climate zone and building type for moving to Standard 90.1-2013 from Standard 90.1-2010.

The incremental cost is negative for some building types and climate zones because of fewer lighting fixtures, or due to the downsizing of heating, ventilating, and air-conditioning (HVAC) equipment.

- Fewer light fixtures are required when the allowed lighting power is reduced.

- Smaller equipment sizes can result from the lowering of heating and cooling loads due to other efficiency measures, such as more wall insulation.

The national cost-effectiveness report contains detailed descriptions of how costs were developed for individual efficiency upgrades (Hart et al. 2015). Where cost is negative it represents a reduction in first costs and a savings that is included in the net LCC savings.

Table 5. Incremental Construction Cost for South Carolina ($/ft^2)

Climate Zone	Small Office	Large Office	Stand-Alone Retail	Primary School	Small Hotel	Mid-Rise Apartment	All Building Types
3A	($0.055)	($23.968)	($1.075)	$1.362	$0.356	$0.479	($0.973)
State Average	($0.055)	($23.968)	($1.075)	$1.362	$0.356	$0.479	**($0.973)**

Simple Payback

Simple payback is the total incremental first cost divided by the annual savings, where the annual savings is the annual energy cost savings less any incremental annual maintenance cost. Simple payback is not used as a measure of cost-effectiveness as it does not account for the time value of money, the value of energy cost savings that occur after payback is achieved, or any replacement costs that occur after the initial investment. However, it is included in the analysis for states who wish to use this information. Table 6 shows simple payback results in years for both scenarios.

Table 6. Simple Payback for South Carolina (Years)

Climate Zone	Small Office	Large Office	Stand-Alone Retail	Primary School	Small Hotel	Mid-Rise Apartment	All Building Types
3A	Immediate	Immediate	Immediate	9.4	3.2	7.4	Immediate
State Average	Immediate	Immediate	Immediate	9.4	3.2	7.4	Immediate

Overview of the Cost-Effectiveness Methodology

This analysis was conducted by Pacific Northwest National Laboratory (PNNL) in support of the U.S. Department of Energy's (DOE) Building Energy Codes Program. DOE supports the development and implementation of energy efficient and cost-effective residential and commercial building energy codes. These codes help adopting states and localities establish minimum requirements for energy-efficient building design and construction, as well as ensure significant energy savings and avoided greenhouse gas emissions. LCC savings is the primary measure DOE uses to assess the cost-effectiveness of building energy codes.

Cost-Effectiveness

DOE uses standard economic LCC cost-effectiveness analysis methods in comparing Standard 90.1-2013 and Standard 90.1-2010. A detailed cost-effectiveness methodology was used as described in detail in the national report (Hart et al. 2015). Under this methodology, two metrics are used:

- **LCC Savings:** LCC is the calculation of the present value of costs over a 30-year period including initial equipment and construction costs, energy savings, maintenance and replacement costs, and residual value of components at the end of the 30-year period. A separate LCC is determined for Standard 90.1-2010 and for Standard 90.1-2013. The LCC savings is the Standard 90.1-2010 LCC minus the Standard 90.1-2013 LCC.

- **Simple Payback:** While not a true cost-effectiveness metric, simple payback is also calculated. Simple payback is the number of years required for accumulated annual energy cost savings to exceed the incremental first costs of a new code.

Two cost scenarios are analyzed:

- **Scenario 1** includes the costs and savings listed above without borrowing or tax impacts.

- **Scenario 2** incudes the same costs as scenario 1 plus financing of the incremental first costs through increased borrowing with tax impacts including mortgage interest and depreciation deductions. Corporate tax rates are applied. Economic analysis factors such as discount rates are also different, as described in Table 8.

The cost-effectiveness analysis compares the cost for new buildings meeting Standard 90.1-2013 compared to new buildings meeting Standard 90.1-2010. The analysis includes energy savings estimates from building energy simulations and LCC and simple payback calculations using standard economic analysis parameters. The analysis builds on work documented in *ANSI/ASHRAE/IES Standard 90.1-2013 Determination of Energy Savings: Quantitative Analysis* (Halverson et al. 2014), and the cost-effectiveness analysis documented in *National Cost-effectiveness of ANSI/ASHRAE/IES Standard 90.1-2013* (Hart et al. 2015).

