ENERGY EFFICIENCY IN THE SOUTH

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EXECUTIVE SUMMARY

The economic recession, climate change concerns and rising electricity costs have motivated many states to embrace energy efficiency as a way to create new local jobs, lower energy bills, and promote environmental sustainability. With this surge of interest in energy efficiency, policymakers are asking how much wasted energy can be eliminated by expanding investments in cost-effective technologies and practices.

This report describes the results of primary in-depth research focused on the size of the South's energy-efficiency resources and the types of policies that could convert this potential resource into reality over the next 20 years. We limit the scope of our analysis to energy-efficiency improvements in three sectors: residential and commercial buildings and industry (RCI). Our rigorous modeling approach – applied uniformly across the multi-state region and accompanied by a detailed documentation of assumptions and methods – separates this study from many previous assessments of energy-efficiency potential.

The major findings are listed below.

1. **Aggressive energy-efficiency initiatives in the South could prevent energy consumption in the RCI sectors from growing over the next twenty years.**

   The initiatives would involve actions at multiple levels (state and local, national, utility, business, and personal). In the absence of such initiatives, energy consumption in these three sectors is forecast to grow by approximately 16% between 2010 and 2030.

2. **Fewer new power plants would be needed with a commitment to energy efficiency.**

   Our analysis of nine illustrative policies shows the ability to retire almost 25 GW of older power plants – approximately 10 GW more than in the reference case. The nine policies would also avoid over the next twenty years the need to construct 49 GW of new plants to meet a growing electricity demand from the RCI sectors.

3. **Increased investments in cost-effective energy efficiency would generate jobs and cut utility bills.**

   The public and private investments stimulated by the nine energy-efficiency policies would deliver rapid and substantial benefits to the region. In 2020, energy bills in the South would be reduced by $41 billion, electricity rate increases would be moderated, 380,000 new jobs would be created, and the region's economy would grow by $1.23 billion.

   The cost/benefit ratios for the modeled policies range from 4.6 to 0.3, with only two showing costs greater than benefits. When the value of saved CO_2 is included, only one policy is not cost effective, and it could be tailored to reduce the amount of subsidy.

4. **Energy efficiency would result in significant water savings.**

   The electricity generation that could be avoided by the nine energy-efficiency policies in the South could in turn conserve significant quantities of freshwater consumed for cooling. In the North American Electric Reliability Council (NERC) regions in the South, 8.6 billion gallons of freshwater could be conserved in 2020 (56% of projected growth in cooling water needs) and in 2030 this could grow to 20.1 billion gallons of conserved water (or 45% of projected growth).

Methodology and Background

The research team used a modified version of the National Energy Modeling System (NEMS) for its analysis, which is referred to as "SNUG-NEMS" (SNUG is short for the Southeast NEMS Users Group). By employing a hybrid approach using both the "bottom-up" and "top-down" modeling features of SNUG-NEMS and Global Insight's macroeconomic model, we are able to characterize a host of complicated interactive effects that are important, but often overlooked consequences of energy and climate policies. These include:

- the interaction of multiple energy efficiency policies on one another and their effect on the final demand for energy;
- the interaction of demand-side policies on supply-side trends;
- the feedback of energy efficiency policies on energy prices, and the subsequent (i.e., second-order) effect of prices on energy demand; and
- the interaction of energy-efficiency policies with the implementation of a carbon constrained future that puts a price on carbon.

We do not examine the impact of energy-efficiency investments on peak demand reductions. While clipping system peaks is critical to improving electric system performance, we treat this as an ancillary benefit of energy efficiency. Nor do we examine the role of demand-response or load-management programs aimed strictly at shifting on-peak consumption to off-peak hours.

The geographic scope covered by this report is defined by the U.S. Census Bureau's definition of the South, composed of the District of Columbia and 16 States stretching from Delaware down the Appalachian Mountains, including the Southern Atlantic seaboard and spanning the Gulf Coast to Texas. The South is the largest and fastest growing region in the United States, with 36% of the nation's population and a considerably larger share of the nation's total energy consumption (44%) and supply (48%). It produces a large portion of the nation's fossil fuels, and the vast majority of the energy it consumes is derived from fossil resources.

Relative to the rest of the country, the South consumes a particularly large share of industrial energy, accounting for 51% of the nation's total industrial energy use. In addition, the region has a higher-than-average per capita energy consumption for each of the end-use sectors covered in this report: the South consumes 43% of the nation's electric power, 40% of the energy consumed in residences, and 38% of the energy used in commercial buildings. This energy-intensive lifestyle may be influenced by a range of factors including:

- the South's historically low electricity rates,
- the significant heating and cooling loads that characterize many southern states,
- its relatively weak energy conservation ethic (based on public opinion polls),
- its low market penetration of energy-efficient products (based on purchase behavior) and
- its lower than average expenditures on energy-efficiency programs.

If the South could achieve the substantial energy-efficiency improvements that have already been proven effective in other regions and other nations, carbon emissions across the South would decline, air quality would improve, and plans for building new power plants to meet growing electricity demand could be downsized and postponed, while saving ratepayers money.

Magnitude of the Energy-Efficiency Resource in the South

The U.S. Energy Information Administration projects energy consumption in the RCI sectors of the South to increase over the next 20 years, expanding from approximately 30,000 TBtu in 2010 to more than 35,000 TBtu in 2030 (Figure ES.1).

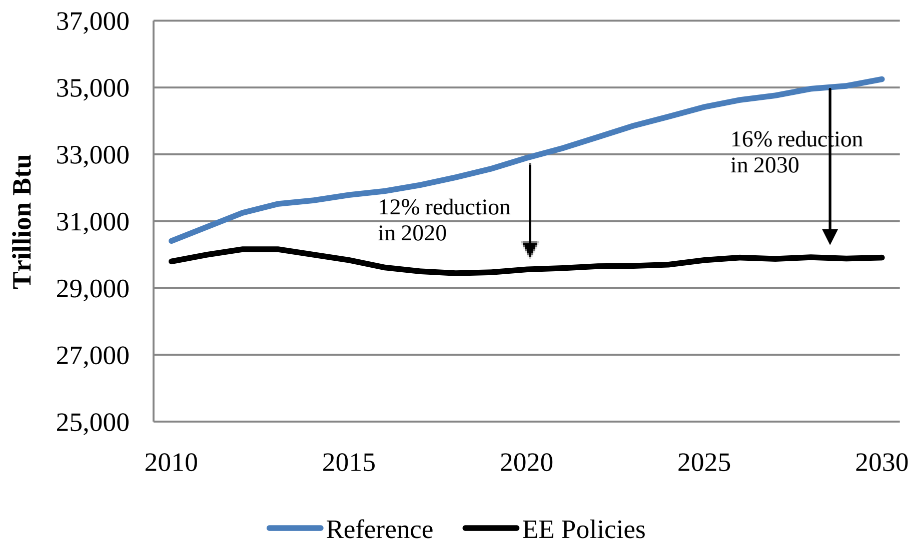

Figure ES.1 Primary Energy Consumption Projections (RCI Sectors) in the South

With the nine energy-efficiency policies, energy consumption does not grow over the next 20 years. This flat consumption trajectory represents a 16% reduction in energy consumption in 2030 relative to the reference forecast, or a savings of 5,600 trillion Btu (that is, 5.6 quads) in that year.

Energy-Efficiency Potential, by End-Use Sector. Among the three energy demand sectors in the South, the potential for improved energy efficiency is greatest in the commercial building sector in terms of percent energy reductions (Figure ES.2), while industrial sector has the largest absolute energy saving.

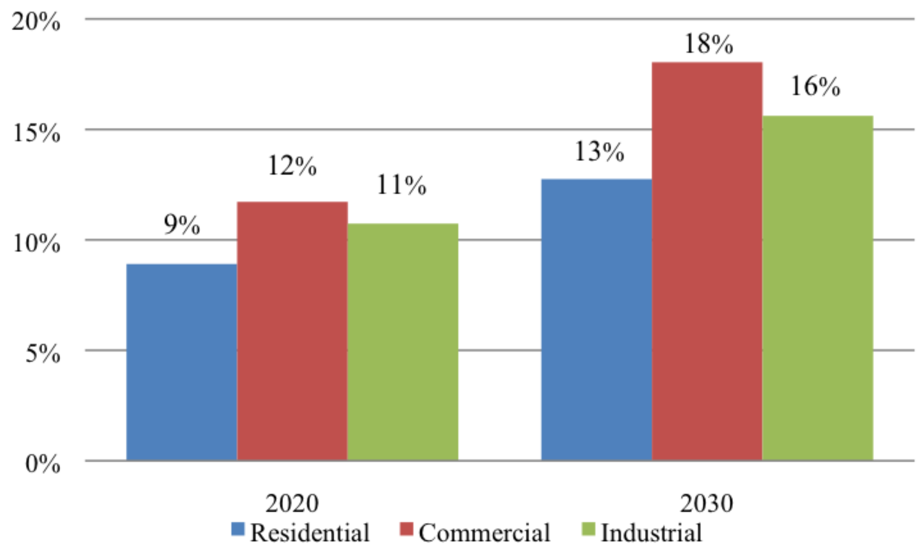

Figure ES.2 Energy-Efficiency Potential by Sector, in 2020 and 2030

Energy-Efficiency Potential, by Policy. Figure ES.3 portrays the energy-efficiency potential of each of the nine policies evaluated in this study.

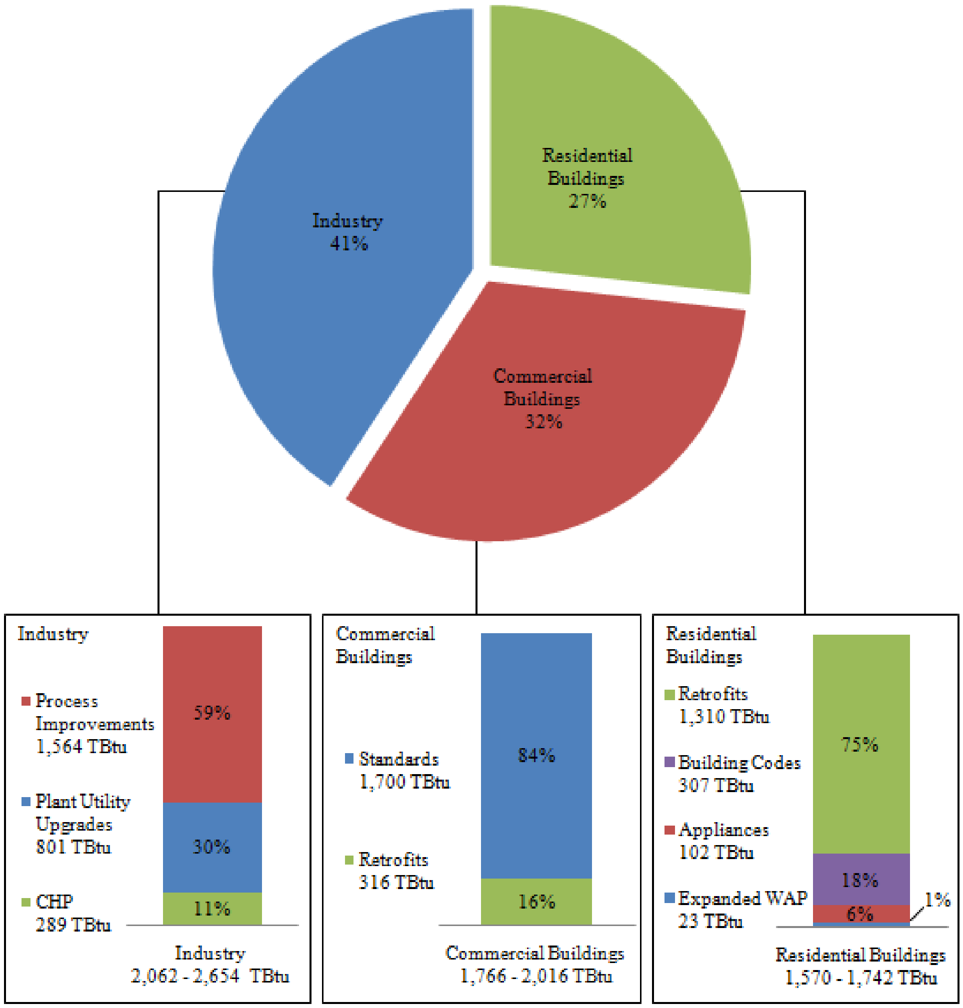

Figure ES.3 Energy-Efficiency Potential by Sector and Policy, in 2030*

(*The range of energy-efficiency potential shown for each sector reflects differences from summing individual policy estimates, SNUG-NEMS modeling of specific sectors, and economy-wide modeling estimates.)