Building Prototypes and Energy Modeling

The cost-effectiveness analysis uses six building types represented by six prototype building energy models. These six are a subset of 16 prototype building energy models and represent 80% of commercial floor space. These models provide coverage of the significant changes in ASHRAE Standard 90.1 from 2010 to 2013 and are used to show the impacts of the changes on energy savings. The prototypes represent common construction practice and include the primary conventional HVAC systems most commonly used in commercial buildings. More information on the prototype buildings and savings analysis can be found at: www.energycodes.gov/development/commercial/90.1_models.

Each prototype building is analyzed for each of the climate zones found within the state. Using the U.S. DOE EnergyPlus™ software, the six building prototypes summarized in Table 7 are simulated with characteristics meeting the requirements of Standard 90.1-2010 and then modified to meet the requirements of the next edition of the code (Standard 90.1-2013). The energy use and cost are then compared between the two sets of models.

Table 7. Building Prototypes

Building Prototype	Floor Area (ft²)	Number of Floors
Small Office	5,500	1
Large Office	498,640	13
Stand-Alone Retail	24,690	1
Primary School	73,970	1
Small Hotel	43,210	4
Mid-Rise Apartment	33,740	4

Climate Zones

Climate zones are defined in ASHRAE Standard 90.1 and include eight primary climate zones, the hottest being climate zone 1 and the coldest being climate zone 8. Letters A, B, and C are applied in some cases to denote the level of moisture, with A indicating moist or humid, B indicating dry, and C indicating marine. Figure 3 shows the national climate zones. For this state analysis, savings are analyzed for each climate zone in the state using weather data from a selected city within the climate zone and state, or where necessary, a city in an adjoining state with more robust weather data.
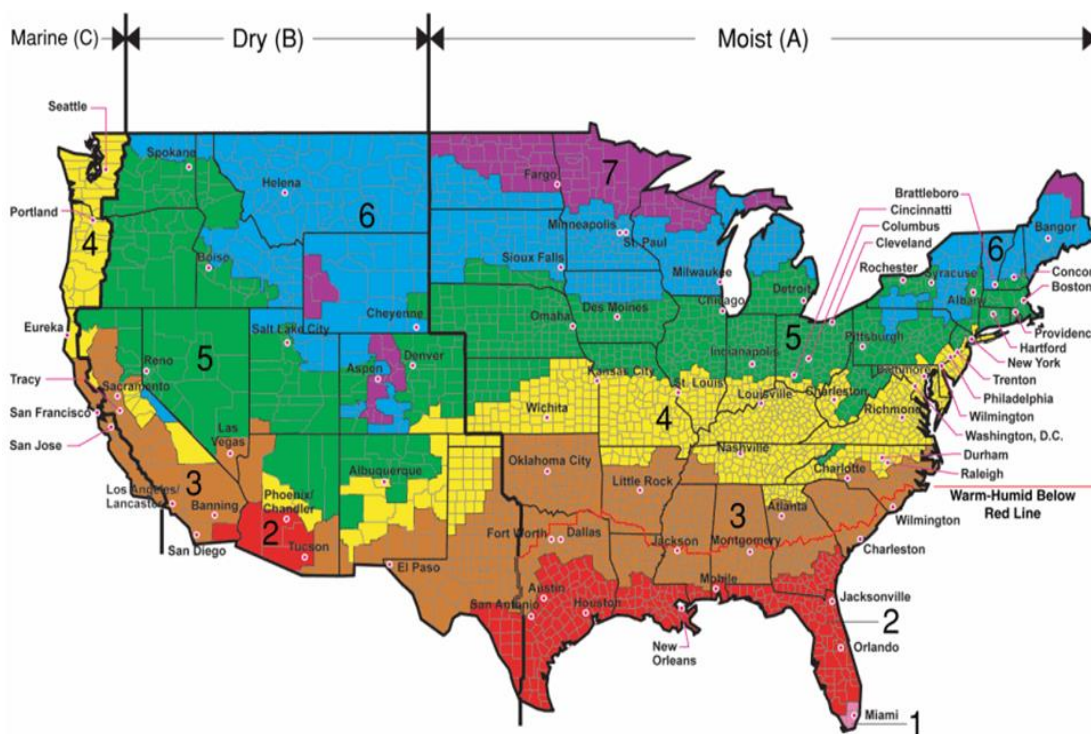
All of Alaska in Zone 7 except for the following Boroughs in Zone 8: Bethel, Dellingham, Fairbanks, N. Star, Nome North Slope, Northwest Arctic, Southeast Fairbanks, Wade Hampton, and Yukon-Koyukuk

Zone 1 includes: Hawaii, Guam, Puerto Rico, and the Virgin Islands

Figure 3. National Climate Zones

Cost-Effectiveness Method and Parameters

The DOE cost-effectiveness methodology accounts for the benefits of energy-efficient building construction over a multi-year analysis period, balancing initial costs against longer term energy savings. DOE evaluates energy codes and code proposals based on LCC analysis over a multi-year study period, accounting for energy savings, incremental investment for energy efficiency measures, and other economic impacts. The value of future savings and costs are discounted to a present value, with improvements deemed cost-effective when the *net LCC savings* (present value of savings minus cost) is positive.

The U.S. DOE Building Energy Codes Program uses an LCC analysis similar to the method used for many federal building projects, as well as other public and private building projects (Fuller and Petersen 1995). The LCC analysis method consists of identifying costs (and revenues if any) and in what year they occur; then determining their value in today's dollars (known as the present value). This method uses economic relationships about the time value of money (money today is normally worth more than money tomorrow, which is why we pay interest on a loan and earn interest on savings). Future costs are discounted to the present based on a discount rate. The discount rate may reflect the interest rate at which money can be borrowed for projects with the same level of risk or the interest rate that can be earned on other conventional investments with similar risk.

The LCC for both scenarios includes incremental initial costs, repairs, maintenance and replacements. Scenario 2 also includes loan costs and tax impacts including mortgage interest and depreciation deductions. The residual value of equipment (or other component such as roof membrane) that has remaining useful life at end of the 30-year study period is also included for both scenarios. The residual value is calculated by multiplying the initial cost of the component by the years of useful life remaining for the component at year 30 divided by the total useful life, a simplified approach included in the Federal Energy Management Program (FEMP) LCC method (Fuller and Petersen 1995). A component will have zero residual value at year 30 only if it has a 30-year life, or if it has a shorter than 30-year life that divides exactly into 30 years (for example, a 15-year life).

The financial and economic parameters used for the LCC calculations are shown in Table 8.

Table 8. LCC Economic Parameters

Economic Parameter	Scenario 1	Scenario 2
Study Period – Years[1]	30	30
Nominal Discount Rate[2]	3.10%	5.50%
Real Discount Rate[2]	3.00%	3.53%
Effective Inflation Rate[3]	0.10%	1.90%
Electricity Prices[4] (per kWh)	$0.1019	$0.1019
Natural Gas Prices[4] (per therm)	$0.9276	$0.9276
Energy Price Escalation Factors[5]	*Uniform present value factors*	*Uniform present value factors*
Electricity Price UPV[5]	20.68	17.71
Natural Gas Price UPV[5]	23.60	20.21
Loan Interest Rate[6]	NA	5.50%
Federal Corporate Tax Rate[7]	NA	34.00%
State Corporate Tax Rate[8]	NA	5.00%
Combined Income Tax Impact[9]	NA	37.30%
State and Average Local Sales Tax[10]	7.19%	7.19%
State Construction Cost Index[11]	0.804	0.804

[1] A 30-year study period captures most building components useful lives and is a commonly used study period for building project economic analysis. This period is consistent with previous and related national 90.1 cost-effectiveness analysis (Hart et al. 2015). It is also consistent with the cost-effectiveness analysis that was done for the residential energy code as described in multiple state reports and a summary report (DOE 2012). The federal building LCC method uses 25 years and the ASHRAE Standard 90.1 development process uses up to 40 years for building envelope code improvement analysis. Because of the time value of money, results are typically similar for any study periods of 20 years or more.

[2] The scenario 1 real and nominal discount rates are from the National Institute of Standards and Technology (NIST) 2014 annual LCC update for the federal LCC method (Rushing et al. 2014). The scenario 2 nominal discount rate is assumed to be the marginal cost of capital, which is set equal to the loan interest rate (see footnote 6). The real discount rate for scenario 2 is calculated from the nominal discount rate and inflation.

[3] The scenario 1 effective inflation rate is from the NIST 2014 annual LCC update for the federal LCC method (Rushing et al. 2014). The scenario 2 inflation rate is the Producer Price Index for non-residential construction, June 1984 to June 2014 (Bureau of Labor Statistics 2015).