- Of the nine policies, commercial appliance standards are estimated to have the greatest energy-savings potential in both 2020 and 2030. Commercial retrofit incentives account for additional cost-effective energy savings potential.
- In the industrial sector, process improvements could save significant quantities of natural gas and other fossil fuels. Significant industrial savings are also possible through policies that promote plant utility upgrades and incentives for combined heat and power systems.
- In the residential sector, retrofit incentives combined with equipment standards for heating, cooling, and water heating, is the dominant policy in terms of estimated energy-savings potential. It accounts for more than the other three residential policies combined (building codes, appliance standards, and expanded weatherization).

Impact on Power Plant Construction

By 2030, the Reference Scenario forecasts the need for an increase of 49 GW of electricity capacity in the southern National Electricity Reliability Council (NERC) regions above the capacity in operation in 2010 (Figure ES.4). This growing demand is expected to be met primarily by the addition of new combined cycle natural gas plants and new combined natural gas/diesel plants, along with some additional nuclear power, coal plants, and renewable power generation. Some oil and natural gas steam plants are retired during this period, as well. This is represented by the part of the bar in Figure ES.4 that is below the zero axis.

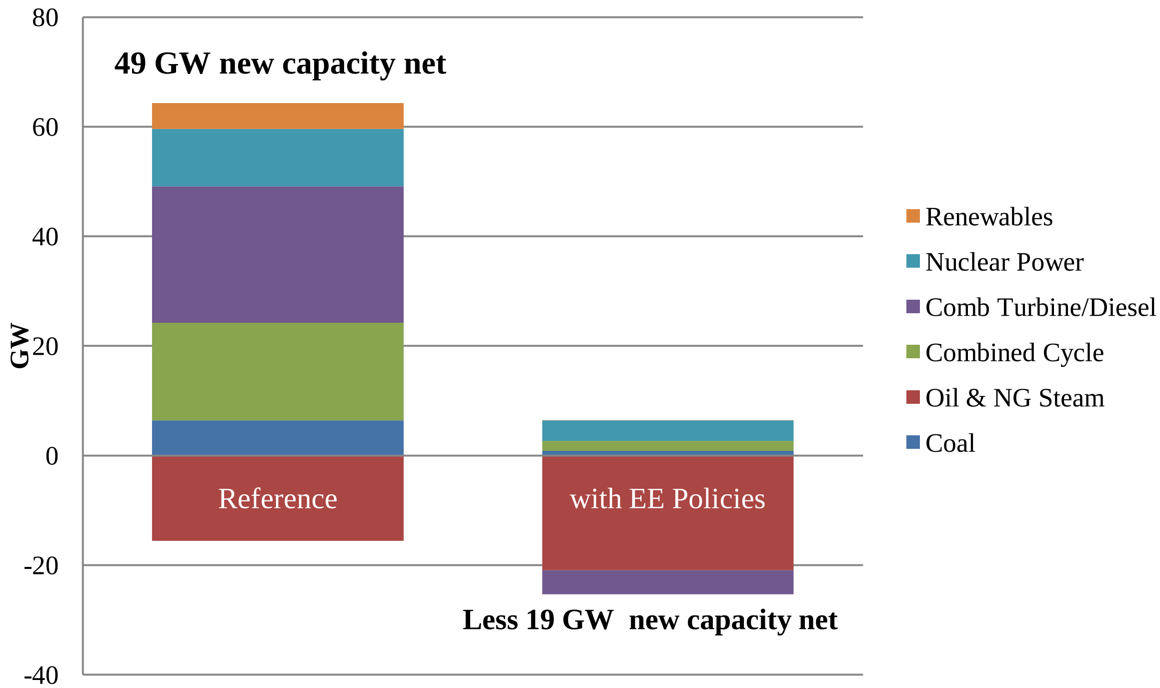

Figure ES.4 Incremental Generating Capacity in 2030 Beyond 2010 -- Southern NERC Regions

In contrast, implementation of vigorous energy-efficiency policies could eliminate the need to expand overall capacity between 2010 and 2030; in fact, the electricity capacity in the Southern NERC regions could decrease over the 20-year period by 19 GW. While new plants are needed, their capacity is more than offset by plant retirements. In addition to retiring more than 20 GW of oil and natural gas steam plants and some natural gas capacity, the energy-efficiency policies eliminate the need for all but 7 GW of new capacity, most of which is expected to be nuclear and natural gas powered, based on the SNUG-NEMS model. Very little new renewable capacity is added in this Energy-Efficiency scenario because the addition of new capacity of any type is minimized, and most renewable power options exceed the cost of power production by new combined cycle natural gas plants.

Economic Impacts

The public and private investments stimulated by the energy-efficiency policies outlined in this study could reduce energy bills in the South, moderate electricity rate increases, create new employment opportunities, and expand the region's level of economic activity (i.e., Gross Regional Product) (Table ES.1).

Table ES.1 Economic and Employment Impacts of Energy-Efficiency Policies in the South

	2020	2030
Annual Energy Savings (billion $2007)	$40.9	$71.0
Annual Public and Private Investment (billion $2007)	$15.8	$22.4
Annual Increased Employment (From Productive Investment and Energy Savings) (in full-time-equivalents)	380,000	520,000
Impact on Gross Regional Product (GRP) (billion $2007)	$1.23	$2.12

Energy Bill Savings. Consumers in the South could save $41 billion in reduced energy bills in the year 2020 as a result of the portfolio of nine energy-efficiency policies. These energy bill savings increase to $71 billion in 2030. For example, a typical household in the South would save $26 on its monthly electricity bill in 2020, and would save $50 each month in 2030. In addition to directly benefiting the consumers who make energy-efficiency investments, these policies benefit all consumers because the reduction in overall energy consumption causes energy prices to rise more moderately than would otherwise occur.

Electricity Rate Impacts. The portfolio of nine energy-efficiency policies modeled together would lead to a moderation of the energy price escalation that is otherwise forecast to occur over the next two decades (Table ES.2). For example, residential electricity rates in 2030 would be 17% lower in the Energy-Efficiency scenario than in the Reference Scenario. The reduced prices resulting from improved energy efficiency occur for both electricity and natural gas and across all sectors. The moderating impact on electricity rates grows over time as electricity consumption declines relative to the Reference case.

Table ES.2 The Effect of Energy-Efficiency Policies on Expected Southern Electricity Rates				
	2015	**2020**	**2025**	**2030**
Residential	-3%	-8%	-11%	-17%
Commercial	-1%	-6%	-8%	-13%
Industrial	-3%	-8%	-11%	-16%

Employment Impacts. The public and private investments stimulated by the energy-efficiency policies outlined in this study will have a positive impact on employment in the South. The electric utility and the natural gas sectors directly and indirectly employ about 5.6 and 8.4 jobs, respectively, for every $1 million of spending in the South. But, sectors vital to energy-efficiency improvements, like construction and manufacturing, generate 16.5 jobs per $1 million of spending.[1] (All of the remaining sectors in the South have an average employment coefficient of 13.9 jobs per million dollars of spending.) By diverting expenditures away from non-labor intensive sectors, energy-efficiency policies can positively impact employment growth.

The results shown in Table ES.1 are based on (1) this study's estimated energy savings and investment costs from implementing nine energy-efficiency policies, (2) national, regional, and state input-output coefficients provided by the Minnesota IMPLAN Group for 2008, and (3) calculators developed by the American Council for an Energy Efficient Economy, the Center for American Progress, and the President's Council of Economic Advisors.

Policies that drive a higher level of efficiency investments can create new jobs quickly, and can sustain a favorable employment balance because of the utility bill savings that foster long-term growth in other productive sectors of the economy. The combination of direct and indirect job growth attributed to the energy-efficiency policy scenario is estimated to be 380,000 in 2020 and 520,000 in 2030. In comparison, there were 5.4 million unemployed residents in the South at the end of 2009.[2]

Impact on Gross Regional Product (GRP). A vigorous commitment to energy efficiency would have a small, positive impact on the level of economic activity of the South. Specifically, the GRP of the South would increase by $1.23 billion in 2020 and by $2.12 billion in 2030. These changes are small relative to the South's $4.7 trillion economy in 2007.[3]

[1] These estimates are based on 2008 IMPLAN data.
[2] Bureau of Labor Statistics. (2010) Civilian labor force and unemployment by state and selected area, seasonally adjusted (Last modified: January 22, 2010, Accessed: March 9, 2010). http://www.bls.gov/news.release/laus.t03.htm
[3] Bureau of Economic Analysis. (2008). GDP by State. http://www.bea.gov/newsreleases/regional/gdp_state/gsp_newsrelease.htm.

Cost-Effectiveness of the Portfolio of Energy-Efficiency Policies

As Table ES.3 shows, the portfolio of nine energy-efficiency policies is cost-effective. The two policies addressing commercial buildings have the highest combined ratio of benefits to costs using the "total resource cost test." Over the 20-year period, an investment of $31.5 billion[4] would generate energy bill savings of $126 billion. Energy bill savings would begin immediately in 2010, would grow through 2030, and would then taper off until 2050 when the useful life of the improved technologies is expected to end. The result is a benefit/cost (B/C) ratio of 4.0 for the commercial sector. That is, for every dollar invested by the government and the private sector, four dollars of benefit is received. The industrial and residential sector policies are similarly cost effective with B/C ratios of 3.4 and 1.3.

The savings from the greater efficiency stimulated by these nine policies would total approximately $448 billion in present value to the U.S. economy. It would require an investment over the 20-year planning horizon of approximately $200 billion in present value terms. These costs include both public program implementation costs as well as private-sector investments in improved technologies and practices.

Among the nine individual policies, only two have benefit/cost ratios of less than one – indicating that they are not cost-effective. These include appliance incentives and standards (with a B/C ratio of 0.3) and combined heat and power incentives (with a B/C ratio of 0.7). When clothes washers and refrigerators are removed from the suite of appliance standards with incentives, the B/C ratio rises to 0.7. When carbon dioxide emission reductions are valued at a range of $15 per metric ton in 2010 rising to $51 in 2030), both of these policies approach or exceed the breakeven B/C ratio of 1.

According to the total resource cost test, the most cost-effective policy is tighter commercial appliance standards (with a B/C ratio of 4.6) followed by B/C ratios of 4.5 for industrial plant utility upgrades and 4.1 for residential building codes with third-party verification. These high B/C ratios combined with the fact that we examined an incomplete set of policies and technologies suggests that greater levels of investment could generate additional, cost-effective energy savings.

[4] In 2007 dollars, using a 7% discount rate.

Table ES.3 Total Resource Cost Tests by Sector (Million $2007)			
Residential Sector Policies			
	NPV Cost	NPV Benefit	B/C Ratio
Building Codes with Third-Party Verification	$10,000	$41,400	4.1
Appliance Incentives and Standards	$25,500	$7,060	0.3
Expanded Weatherization Assistance Program	$5,840	$6,420	1.1
Residential Retrofit and Equipment Standards	$86,600	$119,000	1.4
Combined Policies	**$115,000**	**$143,000**	**1.3**
Commercial Sector Policies			
	NPV Cost	NPV Benefit	B/C Ratio
Tighter Commercial Appliance Standards	$26,300	$109,000	4.6
Commercial Retrofit Incentives	$8,540	$20,900	2.4
Combined Policies	**$31,500**	**$126,000**	**4.0**
Industrial Sector Policies			
	NPV Cost	NPV Benefit	B/C Ratio
Industrial Plant Utility Upgrades	$10,800	$48,400	4.5
Industrial Process Improvement Policy	$36,000	$128,811	3.6
Combined Heat and Power Incentives	$16,900	$11,400 $17,600*	0.67 1.04*
Combined Policies	**$53,200**	**$179,000**	**3.4**

* Includes the environmental benefits from CO_2 emissions avoided by CHP systems.

Water Conservation from Energy Efficiency

Water conservation is an important co-benefit of policies that promote the efficient use of electricity. Based on a water calculator developed for this project, the freshwater consumed in the process of cooling conventional and nuclear thermoelectric power plants in the Southern NERC regions is forecast to grow to 334 billion gallons in 2020 and 381 billion gallons in 2030.

Implementation of the nine Energy-efficiency policies examined here could avoid generation that in turn would save southern NERC regions 8.6 billion gallons of freshwater in 2020 and 20.1 billion gallons in 2030. On a percentage basis, this represents 56% of the projected growth in water consumption over the next decade, and 43% of the projected growth for the following decade. These savings in 2030 represent about one-quarter of the current total water needs of the City of Atlanta.

Policy Supply Curves for Energy Efficiency in the South

Energy-efficiency supply curves have typically focused on individual technologies. Since the emphasis of this report is on energy-efficiency potential that is achievable with policy initiatives, we have developed policy supply curves. The magnitude of energy demand resources that can be achieved by launching aggressive energy-efficiency policies is shown along the horizontal axis, and the vertical axis presents the levelized cost of delivering these energy demand resources. The policies are ordered from the lowest to the highest levelized cost. Only the electricity supply curve is presented here, in Figure ES.5. Chapter 6 also presents energy-efficiency supply curves for total energy savings and natural gas. In all cases, we focus on the year 2020.

The electricity efficiency supply curve for the South (Figure ES.5) illustrates how more than 2,000 TBtu of electricity savings could be realized from implementing eight energy-efficiency policies. (The combined heat and power policy could not be assigned a levelized cost value.)

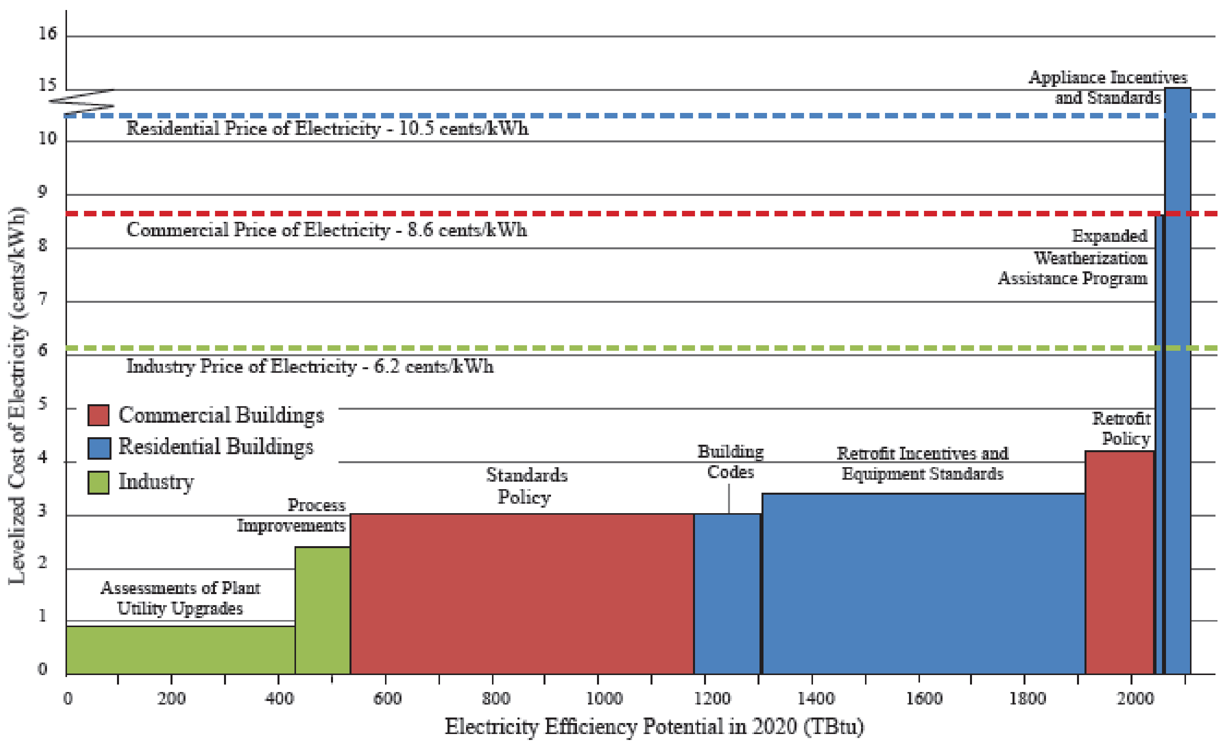

Figure ES.5 Supply Curve for Electricity Efficiency Resources in the South in 2020 (RCI Sectors)

The supply curve also highlights the large, low-cost potential of industrial efficiency opportunities, which together could save more than 500 TBtu of electricity for a levelized cost that is significantly lower than the price of electricity for industrial consumers (6.2 cents/kWh). The next most cost-effective efficiency option is the commercial standards policy, followed by building codes, bringing the cumulative savings for these four policies to nearly 900 TBtu. When the retrofit incentives and equipment standards are added, a large additional savings can be achieved. The three remaining policies do not save as much electricity and are more costly.

The natural gas supply curve distributes approximately 1,450 TBtu of savings across the eight efficiency policies. Commercial standards and residential building codes offer particularly low-cost, but somewhat limited natural gas savings. Industrial plant utility upgrades and process improvements, on the other hand, offer low-cost and large-scale opportunities for natural gas savings in the South.

Carbon Constrained Sensitivity Analysis

An analysis of the sensitivity of our study's findings to a particular key parameter was undertaken to ensure the analysis helps capture some of the uncertainties associated with SNUG-NEMS forecasting. This sensitivity is called the Carbon-Constrained Future (CCF). It was chosen because the national regulation of greenhouse gases appears possible and will affect how energy-efficiency policies are perceived and implemented. The scenario is modeled by assuming a \$15/tCO_2 price on carbon in 2010, increasing linearly to \$51/tCO_2 in 2030.

Given our interest in how energy-efficiency policies interact with other supply- and demand-side initiatives, we evaluated the CCF constraint both on its own and in the presence of energy-efficiency polices. In this combined set up of CCF + energy-efficiency policies, the effect of efficiency policies on consumption under the assumption of a Carbon Constrained Future appears to be additive. That is, the efficiency policies reduce consumption by approximately the same increment when added to either the Reference scenario or the CCF.

However, this is not to say that there is no interactive effect at all. Rather, the interaction is apparent when examining the reduction in CO_2 emissions. Emission reductions from energy-efficiency policies result from the consumption of less energy, while the reductions from the Carbon-Constrained Future result primarily from switching to cleaner fuels. When these two policy scenarios are imposed simultaneously, the interactions between them grow over time, as the cleaner fuels predicted in a CCF scenario become the fuels not consumed as the result of energy-efficiency investments. This effect is noticeable in Figure ES.6 starting around 2025.

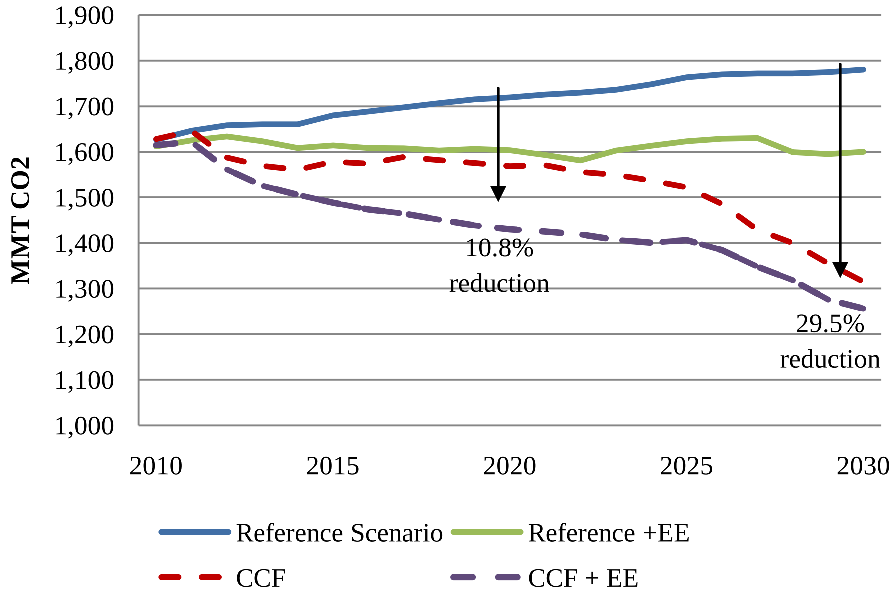

Figure ES.6 Carbon Dioxide Emissions with Energy-Efficiency Policies

Conclusions

If the South could achieve the substantial energy-efficiency improvements that have already been shown effective in other regions and nations, carbon emissions across the South would decline, air quality would improve, and plans for building new power plants could be downsized or postponed, all while saving ratepayers money.

While we examined nine policies, others exist that would lead to additional efficiency. However, these nine were chosen because they were all deemed likely to be cost-effective, significant, large, realistic, and quantifiable. We do not examine the impact of energy-efficiency investments on peak demand reductions. While clipping system peaks is critical to electric power planners, we treat this as an ancillary benefit of improved energy efficiency. Nor do we examine the role of demand-response or load-management programs aimed strictly at shifting on-peak consumption to off-peak hours. These are also valuable "demand-side" resources that merit further assessment.

The energy-efficiency policies described in this report could set the South on a course toward a more sustainable and prosperous energy future. If utilized effectively, the region's substantial energy-efficiency resources could reverse the long-term trend of expanding energy consumption. With a concerted effort to use energy more wisely, the South could grow its economy, create new jobs, and improve the health of its citizens and ecosystems.

Without new supporting policies, this potential for energy-efficiency improvement will not be realized. Energy-efficiency upgrades require consumer and business investment and they compete with other priorities. With so many demands on financial and human capital, cost-effective energy-efficiency improvements are easily ignored. Through a combination of information dissemination and education, financial assistance, regulations, and capacity building, consumers can be encouraged to invest in energy efficiency. In addition, expanded research and development and public-private partnerships are needed to innovate and deploy transformational technologies that enlarge the efficiency potential over the long run.

The ability to convert this vision into reality will depend on the willingness of consumer, business and government leaders to champion the kinds of policies modeled here.

1. INTRODUCTION

For the past several years, U.S. House and Senate committees have debated the pros and cons of alternative energy and climate legislation. Emerging from this dialogue is a consensus that energy efficiency should play a key role in transitioning the nation to a clean energy future. Energy efficiency is generally seen as a large, affordable, and environmentally attractive energy resource. Investments in energy efficiency can save consumers and businesses money while reducing pollution, mitigating greenhouse gas (GHG) emissions, and conserving water.

In the electricity sector, evidence has shown that energy efficiency can be as reliable as the construction of new power plants and the purchase of electricity via long-term contracts or spot markets (Vine, Kushler, and York, 2007). Energy efficiency is also a low-cost contributor to system adequacy – the ability of the electric system to supply the aggregate energy demand at all times. In addition to environmental benefits, energy efficiency often comes hand-in-hand with productivity gains and job growth.

At the same time, energy efficiency typically requires increased utility and government incentives, regulations, information, and other policies to overcome barriers and transform markets. As a result, specific estimates of the size of energy-efficiency resources are highly variable. The supply of cost-effective energy-efficiency varies according to assumptions made about future policies, future energy prices, rates of economic growth, and a host of other factors.

Energy Efficiency in the South examines these factors in the design of its detailed primary and in-depth research on the size of cost-effective energy-efficiency potential in the South.

1.1 GOALS AND ORGANIZATION OF THE REPORT

By implementing new policy approaches that tackle key barriers, create new incentives, set minimum standards, and enable change, how much energy efficiency can be stimulated? Which technologies hold the greatest potential and what policies and programs can most effectively translate that potential into reality? These are the essential questions addressed by this study.

Energy Efficiency in the South is organized into six chapters followed by references and numerous appendices. The chapters can be grouped into three sections:

Introduction (Chapter 1) and Methodology (Chapter 2): The remainder of this chapter sets the context for the empirical analysis, describing energy production and consumption in the South and characterizing current efforts to tap demand-side energy resources. Chapter 2 provides a broad overview of the methodology used in the policy analysis and energy-efficiency resource assessments. This chapter also outlines the portfolio of policies modeled in the analysis and describes the alternative future scenarios that could shape their influence.

Energy-Efficiency Resources, by Sector (Chapters 3-5): These chapters estimate the potential for cost-effective efficiency policies in each of the Region's major sectors: residential and commercial buildings and industry (the RCI sectors). These assessments begin with a description of energy consumption in the South and the energy-efficiency levels assumed in the "Reference Scenario" forecast. The chapters then describe each of the energy efficiency policies, the methodology used to analyze them, and the estimates of energy savings and costs. The chapters then estimate the cost-effectiveness of each policy, compare their results with other studies, and describe the limitations including needs for further research.

Integrated Analysis (Chapter 6): This chapter describes the integrated engineering and economic results of our assessment of energy-efficiency potential in the South. In addition to presenting the economy-wide cost-effectiveness tests, this chapter characterizes the employment and macroeconomic impacts of each scenario, as well as the water conservation benefits of the energy-efficiency policies. In addition to the Reference Scenario forecast, we examine a Carbon Constrained Future Scenario for a measure of sensitivity analysis. The chapter concludes with a discussion of the study's principal findings.

These chapters are supplemented by detailed appendices that provide additional background on the current federal policy environment that operates as a backdrop for the proposed new and expanded policy initiatives, description of our assumptions and methodologies, and in a few cases, a more detailed description of our findings.

- Appendix A describes the hundreds of federal policies and measures that are currently in place, which seek to promote investments in energy-efficient buildings and industry.
- Appendix B provides supplemental information about the study's overall methodological approach.
- Appendices C through E provide additional information about the methodologies used to analyze each sector.
- Appendix F provides further information on the baseline analysis and the use of the use of the ACEEE employment calculator, as well as the methodology used to evaluate water conservation benefits of the Energy-Efficiency Policy Scenario.
- Appendix G contains short (8- to 10-page) profiles of the findings for each of the 16 states in the South, along with the District of Columbia. These profiles are posted on the website of the Southeast Energy Efficiency Alliance (http://www.seealliance.org/).