[4] Scenario 1 and 2 electricity and natural gas prices are state average annual prices for 2014 from the United States Energy Information Administration (EIA) *Electricity Power Monthly* (EIA 2015a) and *Natural Gas Monthly* (EIA 2015b).

[5] Scenario 1 energy price escalation rates are from the NIST 2014 annual update for the FEMP LCC method (Rushing et al. 2014). The NIST uniform present value (UPV) factors are multiplied by the first year annual energy cost to determine the present value of 30 years of energy costs and are based on a series of different annual escalation rates for 30 years. Scenario 2 UPV factors are based on NIST UPVs with an adjustment made for the scenario difference in discount rates.

[6] The loan interest rate is estimated from multiple online sources listed in the references (Commercial Loan Direct 2015; Watts 2015).

[7] The highest federal marginal corporate income tax rate is assumed to apply.

[8] The highest marginal state corporate income tax rate is assumed to apply from the Federation of Tax Administrators (FTA 2015).

[9] The combined tax impact is based on state tax being a deduction for federal tax, and is applied to depreciation and loan interest.

[10] The combined state and average local sales tax is included in material costs in the cost estimate (Tax Foundation 2015).

[11] The state construction cost index based on weighted city indices from the state (Means 2014c).

Detailed Energy Use and Cost

On the following pages, specific detailed results for South Carolina are included:

- Table 9 shows the average energy rates used.

- Table 10 shows the per square foot energy costs for Standard 90.1-2010 and Standard 90.1-2013 and the cost savings from Standard 90.1-2013.

- Table 11 shows the per square foot energy use for Standard 90.1-2010 and Standard 90.1-2013 and the energy use savings from Standard 90.1-2013.

- Table 12.A shows the energy end use by energy type for each climate zone in the state.

Table 9. Energy Rates for South Carolina, Average $ per unit

Electricity	$0.1019	kWh
Gas	$0.9276	Therm

Source: Energy Information Administration, annual average prices for 2014 (EIA 2015a,b)

Table 10. Energy Cost Saving Results in South Carolina, $ per Square Foot

Climate Zone:		3A		
Code:	90.1-2010	90.1-2013	Savings	
Small Office				
Electricity	$0.978	$0.867	$0.111	11.3%
Gas	$0.002	$0.002	$0.000	0.0%
Totals	$0.979	$0.869	$0.111	11.3%
Large Office				
Electricity	$2.036	$1.985	$0.051	2.5%
Gas	$0.021	$0.034	-$0.013	-61.9%
Totals	$2.057	$2.019	$0.038	1.8%
Stand-Alone Retail				
Electricity	$1.319	$1.153	$0.166	12.6%
Gas	$0.059	$0.051	$0.008	13.6%
Totals	$1.378	$1.204	$0.174	12.6%
Primary School				
Electricity	$1.342	$1.187	$0.155	11.5%
Gas	$0.128	$0.137	-$0.009	-7.0%
Totals	$1.469	$1.324	$0.146	9.9%
Small Hotel				
Electricity	$1.188	$1.076	$0.111	9.3%
Gas	$0.202	$0.203	-$0.001	-0.5%
Totals	$1.390	$1.279	$0.111	8.0%
Mid-Rise Apartment				
Electricity	$1.216	$1.150	$0.066	5.4%
Gas	$0.021	$0.024	-$0.003	-14.3%
Totals	$1.237	$1.174	$0.063	5.1%

Table 11. Energy Use Saving Results in South Carolina, Energy Use per Square Foot

Climate Zone:		3A		
Code:	90.1-2010	90.1-2013	Savings	
Small Office				
Electricity, kWh/ft^2	9.594	8.505	1.089	11.4%
Gas, therm/ft^2	0.002	0.002	0.000	0.0%
Totals, kBtu/ft^2	32.913	29.243	3.670	11.2%
Large Office				
Electricity, kWh/ft^2	19.981	19.480	0.502	2.5%
Gas, therm/ft^2	0.023	0.037	-0.014	-60.9%
Totals, kBtu/ft^2	70.479	70.184	0.295	0.4%
Stand-Alone Retail				
Electricity, kWh/ft^2	12.943	11.313	1.630	12.6%
Gas, therm/ft^2	0.064	0.055	0.009	14.1%
Totals, kBtu/ft^2	50.538	44.099	6.439	12.7%
Primary School				
Electricity, kWh/ft^2	13.165	11.644	1.521	11.6%
Gas, therm/ft^2	0.138	0.148	-0.010	-7.2%
Totals, kBtu/ft^2	58.712	54.513	4.199	7.2%
Small Hotel				
Electricity, kWh/ft^2	11.657	10.564	1.093	9.4%
Gas, therm/ft^2	0.218	0.219	-0.001	-0.5%
Totals, kBtu/ft^2	61.583	57.907	3.676	6.0%
Mid-Rise Apartment				
Electricity, kWh/ft^2	11.930	11.284	0.647	5.4%
Gas, therm/ft^2	0.023	0.026	-0.003	-13.0%
Totals, kBtu/ft^2	43.006	41.122	1.884	4.4%