1.2 OVERVIEW OF THE SOUTH CENSUS REGION

The South census region is comprised of the District of Columbia and 16 States, covering two of the most populous states in the country – Texas and Florida. The U.S. Census Bureau divides the South into three divisions. The **South Atlantic** includes eight states and the District of Columbia; all but West Virginia sit along the eastern seaboard. The **East South Central** region includes Alabama and three states with western borders that touch the Mississippi River. The **West South Central** region also includes four states, which all lie west of the Mississippi River.

The South as defined by the U.S. Census Bureau is almost identical to the Region served by the Southern Governors' Association (SGA).[5] It is slightly larger than the 11-state region served by the Southeast Energy Efficiency Alliance.[6]

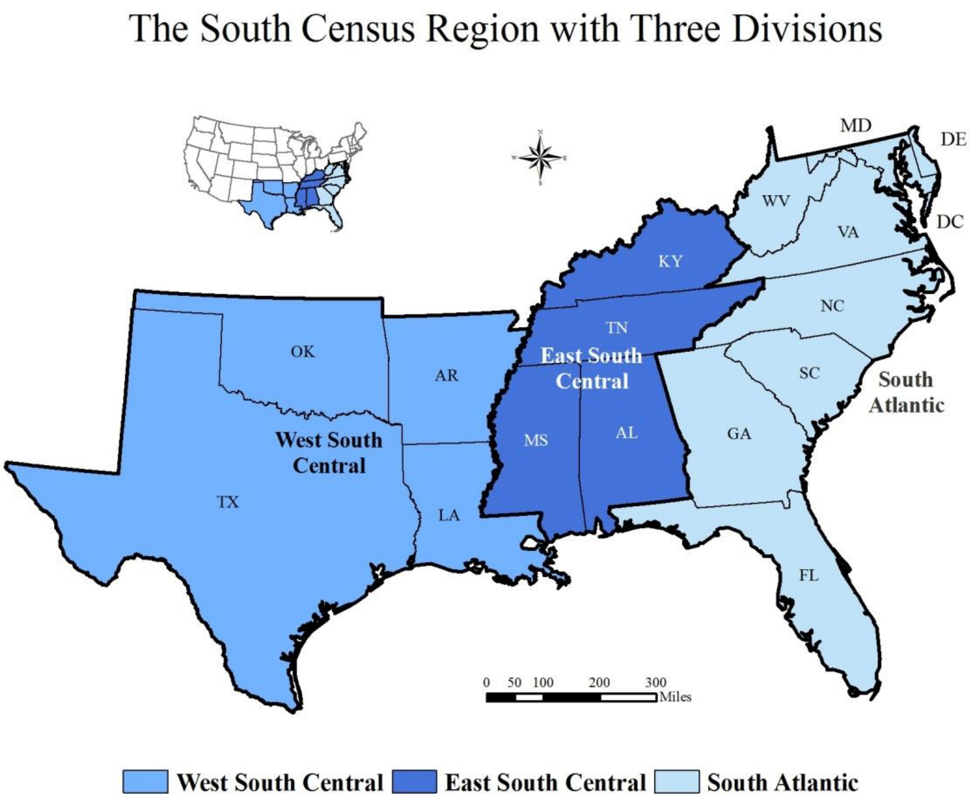

Figure 1.1 The South Census Region with Three Divisions[7]

[5] All of the SGA member states except for Missouri are located in the South; Missouri is in the West North Central region. In the South Atlantic region, all states except for DC and DE are member states of SGA. SGA also includes the U.S. Virgin Islands and Puerto Rico.

[6] The region as defined by SEEA includes the 11 states from Kentucky and Virginia south, and from Arkansas and Louisiana east – see www.seea.us.

[7] Map and definition from U.S. Census Bureau document on Regions and Divisions of the United States *www.census.gov/geo/www/us_regdiv.pdf*

With 36.4% of the country's population in 2009, the South is the most populous of the four census regions of the United States (U.S. Bureau of the Census, 2009). The South region leads the nation not only in population but also in in-migration and population growth.[8] As the nation's largest and fastest growing region, the South has experienced a 20% population growth over the past decade, and this rapid expansion is expected to continue.

1.3 ENERGY SUPPLY IN THE SOUTH

The South produces significant portions of the nation's fossil fuels. In 2007, the region supplied 48% of the nation's energy resources, proportionately more for fossil energy resources than for renewable energy resources. Specifically, the region accounts for the following percentages of the nation's energy production, by fuel (EIA, 2009b):

- 56% of conventional oil
- 65% of natural gas marketed production
- 38% of coal production
- 43% of nuclear power
- 28% of renewable energy production.

With a fuel mix for generating electricity that is 77% derived from nonrenewable fossil fuels (EIA, 2009c), achieving the substantial energy efficiency improvements experienced in many other parts of the United States would postpone the need for new power plants to meet growing demand and could improve air quality and reduce carbon emissions across the region. In 12 of the 16 states in the South, coal is the primary source of power production.

In part because of its heavy reliance on coal and petroleum and it small production (and consumption) of renewable energy, the South accounts for 41% of U.S. carbon emissions.

1.4 ENERGY USE IN THE SOUTH

The South accounted for 43.6% of the nation's total energy consumption in 2006, considerably more than its share of the country's population of 36%. Its higher-than-average per capita energy consumption is true for each of the major end-use sectors: residential buildings (39%), commercial buildings (38%), industry (51%), and transportation (41%), and for electric power (43%).

[8] The South has the highest in-migration and population growth in persons, but the West leads the nation in growth rate on a percentage basis. For the period from 2000 to 2008, population growth for the whole U.S. was estimated at 7.8% with growth for the South at 11.1% and the West at 11.7%; over the same time, the average annual population growth rate for the whole U.S. was 0.94% with average annual population growth rates for the South at 1.32% and West at 1.39% (U.S. Bureau of the Census, 2008).

1.4.1 Energy Consumption by Source

As is the case nationwide, coal is forecast to increase its share of energy use in the Region between 2015 and 2030, in the absence of restrictions on CO_2 emissions (Figure 1.2). However, the market share of western coal is expected to increase, while Appalachian coal production is forecast by EIA to decline slightly. EIA states, "Although producers in Central Appalachia are well situated to supply coal to new generating capacity in the Southeast, that portion of the Appalachian basin has been mined extensively, and production costs have been increasing more rapidly than in other Regions" (EIA, 2008a, p. 84). With 67% of the nation's jobs in the U.S. coal industry supporting only 35% of U.S. coal production, Appalachia has significantly lower levels of labor productivity and therefore higher costs. In contrast, the Powder River Basin has vast remaining surface-minable reserves that can be reached by large earth-moving equipment with significant benefits from economies of scale.

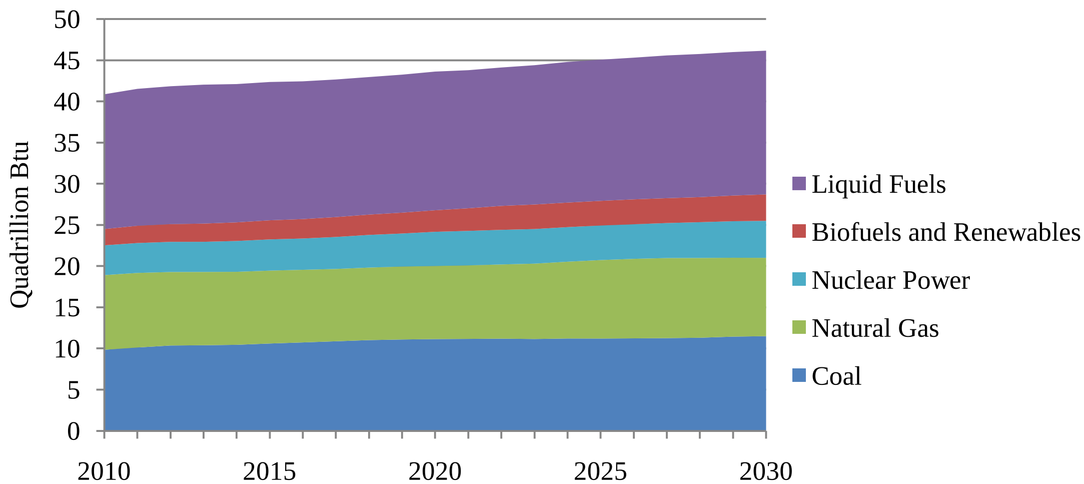

Figure 1.2 Energy Consumption Projection for the South, by Source, 2007-2030 (including transportation, EIA, 2009c)

Availability of reasonably priced and reliable energy has been a value to business in the South and has helped to drive the region's economic development. For example, in 2007, the South enjoyed an average population-weighted residential electricity price of 10.1 cents per kWh, compared with a national average of 10.6 cents (EIA, 2009d). Within the South, electricity rates are lowest in the East South Central Division and highest in the West South Central Division, although there is variation between and within states accounting for different service providers.

Despite its generous endowment of energy resources, the region is economically challenged. It accounts for only 33% of the nation's gross domestic product (BEA, 2009), and it has the largest proportion of households living in poverty, of all the Census regions.

As Table 1.1 shows, coal dominates electricity generation in the South, accounting for 54% in 2008, which is slightly higher than the U.S. average of 51%. In contrast, hydropower in the South, at 2% of generation, is considerably smaller than the 8% national average. The South depends less on renewable sources of electricity than any other region. As a result of this heavy reliance on fossil fuels, the South accounts for 41% of U.S. carbon emissions. These regional averages mask a great deal of state-by-state diversity. Three states in the South rely primarily on natural gas for power production, and one state (South Carolina) relies primarily on nuclear power.

Table 1.1 Energy Consumption for Electric Power in the South and the U.S.

	Coal	Renewables	Fuel Oil	Petroleum Coke	Natural Gas	Nuclear	Imports
U.S.	51.3%	8.7%	1.2%	0.4%	17.3%	20.9%	0.3%
South	53.8%	2.9%	1.2%	0.7%	20.8%	20.5%	0.0%

http://www.eia.doe.gov/emeu/states/sep_sum/html/pdf/sum_btu_eu.pdf

EIA forecasts that fuel consumption in the future will correspond to the total energy consumption projections. EIA forecasts that the South will increase its share of coal consumption for electricity generation between 2020 and 2030 as shown in Figure 1.3.

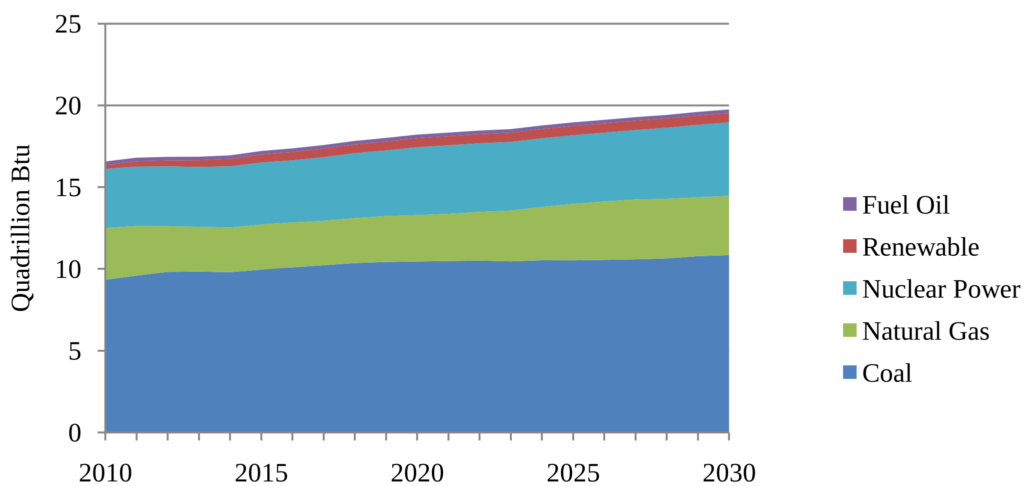

Figure 1.3 Energy Consumption for Electric Power Generation in the South, 2007-2030 (EIA, 2008a)

States in other regions of the nation are meeting one to two percent of their electricity consumption each year with energy efficiency at a cost of approximately $0.03 per kilowatt-hour (kWh) compared with projected costs of $0.05 to $0.07 per kWh of electricity from coal, gas combined cycle, wind or nuclear plants (Brown and Chandler, 2008; Kushler, York and Witte, 2004). California, New York, Vermont, and other states have shown that energy efficiency can represent a low-cost, low-risk energy strategy.

California, in part due to aggressive and sustained energy-efficiency measures, has kept per capita electricity use flat over recent decades (National Academy of Sciences, 2008). This is in direct contrast to national trends over the last 25 years, where U.S. per capita electricity use as a whole has risen about 50%. Rufo and Coito (2002) have shown that the potential for further energy-efficiency improvements in California remains strong. A similar potential for aggressive and sustained energy-efficiency programs has been demonstrated in Vermont and other states, where electricity consumption per capita has remained fairly flat while the state's economy has grown significantly. Thus, these states have shown that energy demand growth can be significantly reduced without compromising economic growth. The challenge is to move these energy-efficiency "best practices" to the South.

1.4.2 Energy Consumption by Sector

In 2007, the South consumed 16.6 quads of energy in the industrial sector, more than any other sector in the South and proportionately more than the industrial sector in the United States as a whole (Figure 1.4). This high industrial energy consumption reflects the strong industrial base of this region, and the heavy representation of energy-intensive industries in the South. Consequently, compared with the nation as a whole, the South consumes slightly less of its energy on buildings and transportation. The industrial share is projected to decline over time but the industrial energy will still be the largest portion by far in 2030 (Table 1.2).

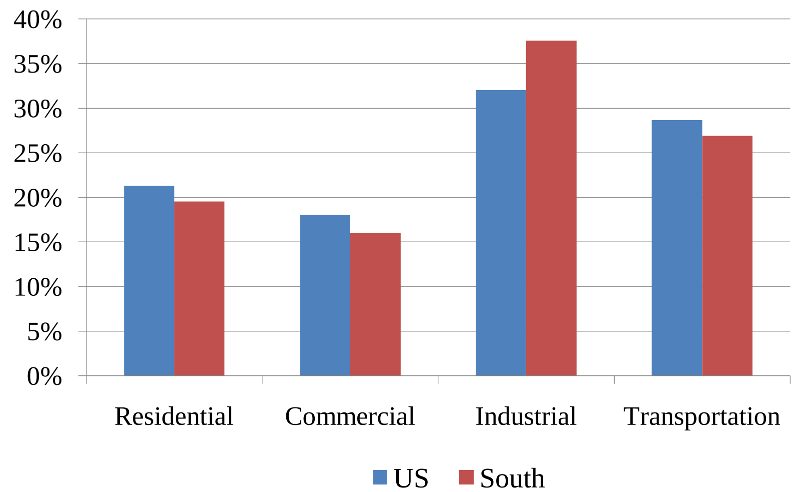

Figure 1.4 Energy Consumption Shares in the U.S. and the South by End-Use Sectors, in 2007

Table 1.2 Energy Consumption Forecast for the South (quadrillion Btu)				
Year	**RCI Total**	**Residential Buildings**	**Commercial Buildings**	**Industry**
2007	31.7	8.3	6.8	16.6
2020	31.6	8.9	7.9	14.9
2030	33.2	9.8	8.9	14.5

(EIA, 2009c ***Annual Energy Outlook)***

The energy consumption of each sector is forecast to increase over the next 25 years. Compared to 2007, consumption expands in 2030 to 9.8 quads of energy (18%) in the residential sector, and 8.9 quads (31%) in the commercial sector. In contrast, energy consumption in industry declines by 13% to 14.5 quads in the year 2030.

1.4.3 Energy Prices

Energy in the South is relatively cheap, and EIA forecasts that this comparative advantage will continue through 2030. Table 1.3 compares U.S. and Southern prices.

Analysis by the Center for Business and Economic Research (2006), the Electric Power Research institute (EPRI), and others suggests that residential and commercial consumers are fairly insensitive in the short-run to increases in the price of electricity. If this price insensitivity applies across all energy sources, which is likely, then strong policy interventions will be needed to promote energy-efficient purchases and practices. Notwithstanding short-term price insensitivity, smart policies can accelerate investments in energy efficiency (Brown, et al, 2001; Geller et al., 2006). It is this perspective that we actively explore in the analysis that follows.

Table 1.3 Average Energy Prices to All Users in the South and the United States (in 2006 dollars per million Btu)

Fuel Type	**United States**			**The South**		
	2007	**2020**	**2030**	**2007**	**2020**	**2030**
Distillate Fuel Oil	$19.5	$25.9	$27.9	$19.5	$25.6	$27.4
Natural Gas	$11	$10.9	$11.9	$8.2	$8.3	$9.7
Electricity	$44.2	$38.6	$41.5	$25.0	$26.4	$29.1

(EIA, 2009c)

1.4.4 Carbon Footprint

When the greater intensity of energy consumption in the South is compounded by its lower-than-average use of renewable fuels, the Region's carbon footprint expands well beyond the national average. A recent study by Brown, Southworth and Sarzynski (2009) estimated the per capita carbon footprint of the nation's largest 100 metropolitan areas, measured in terms of the metric tons of carbon emissions per capita from the consumption of residential electricity, residential energy and light duty vehicle and freight trucks fuels. Eleven of the 20 metropolitan areas with the largest carbon footprints are located in the South (Figure 1.5). Thus, from a climate policy perspective, while the South may be more vulnerable to the costs associated with any national climate policy, it could perhaps gain the most by capitalizing on opportunities to transform its energy system, compared with other areas of the country.

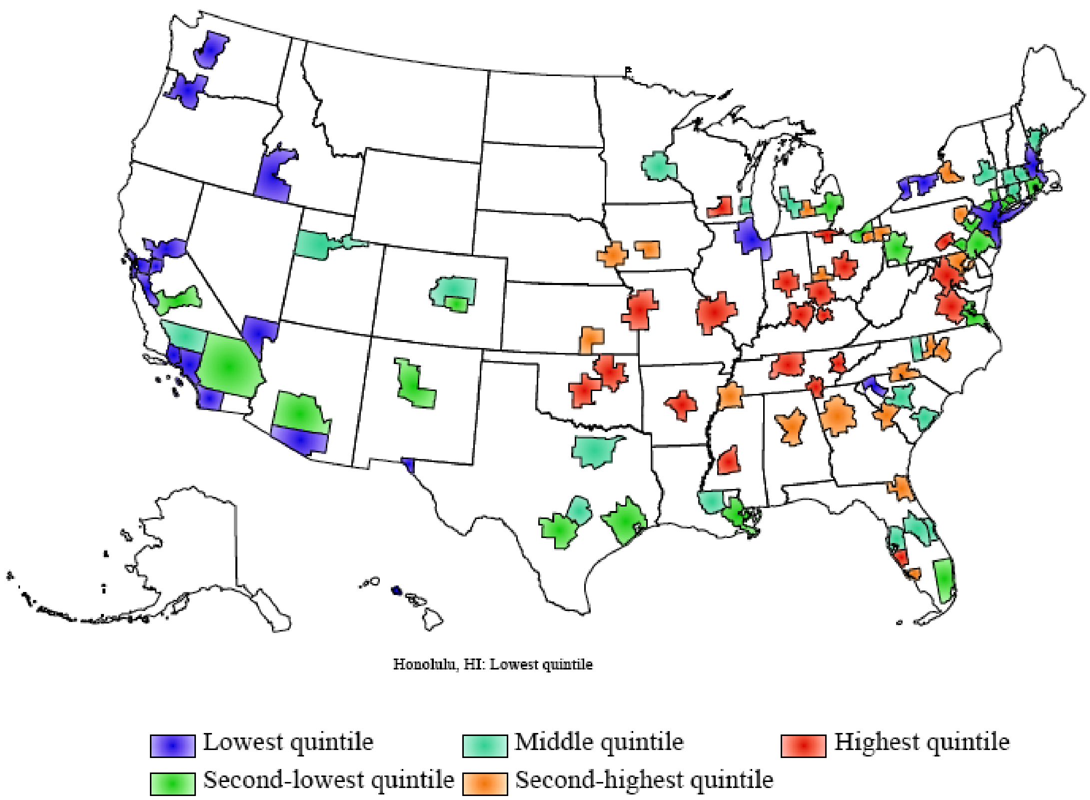

Figure 1.5 Carbon Footprints of Metropolitan Areas in the South, 2005
(Map drawn from data published in Brown, Southworth, and Sarzynski, 2009)

1.5 ENERGY-EFFICIENCY PROGRAMS AND PRACTICES IN THE SOUTH

1.5.1 Illustrative Energy-Efficient Technologies and Policies

A large potential for improved efficiency exists in numerous energy-consuming equipment and practices. For instance, high-quality adjustable-speed electronic motor drives, once exotic and costly, are now mass-produced in Asia and are widely used because of their protective and softstart circuits. High-efficiency compact fluorescent lamps sell for a fifth of their 1983 price, now that a billion are made yearly. Real prices have fallen several fold in 15 years for electronic lighting ballasts and heat-reflecting window coatings. The economic potential for energy efficiency continues to grow (Lovins, 2007).

Layers of energy inefficiency exist throughout the U.S. economy. For example, converting coal at the power plant into useable light given off by incandescent lamps is only two percent efficient (National Academy of Sciences, 2008). By simply replacing incandescent bulbs with *compact fluorescents*, a four-fold improvement in efficiency can be achieved. The payback period can be quite short – in this case for compact fluorescent light (CFL) bulbs, less than a year or as little as a month, depending on how may hours each day the CFL is used. However, as with many (but not all) energy-efficiency improvements, consumers need to purchase a more expensive device in order to generate the energy savings. How can reluctant consumers be persuaded to pay more up front to save money in the future when they often do not understand the sometimes complex economic analysis that goes into such a purchasing decision?

Energy-efficiency policy mechanisms are numerous and are implemented at all levels of government from the local jurisdiction and state to the regional and national scale. To make matters more complicated, energy-efficiency measures and incentives can be delivered by a multiplicity of actors and agents, including independent organizations, non-government statewide organizations, fully integrated independently owned utilities, unaffiliated distribution companies, as well as government agencies (Harrington and Murray, 2003). In this report, we use the typology developed by the Committee on Climate Change Science and Technology Integration (2009) to inventory existing policies and to consider alternatives (see Appendix A).

Together, energy efficiency and demand response can delay or completely avoid the need for expensive new generation and transmission investments, thus keeping the future cost of electricity affordable and freeing up energy dollars to be spent on other resources to expand the Region’s economy. A greater share of the dollars invested in energy efficiency goes to local companies that create new jobs compared with conventional electricity resources where much of the money flows out of the Region to equipment manufacturers and fuel suppliers.

1.5.2 Energy-Efficiency Practices in the South

The *Digest of Climate Change and Energy Initiatives in the South* (SSEB, 2009) provides an overview of the climate change and energy policy initiatives currently underway in the South. It catalogues a large number of energy efficiency programs currently operating throughout the region. In summarizing the nature of these initiatives, it concludes the following about the approach of the South:

> "Rather than attempting to craft regional cap and trade programs or mandating specific technologies, Southern states are focusing on incentives for building energy efficiency, fostering a bioeconomy through industry, supporting research and development of clean energy technologies and adopting 'lead by example' policies for state governments." (SSEB, 2009, p. 5)

Other assessment of energy policies have noted that per capita spending on electric utility energy efficiency programs in the Southeast is just one-fifth the national average (Elliott et al., 2003; Elliott and Shipley, 2005). In 2003 and 2005, ten southern states were given a "D" grade for current policies and environment (the lowest grade given to any state). Texas was the only state in the South to receive an "A". For context, of the 48 contiguous states, the grades distributed were: A (12), B (12), C (8), and D (16).

As illustrated in Table 1.4, States in the South are comparable to the nation as a whole in terms of their adoption of 2006 (or more recent) International Energy Conservation Codes for residential and commercial buildings. On the other hand, their adoption of Leadership for Environment and Energy Design (LEED) standards for State buildings is much lower than the national average, as is the market penetration of Energy Star Homes.

In terms of utility policies that support energy efficiency investments, southern States also lag behind the rest of the nation. Only 71% of the States in the South have adopted net metering policies. Net metering allows customers with small generating facilities to use a single meter to measure both power drawn from the grid and power fed back into the grid from on-site generation. This enables customers to receive retail prices for the excess electricity they generate, which can be critical to the economic viability of industrial combined heat and power systems as well as on-site renewable generation.

Only a few States in the South have adopted provisions to decouple profits from sales of either electricity or natural gas, to provide a "level playing field" for energy efficiency. "Decoupling" of utility revenues and profits can be achieved either through periodic and frequent true-ups of projected sales or by other mechanisms that provide utilities with timely cost recovery and earnings opportunities for operating energy-efficiency programs (Brown, et al., 2009). Similarly, only four southern states have undergone active electric utility restructuring, three are part of regional carbon cap and trade programs, and only two have promulgated state appliance or equipment standards that exceed federal requirements.

Table 1.4. Energy Efficiency Policies Implemented by States in the South

Census Division	State	IECC 2006 Building Code or Better		LEED Standard or Equivalent for State Buildings	Market Penetration of Energy Star Homes > 20%	Net Metering State Policy
		Commercial	Residential			
South Atlantic	Delaware					✓
	D.C.	✓	✓			✓
	Florida	✓	✓	✓		✓
	Georgia	✓	✓			✓
	Maryland	✓	✓	✓		✓
	North Carolina	✓	✓			✓
	South Carolina	✓	✓	✓		
	Virginia	✓	✓	✓		✓
	West Virginia					✓
East South Central	Alabama					
	Kentucky	✓	✓	✓	✓	✓
	Mississippi					
	Tennessee					
West South Central	Arkansas					✓
	Louisiana	✓	✓			✓
	Oklahoma			✓	✓	✓
	Texas				✓	
South Total		9/17	9/17	6/17	3/17	12/17
U.S. Total		29/51	27/51	24/51	13/51	44/51

Table 1.4. Energy Efficiency Policies Implemented by States in the South (cont.)