Table 12.A. Annual Energy Usage for Buildings in South Carolina in Climate Zone 3A

Energy End-Use	Small Office Electric kWh/ ft²·yr	Small Office Gas therms/ ft²·yr	Large Office Electric kWh/ ft²·yr	Large Office Gas therms/ ft²·yr	Stand-Alone Retail Electric kWh/ ft²·yr	Stand-Alone Retail Gas therms/ ft²·yr	Primary School Electric kWh/ ft²·yr	Primary School Gas therms/ ft²·yr	Small Hotel Electric kWh/ ft²·yr	Small Hotel Gas therms/ ft²·yr	Mid-Rise Apartment Electric kWh/ ft²·yr	Mid-Rise Apartment Gas therms/ ft²·yr
ASHRAE 90.1-2010												
Heating, Humidification	0.181	0.002	0.009	0.014	0.000	0.029	0.000	0.077	0.371	0.007	0.000	0.023
Cooling	1.547	0.000	3.423	0.000	2.361	0.000	2.931	0.000	2.616	0.000	1.657	0.000
Fans, Pumps, Heat Recovery	1.137	0.000	1.643	0.000	2.690	0.000	1.789	0.000	1.802	0.000	1.649	0.000
Lighting, Interior & Exterior	3.335	0.000	2.506	0.000	5.702	0.000	3.198	0.000	3.069	0.000	1.439	0.000
Plugs, Refrigeration, Other	2.484	0.000	12.401	0.000	2.190	0.000	5.150	0.046	3.799	0.092	4.210	0.000
Service Water Heating (SWH)	0.910	0.000	0.000	0.009	0.000	0.035	0.097	0.014	0.000	0.119	2.975	0.000
Total	9.594	0.002	19.981	0.023	12.943	0.064	13.165	0.138	11.657	0.218	11.930	0.023
ASHRAE 90.1-2013												
Heating, Humidification	0.198	0.002	0.009	0.028	0.000	0.020	0.000	0.087	0.425	0.007	0.000	0.026
Cooling	1.036	0.000	3.206	0.000	2.096	0.000	2.464	0.000	2.250	0.000	1.318	0.000
Fans, Pumps, Heat Recovery	0.974	0.000	1.596	0.000	2.224	0.000	1.576	0.000	1.790	0.000	1.543	0.000
Lighting, Interior & Exterior	2.949	0.000	2.281	0.000	4.807	0.000	2.880	0.000	2.514	0.000	1.242	0.000
Plugs, Refrigeration, Other	2.438	0.000	12.388	0.000	2.186	0.000	4.626	0.046	3.585	0.092	4.208	0.000
Service Water Heating (SWH)	0.910	0.000	0.000	0.009	0.000	0.035	0.097	0.014	0.000	0.119	2.973	0.000
Total	8.505	0.002	19.480	0.037	11.313	0.055	11.644	0.148	10.564	0.219	11.284	0.026
Total Savings	1.089	0.000	0.502	-0.014	1.630	0.009	1.521	-0.010	1.093	-0.001	0.647	-0.003

References

(ASHRAE) ANSI/ASHRAE/IES – American National Standards Institute, American Society of Heating, Refrigerating and Air-Conditioning Engineers, and Illuminating Engineering Society. 2010. *ANSI/ASHRAE/IES 90.1-2010, Energy Standard for Buildings Except Low-Rise Residential Buildings.* American Society of Heating, Refrigerating and Air-Conditioning Engineers, Atlanta, Georgia.

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The U.S. Department of Energy (DOE) provides estimates of energy and cost savings from code adoption at the National, Climate Zone, and State levels. For more information on how these estimates were developed, visit the DOE Building Energy Codes website:
www.energycodes.gov/development/commercial

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