Census Division	State	Decoupling		Active Electricity Restructuring by State	Regional Carbon Cap and Trade	Appliance and Equipment Standards
		Natural Gas	Electricity			
South Atlantic	Delaware		✓	✓	✓	
	D.C.			✓	✓	✓
	Florida					
	Georgia					
	Maryland	✓	✓	✓	✓	✓
	North Carolina	✓				
	South Carolina					
	Virginia	✓				
	West Virginia					
East South Central	Alabama					
	Kentucky					
	Mississippi					
	Tennessee					
West South Central	Arkansas	✓				
	Louisiana					
	Oklahoma					
	Texas			✓		
South Total		4/17	2/17	4/17	3/17	2/17
U.S. Total		18/51	6/51	15/51	33/51	13/51

Sales data suggest a low market penetration of energy-efficiency products in the South. For Energy Star appliances with sales data that are tracked by EPA, the South has the lowest rates of market penetration (McNary, 2009). This purchase behavior is undoubtedly a function of the historically low electricity rates that the South has enjoyed. It would also appear to reflect a relatively weak energy conservation ethic. Evidence of this is provided by the results of a poll conducted in January 2009 by Public Agenda.

The poll suggests that Americans are divided geographically in terms of their views on energy conservation and regulating energy use and prices versus exploring, mining, drilling and construction of new power plants. Yuliya Chernova, a reporter in New York for Clean Technology Insight, a Dow Jones & Co. newsletter, notes that conservation is supported by a large majority nationwide, however, it is close to even with exploration and drilling in the South, 48% to 45%, (Figure 1.6).

Conserve or Drill?

Americans are somewhat divided by region on whether U.S. energy policy should favor conserving and regulating energy use or exploration, drilling and construction of new power plants, according to a January 2009 poll by Public Agenda, though conservation was supported by a large majority.

Expanding exploration, mining and drilling, and the construction of new power plants

Northeast	35%
Midwest	30
South	45
West	31
Nationwide Total	37

More energy conservation and regulation on energy use and prices

Northeast	57%
Midwest	62
South	48
West	60
Nationwide Total	56

Figure 1.6 Public Agenda Poll
(Chernova, 2009)

On the other hand, utilities in the South have embraced demand-side management as a means of reducing the peak power requirements of their largest customers. According to Goldman (2006), there were 2,700 commercial and industrial customers enrolled in TOU programs in 2003, representing 11,000 MW. Three utility programs in the Southeast (TVA, Duke Power, and Georgia Power) account for 80% of these participants, and they primarily engage large energy users.

1.5.3 Previous Estimates of Energy-Efficiency Potential in the South

Many studies have examined the potential for deploying greater energy efficiency in the South. Nineteen of these were recently examined in a "meta-review" by Chandler and Brown (2009). These studies contain more than 250 estimates of the energy efficiency potential for different fuels (electricity, natural gas, and other fuels), sectors of the economy (residential buildings, commercial buildings, and industry), and types of potential (technical, economic, maximum achievable, and moderate achievable).

The meta-review concludes that a reservoir of cost-effective energy savings exists in the South. The full deployment of these nearly pollution-free opportunities could largely offset the growth in energy consumption forecast for the region over the next decade. Such deployment would reduce capacity-related costs associated with the expansion of electricity and natural gas infrastructure and supply. The full deployment of energy-efficient technologies could bring energy consumption in 2020 down 9 percent below projected levels, which would bring future consumption to slightly less than present levels, as shown in Figure 1.7. This would entirely offset the need to expand electricity generation capacity in the South through the year 2020.

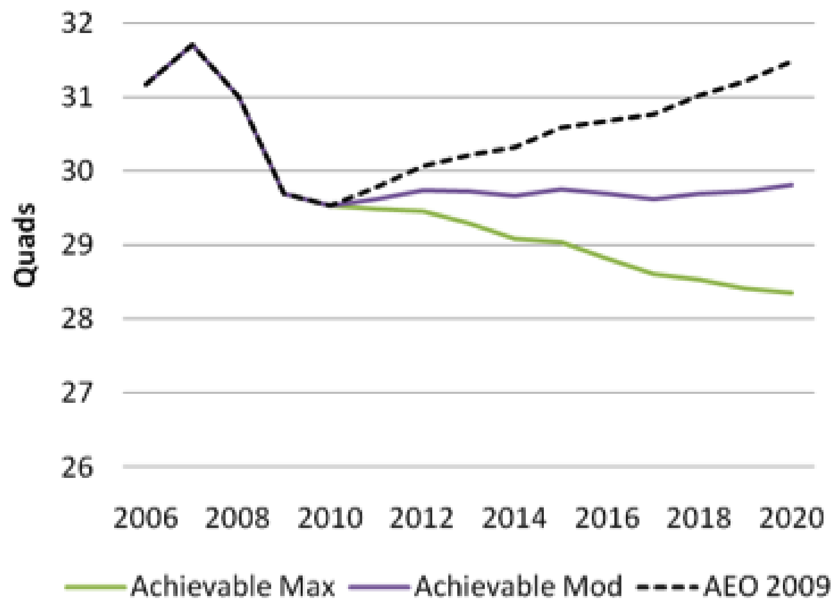

Figure 1.7 Achievable Energy Efficiency Potential in the South: Results of a "Meta Review"
(Chandler and Brown, 2009)

By "full deployment" the report means the maximum achievable energy efficiency potential that is also cost-effective. The meta-review concludes that the South has the technical potential to reduce its energy consumption over the next decade by 2 percent per year, but some of this potential is not cost-effective at current energy prices. The region has the economic potential to reduce its energy consumption by 1.5 percent per year, but some of this potential is not achievable with feasible policy interventions. With vigorous policies, it is possible to reduce energy consumption in the South by 1 percent per year, which would more than eliminate the projected growth in energy demand in the region. "Maximum achievable potential" refers to the economic energy savings potential that can be achieved with such public policies.

More recently, McKinsey Global Energy and Markets (2009) published an assessment of economic potential for energy efficiency improvements in the RCI sectors of the U.S. Specifically, it focused on the opportunities that are "net-present-value positive" and therefore should be considered to be economically attractive. Their estimates do not discount economic potentials to reflect the difficulty of realizing these opportunities through policy or other interventions.

The McKinsey study concluded that the South has the largest energy efficiency resource of any region of the country (see Figure 1.8). In combination, the Southeast and Southwest account for 41% of the national potential for economic energy efficiency improvements. Almost half of this demand-side resource is estimated to be available in the electricity sector, and the commercial sector has the potential to reduce its consumption by more than any other sector on a percentage basis, with a savings opportunity of 29% by 2020.

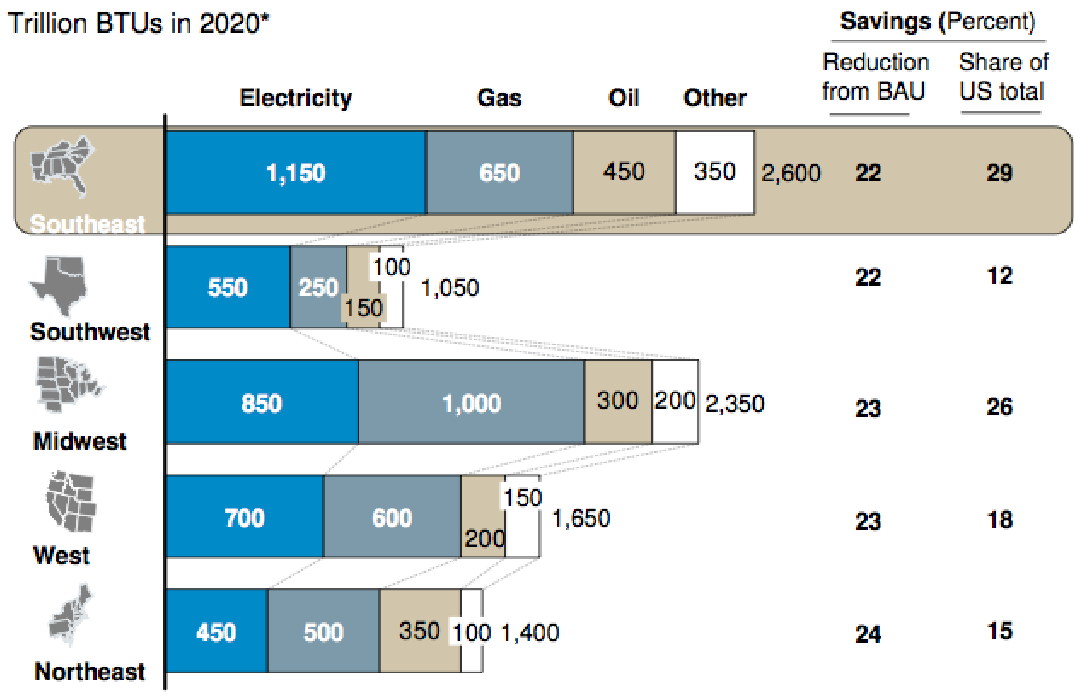

Figure 1.8 Energy Efficiency Opportunities by Region of the U.S.
(Ostrowski, 2009)

In sum, a large body of evidence suggests that the South's energy- and carbon-intensive lifestyles could be made more efficient and affordable through the judicious investment in technologies currently available in the marketplace. Other regions of the country have motivated such investments with strong policy initiatives. Our report looks at the public policies that could transform markets for energy efficiency in the South.

2. METHODOLOGY

Many different approaches have been used to assess the potential for improved energy efficiency in the United States. They are often classified as either "bottom-up" or "top-down."[9] We use a hybrid approach that combines the strengths of both. Specifically, by using a version of the National Energy Modeling System (a multi-regional general equilibrium model) supplemented by spreadsheet analysis our approach produces technologically explicit and behaviorally realistic results typical of a "bottom-up" approach. By evaluating these technology and behavioral effects including the Global Insight macroeconomic module, we are able to account for the economy-wide macroeconomic feedback effects, which are the strength of "top-down" approaches.

This chapter provides an overview of the methodology we developed to estimate cost-effective and achievable energy-efficiency improvements in the South. The general approach and methodology is summarized in a flow chart showing eight interrelated steps (see Figure 2.1). The policy-specific methodologies are summarized in each chapter and detailed in Appendices B through E. We do not examine the transportation sector.

The first step involves identifying a set of policies that could effectively transform markets for energy efficiency in residential and commercial buildings and industry – the RCI sectors (box 1).[10] The Energy Efficiency Policies were then evaluated based on the published literature and spreadsheet analysis (box 2). Simultaneously, we considered how to model these policies in SNUG-NEMS[11] (box 3). Testing and modeling these policies in SNUG-NEMS was an iterative process. Often a preliminary policy design was fine-tuned as results were evaluated (box 4). For example, modeling the extension of tax incentives for industrial CHP systems was found to have only a minor impact in the absence of expanded R&D to deliver superior technologies over the 20-year period; as a result, the fiscal policy was enhanced with an increased R&D effort. Eventually when the modeling of individual policies delivered the types of effects consistent with the literature, SNUG-NEMS (including Global Insight's macro-economic module to ensure system-side adjustments) used to calculate changes in energy consumption and rates, capacity and generation, as well as utility bills (box 5).

The resulting indicators were then used to perform three different analyses. First, economic analysis using total resource cost test, for each of the policies (box 6). Second, results were transformed into state level values so that our key results could be presented at a level of geographic granularity that exceeds the NEMS outputs. GRP impacts were estimated with the

[9] Supply curves of energy savings and carbon mitigation opportunities are an example of a bottom up approach. They provide a means of identifying least-cost technology investments (McKinsey, 2009); however, they do not fully account for cross-sector influences and price feedback effects. "Top-down" approaches use macroeconomic models to identify the response of markets to changes in energy prices. They typically do not offer the degree of technology specificity needed to understand how markets are responding.

[10] These policies are implemented in the same manner for both the Reference Scenario forecast that does not assume the creation of a price on greenhouse gases, and for a Carbon-Constrained Future scenario forecast that assumes the promulgation of a generic carbon cap and trade or another carbon constrained system. The specifics of the CCF scenario are described in Section 2.5.

[11] SNUG-NEMS is Southeast NEMS User Group, a version of EIA's NEMS, described in Section 2.2.

ACEEE calculator tool (box 7). Regional results are provided in the main report, while state level results can be found in Appendix G. Third, an off-line spreadsheet was developed to analyze the SNUG-NEMS output on electricity plants in the South to estimate the impact of the Energy-Efficiency Policy Scenario on water consumption (box 8).

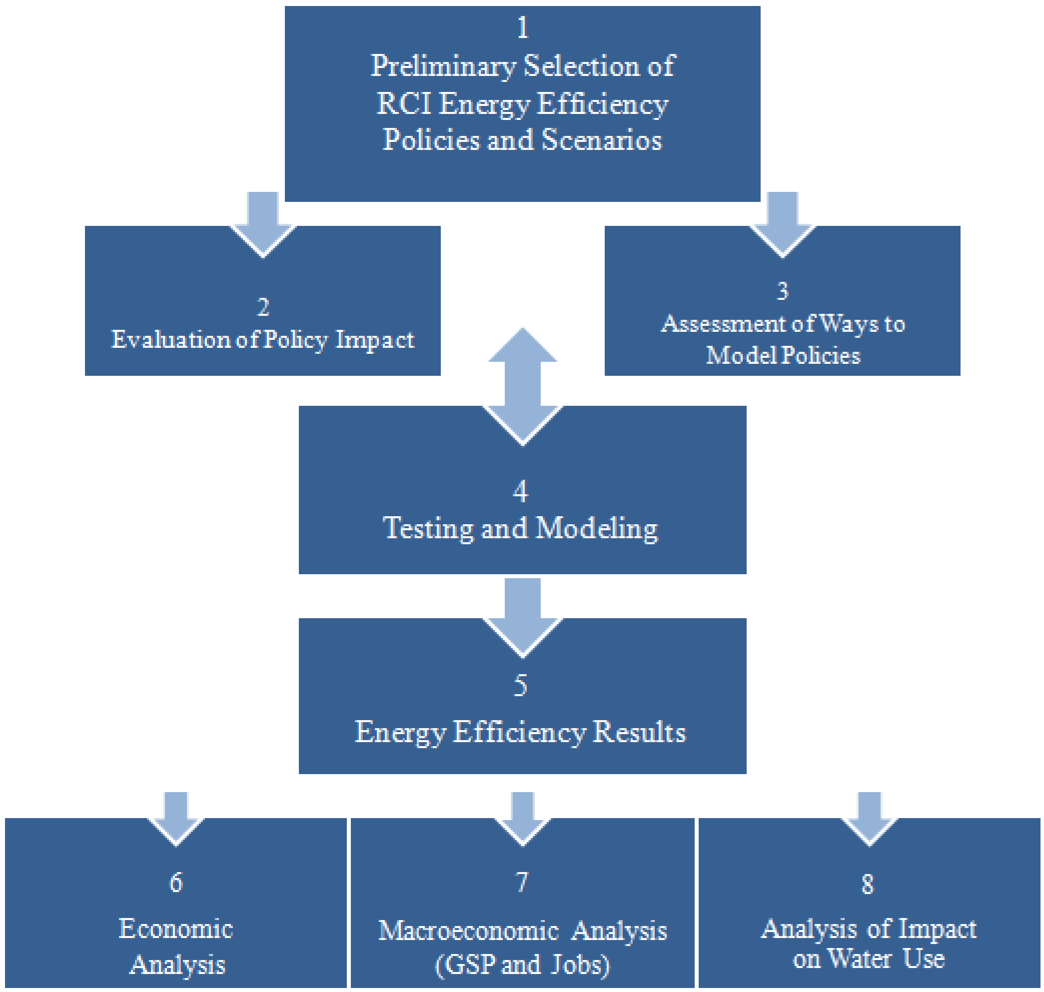

Figure 2.1 Flow Diagram of Study's Methodology

The advantage of using an integrated energy model for this type of analysis, one that evaluates a range of policy options both separately and together, is that such a model captures a wide array of associated costs, benefits, and interactive effects, as well as robust feedback. An integrated model can capture second order effects, price interactions (unlike spreadsheet models or supply curves), the impacts of regional actions on individual states, and non-participant economic effects. In additional, sensitivity analysis requires fewer assumptions, and layering policies one on top of another is relatively easy.

2.1 PORTFOLIO OF ENERGY-EFFICIENCY POLICIES

Hundreds of policies have been promulgated by local, state and federal agencies to promote the more efficient use of energy in the United States. According to a recent DOE inventory, approximately 125 Federal policies, programs, and measures are currently in place to encourage more efficient use of energy in buildings, and 72 federal policies and measures promote more efficient use of energy in industry (CCCSTI, 2009; see Appendix A). An even larger array of policies has been implemented by state and local agencies. For example, more than 200 policies promote energy efficiency in the 13 states that comprises Appalachia (Brown, et al., 2009): 91 percent of them operate at the state level and 9 percent are local policies. These policies differ widely in scope, intent, and level of support, and the evidence of their effectiveness is highly uneven. Because of the large commitment of resources, many Federal policies have been extensively evaluated, providing a basis for judging whether or not further investment might be justified.

Energy policies can be organized into 12 distinct categories as described by Geller (2002), ranging from capacity building, market reforms, and procurement policies to pricing, financial incentives, regulations, and information dissemination and training. Based on a review of the literature, we selected a portfolio of nine aggressive energy policies to begin to assess the magnitude of cost-effective, energy-efficiency improvements in the South. These policies are assumed to be adopted throughout the South beginning in 2010. They include a combination of federal and state energy codes and standards, financial incentives to reduce up-front technology costs, and R&D expenditures that improve the performance and reduce the cost of energy-efficient technologies.

Table 2.1 lists the portfolio of nine policies by sector. Our goal was to identify a set of policies that address many of the largest barriers to energy efficiency investments in the South. In some cases, the policies involve expanding current programs that are seen to have significant potential for greater impact (e.g., the low-income weatherization program and industrial energy assessments). In other cases, existing policy interventions are strengthened as with building energy codes and appliance standards. These policies are made more effective by the presumption of greater enforcement and the availability of improved technologies made possible by expanded public-private R&D partnerships. The nine policies modeled in this study are not comprehensive; additional policies could be layered on top of this portfolio in order to expand the energy efficiency improvements. Each of the three sector chapters describes some of the policies that could enhance our portfolio. The existence of multiple policy options illustrates the robustness of our study. Rather than proscribing specific policies that are to be administered by specific agencies, we emphasize that the efficiency improvements modeled here could be brought about by many different policy interventions. The nine policies listed in Table 2.1 provide the structure for modeling impacts, but in fact many policies could be implemented with a similar result. The sector assessments (Chapters 3-5) describe these policies in more detail.

Table 2.1 Portfolio of Energy-Efficiency Policies		
Residential Buildings	**Commercial Buildings**	**Industry**
Appliance Incentives and Standards	Aggressive Commercial Appliance Standards	Process Improvement Policy
Residential Retrofit and Equipment Standards	Commercial Retrofit Incentives	Assessments of Plant Utility Upgrades
Expanded Weatherization Assistance Program		Combined Heat and Power Incentives
Building Codes with Third-Party Verification		

2.2 NATIONAL ENERGY MODELING SYSTEM (NEMS)

NEMS models U.S. energy markets and is the principal modeling tool used by EIA and DOE. It consists of four supply-side modules, four demand-side modules, two conversion modules, two exogenous modules, and one integrating module (Figure 2.2). NEMS is one of the most credible national modeling systems used to forecast the impacts of energy, economic, and environmental policies on the supply and demand of energy sources and end-use sectors. Its “reference case” forecasts are based on federal, state, and local laws and regulations in affect at the time of the prediction. The baseline projections developed by NEMS are published annually in *the Annual Energy Outlook*, which is regarded as a reliable reference in the field of energy and climate policy. It is also widely utilized to conduct the sensitivity analyses of alternative energy policies and to validate research findings conducted by other government agencies including the Environmental Protection Agency, Lawrence Berkeley National Laboratory, Oak Ridge National Laboratory, and the Pacific Northwest National Laboratory.

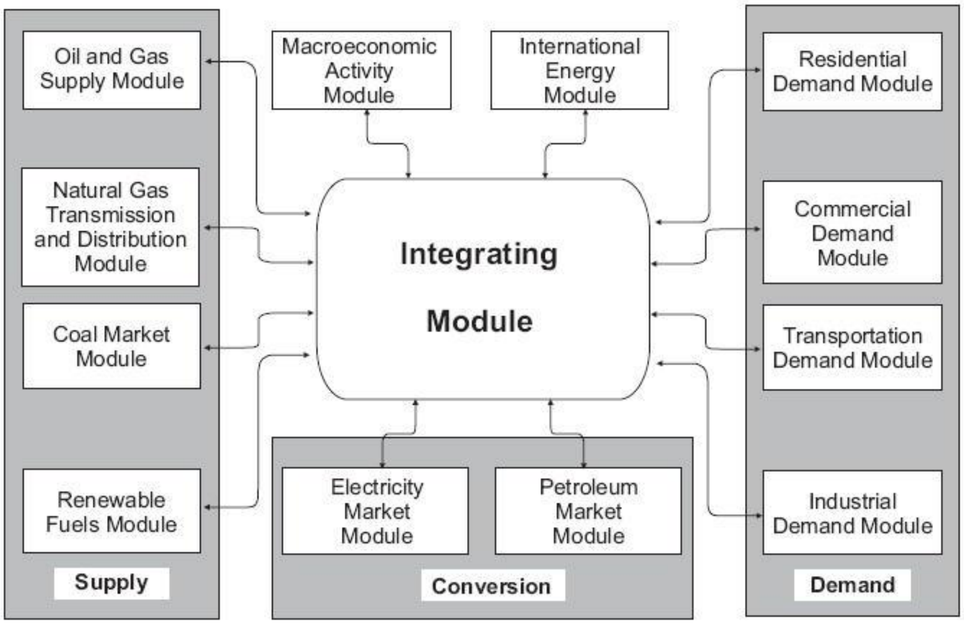

Figure 2.2 National Energy Modeling System (NEMS)
(EIA, 2008)

The version of NEMS used for this modeling is SNUG-NEMS, which is short for Southeast NEMS Users Group. Duke and Georgia Tech have calibrated SNUG-NEMS to the stimulus release of NEMS, in March 2009. Any references to "NEMS" in this report indicate generic attributes of EIA's model. The distinction of SNUG-NEMS is that while it uses all the same initial data as NEMS, SNUG-NEMS incorporates changes specified for this study and does not run on EIA's system.

2.2.1 The Baseline Forecast

The starting point, or baseline, for any analysis that is measuring avoided energy consumption or avoided expenses in the future, i.e. something that does not happen that otherwise might have, is critical to the results. Our baseline forecast (henceforth called Reference Scenario) of energy consumption for the South, its three Census Divisions, the 16 individual states and the District of Columbia are derived for this study from the updated *Annual Energy Outlook 2009 (AEO2009)*[12] reference projections. This Reference Scenario forecast takes into account the Economic Stimulus Package 2009 (EIA, 2009a).

EIA's *Annual Energy Outlook 2009* provides energy consumption for the nation, its four census regions, and its nine census divisions, including the three that are in the South (South Atlantic, East South Central, and West South Central). Energy production projections are provided by

[12] The AEO 2009 was released three times. The final version, the "updated AEO 2009" is the one that will be discussed as the basis for the Baseline Scenario throughout this document.

NERC region. The difference between NERC regions and census divisions is illustrated in Figure 2.3. The lines represent census divisions and the colors the NERC regions.

This Reference Scenario portrays the South in 2030, much as it is today. It assumes that over the next 20 years, the nation remains uncommitted to climate policy, and coal continues to be an economically competitive energy resource. As such, energy efficiency is expected to carry the external benefits of reduced greenhouse gas emissions and improved energy security. Many energy-efficiency investments are more cost-effective than many supply-side options, but numerous barriers including the policy environment often hinder energy-efficiency investments (Prindle, 2007; Brown and Chandler, 2008).

Figure 2.3 Overlapping Census and NERC Regions
(Fritze, 2009)

Because the *AEO* 2009 includes several strong efficiency policies promulgated in the Energy Independence and Security Act of 2007 (EISA, 2007) and the American Recovery and Reinvestment Act of 2009 (ARRA, 2009), it includes more "naturally occurring energy-efficiency improvement" than was forecast in the *AEO* 2007. In addition, the *AEO* 2009 uses higher energy prices and a slower GDP growth rate.

2.3 DEFINITION OF PROGRAM ACHIEVABLE POTENTIAL

When evaluating the potential for any energy alternative to be deployed in future years, several types of estimates are generally used (Rufo and Coito, 2002; NYSERDA, 2003; Eldridge, Elliott, Neubauer, 2008). *Technical potential* refers to the complete penetration of all energy-efficient applications that are technologically feasible, regardless of economic cost-effectiveness. We do not quantify this potential because it would involve assessing many other policies and some that are not cost-competitive. *Economic potential* is defined as that portion of the technical potential that is judged cost-effective. While this is a useful way to frame the current potential, it includes investments that will not occur because decision-makers cannot be assumed to make optimal decisions every time a technology or practice is selected. *Program achievable potential* is defined as the amount of cost-effective (economic) potential that would occur in response to specific policies such as subsidies and information dissemination. It recognizes that the full economic potential is difficult to achieve, but that effective policies and programs can cause much of the cost-effective potential to be realized. As such, program achievable potential is the focus of our analysis. Of course, the program achievable potential identified in this study is not a maximum program achievable, as time and modeling constraints kept us from evaluating a wider range of cost-effect policies.

2.3.1 Cost-Effectiveness Tests

A number of economic approaches have been used to measure the cost-effectiveness of energy efficiency investments. The most common approaches look at different actors and their perspective of cost-effectiveness: only program participants, only utilities, society as a whole, and more narrowly regional utility and customers (NAPEE, 2007b).

We focus on the total resource cost (TRC) test to evaluate the cost-effectiveness of each of the modeled energy policies. Originally developed to evaluate utility demand-side management programs (OTA, 1993), the TRC test concludes that a policy or program is considered cost-effective if the net present value of benefits is greater than the net present value of costs. It is a measure of the total net benefits of a program from the point of view of the utility and its ratepayers as a whole. In sum, a policy or program is cost-effective if it does not increase the total costs of meeting the customers' service needs. A seven percent discount rate is used with the total resource cost test (Office of Management and Budget's Circular No. A-94 p. 8).

According to NAPEE (2007b) the total resource cost test includes the following potential benefits: avoided supply costs (production, transmission, and distribution) based on net energy and load reductions, as well as other benefits that do not affect a utility such as fuel oil savings and water savings. Energy efficiency costs include program administration costs and net participant costs.

Numerous types of co-benefits tend to be excluded from TRC tests, such as improved comfort and safety, reduced operation and maintenance costs, increased worker productivity, higher resale value associated with energy-efficient building upgrades, greenhouse gas emission reductions, and improved air quality. These benefits are often difficult to monetize. For example, no consensus exists today to place a value on avoiding the emission of a ton of carbon dioxide (Tol, 2005). Numerous co-costs also tend to be excluded because they, too, tend to be difficult to monetize, such as aesthetic issues (e.g., associated with compact fluorescent bulbs) and increased maintenance costs due to unfamiliarity with new energy-efficient equipment.

The reason that the TRC test is well matched for SNUG-NEMS is the same reason that another approach, the participant cost test, is less so. SNUG-NEMS integrates the effects of the policies throughout the modeling, so it captures benefits and costs to all customers. To separately calculate the investments and benefits solely to participants is more difficult.

2.3.2 Measuring Energy Savings: Delivered and Primary

Resolving which energy is to be measured when determining potential energy savings is a non-trivial point. After all, energy is required to extract, process, and bring an end user consumable energy. The energy required to produce a unit of fuel or electricity for consumption by an "end-user" can be large relative to the energy contained in the "delivered" unit of fuel or electricity. Energy is required to mine coal and drill for petroleum; energy is used to create the compressed air that drives natural gas pipelines; fuels are used to propel the trains and barges that ship coal; and energy is lost in the transmission of electricity from the power plant to the consumer. Energy is also embodied in the power plants, trucks, trains, and other equipment that comprises the energy production and delivery supply chain. As a result, various "adders" have been created to augment the energy contained in the delivered fuel or electricity to account for the full life cycle of energy consumed. As explained below, we use an electricity adder in this study, but we do not use adders for other fuels.

In the case of electricity, we assume that 2.159 million Btu are lost in the electric generation, transmission and distribution steps that deliver 1 million Btu to the consumer in the form of delivered energy. That is, 68% of the energy embodied in the fuel used to generate electricity in the United States in 2007 is lost principally in the form of waste heat (EIA, 2009c, Table A2). These electricity-related losses do not include the energy required to mine the coal or the energy embodied in the various supply chain equipment. However, this adder of 2.159 is a typical factor used to more completely account for the energy saved when less energy is used by the consumer. This adder is also justifiable because most electricity-related losses from electricity consumption in the South occur within the South.

2.4 RESULTS

The four scenarios used for the integrated analysis include the following:

- **Reference Scenario:** The baseline forecast consistent with EIA's stimulus data setup.
- **Energy-Efficiency Policies Scenario:** Built on top of Reference Scenario data including all changes described in Chapters 3 through 5 for the nine energy efficiency policies.
- **Carbon-Constrained Future (CCF):** Sensitivity of the Reference Scenario. Adding a carbon price as noted above to $15 per ton in 2012 growing annually at 7%. Allowances are redistributed to load serving entities as described above, and there are no carbon offsets.

- **All Energy-Efficiency Policies and a Carbon Constraint:** This sensitivity layers all of the energy efficiency policies on top of the CCF scenario.

The SNUG-NEMS analysis of the Energy Efficiency Policies looked at the policies from multiple directions. Policies were evaluated one at a time, together within a sector as well as all nine policies together. The major results were estimates of reductions in energy consumption by sector (aka, energy savings), change in electricity and natural gas rates, energy efficiency, change in electricity generation and new capacity, as well as energy bill changes. Decreased water demand was evaluated in a spreadsheet, while jobs and gross regional product (macro-economic indicators) are captured by the DEEPER model.

For the purposes of this study, energy savings is avoided energy consumption in the future due to program achievable potential from efficiency policies. Energy efficiency refers to the percent reduction of one future year's projected energy consumption represented by the energy savings in that year, as a result of the program potential. Energy bill savings is a measure of reduced expenditures associated with energy as a result of efficiency policies and any second order effects. Changes in future generation and capacity needs due to the policy bundle are reported by NERC region as NEMS evaluates electricity supply and dispatch as such, while demand is grouped by census regions (the mapping of census and NERC regions is shown above in Figure 2.3).

As there is no direct mapping of supply and demand regions. Southern totals will have a bit of uncertainty. Three NERC regions are almost entirely within the Southern census regions, while two others contain large chunks of Southern states.[13]

2.5 SENSITIVITY ANALYSIS CASE: CARBON CONSTRAINED FUTURE

The integrated analysis involved combining the residential, commercial, and industrial energy efficiency policies into one is known as the "Energy-Efficiency Policies" Scenario.
This full policy analysis, is done twice starting at two different points. The Reference Scenario is the obvious starting point, while the sensitivity case is a future with a carbon constraint (the "Carbon-Constrained Future" or CCF Scenario). Based on current political concerns it seems prudent to evaluate whether the Energy Efficiency Policies hold up better, worse or similarly in the event that a price will be placed on greenhouse gas emissions over the next 20 years.

We approximate the impact of a carbon constraint by adjusting several parameters in SNUG-NEMS. First, after examining the allowance price projections estimated by the Energy Information Administration (EIA), Congressional Budget Office (CBO), Environmental Protection Agency (EPA), and Natural Resource Defense Council (NRDC), we set a carbon

[13] Some details of NERC regions mapping to census regions as per Figure 2.3: FERC is part of South Atlantic, ERCOT is part of WSC region, and SERC other than a piece of Missouri is a piece of all three Southern census regions. Parts of SPP, including all of Oklahoma overlap with WSC and SA, while ECAR, particularly all of Kentucky and West Virginia are within ESC and SA respectively. MAAC encompasses the tip of SA.

price starting at $15 per ton of carbon dioxide (2005 dollars) in 2012, growing at 7% annually, and reaching $51 per ton in 2030. We also implemented an allowance redistribution system that gives 34% of allowances to local distribution companies (LDCs) starting in 2013, this share smoothly decreases to 26% until 2026. From 2027 on, this share drops by 5% annually. In 2030, which is the last year of our study horizon, the allowances allocated to LDCs are 5%.[14] The allowances given to the LDC are assumed to be passed through to consumers and subdue the increase in retail electricity prices. Table B.1 in Appendix B gives the annual share of allowances that are given to LDC.

We do not model the impact of carbon offsets, but if they were to be included, the cost of the CCF Scenario would be lower. The CCF Scenario did not include any modifications to the nine policies, while more aggressive policies might be expected we wanted to compare the same exact policies under two scenarios. Therefore, we must note that this CCF sensitivity measures the modeling effect of combining efficiency with a carbon constraint, but does not capture increased investment or public interest in efficiency measures that would likely accompany a mandated constraint on carbon emissions. This report avoids jumping into the complicated design of a carbon constraint, including such issues as alternative systems for distributing carbon allowances, and the role of domestic and international offsets.

2.6 ESTIMATING GRP AND EMPLOYMENT IMPACTS

To calculate the impact of our policy scenarios on the Gross Regional Product (GRP) in the South, we used the 2008 impact coefficients for the South Census Region and for individual States and the District of Columbia, derived from the Minnesota IMPLAN Group.

For estimating employment impacts of the residential, commercial and industrial policies outlined in this report, we used three different published methodologies:

- The American Council for an Energy-Efficient Economy Input-Output Calculator.
- A study of the Center for American Progress (Pollin *et. al.*, 2008).
- A multiplier used to estimate the job impacts of programs of the American Recovery Reinvestment Act – including Weatherization, the State Energy Program and other efficiency efforts (Council of Economic Advisors, 2009).

Additional methodological details are provided in Chapter 6 and Appendix F.

2.7 CALCULATING WATER CONSERVATION FROM ENERGY EFFICIENCY

Using the energy-efficiency potential outlined in this study, we project the decrease in freshwater consumption for the cooling of conventional and nuclear thermoelectric power-plants in three NERC regions: SERC (Southeast), FRCC (Florida) and TRE (Texas). A few other NERC

[14] This allowance allocation was suggested by EIA and is similar to their approach for current legislative analyses.

regions include fractions of the South (as shown in Figure 2.3 above), but we chose to focus on these three which are almost exclusively within the South. Using data from the Electric Power Research Institute, we estimate average water consumption in gallons per megawatt hour based on plant and cooling system type (see Chapter 6 and Appendix F for further details).

One assumption made is that half of current plants in use would have once-through cooling systems, but that all potential new generation would use recirculating (close-loop) systems due to permitting restrictions on open-loop systems. These assumptions are consistent with NETL and EIA data. Finally, we assumed that the ratio of freshwater to saltwater from power-plant cooling would remain consistent in each of the NERC regions (See Table B.2 for USGS data on the current freshwater and saltwater percentages).

2.8 METHOD FOR DERIVING STATE-SPECIFIC ESTIMATES

For Appendix G, a "proportioning" methodology was used to produce "business as usual" baseline forecasts for the 16 individual states and the District of Columbia, which comprise the Census-defined South. The forecasts are derived from the third version of *Annual Energy Outlook 2009 (AEO2009)* reference projections, which takes into account the Economic Stimulus Package 2009 (EIA, 2009a). The methodology is based on the approach used by Stan Hadley in his study of the energy efficiency and renewable energy potential in North Carolina (Hadley, 2003).

EIA's *Annual Energy Outlook 2009* provides energy consumption and production projections for the nation, its four census regions, and its nine census divisions, including the three that are in the South (West South Central, and East South Central, and South Atlantic). To create state estimates, we combine the values for all states in each census division and calculate the share of each state to the total. In addition to the method, we adjust the state specific proportions, considering the variation and difference in population growth rates across the states.

The Southern Energy Efficiency Center (SEEC) has developed measurement and verification protocols to estimate the energy consumption of individual states. According to that study, the energy use per capita of each southern state in each sector has been relatively constant over the last decade. The SEEC study supports our assumption that the energy use by state increases proportionally to the population growth.

The methodology used here involves four steps:

- First, we calculated the Normalized Energy Use per Capita (NEUC) from 2004 to 2006 with the historical energy consumption and population by state from the EIA's State Energy Data System (SEDS) (EIA, 2009e).
- Second, we approximated the energy use by state with the fixed NEUC and population projections from the U.S. Census Bureau.
- Then, we derived the annual share of each state to the total division.
- Finally, using the state specific percentages, we allocated out the regional AEO projections to each state.

3. ENERGY EFFICIENCY IN RESIDENTIAL BUILDINGS

3.1 INTRODUCTION TO THE RESIDENTIAL BUILDINGS IN THE SOUTH

In 2007, the total residential consumption in the South Census Region was 8.52 quadrillion Btu. This represented 19.5% of the total energy consumption in the region. Nationally, the residential sector was 21.3% of total energy consumption. Due to the South's heavy industrial energy consumption, the residential sector represents less of the total South's energy consumption than that of the nation (EIA, 2009a; Table S1). Though the residential sector is a smaller fraction of the total energy consumed, per capita residential energy consumption is higher than the national average. In 2007, the South had an estimated 36.6% of the nation's population while its residential sector consumption was 39.5% of all U.S. residential consumption (EIA, 2009a; Census, 2009a). This higher energy consumption points to a greater potential for residential energy efficiency in the South than the rest of the nation.

The South's residential sector relies more on electricity than the national average. Retail electricity sales composed 27% of residential consumption in the South compared to 22% nationally (EIA, 2009b; Table S4). Since electricity generation in the South is more reliant on coal, natural gas, and petroleum than the nation (EIA, 2009c; Table S8), the electricity consumed in the South is more carbon intensive and is associated with higher electrical system losses. Figure 3.1 compares residential fuel consumption between the South and the United States.

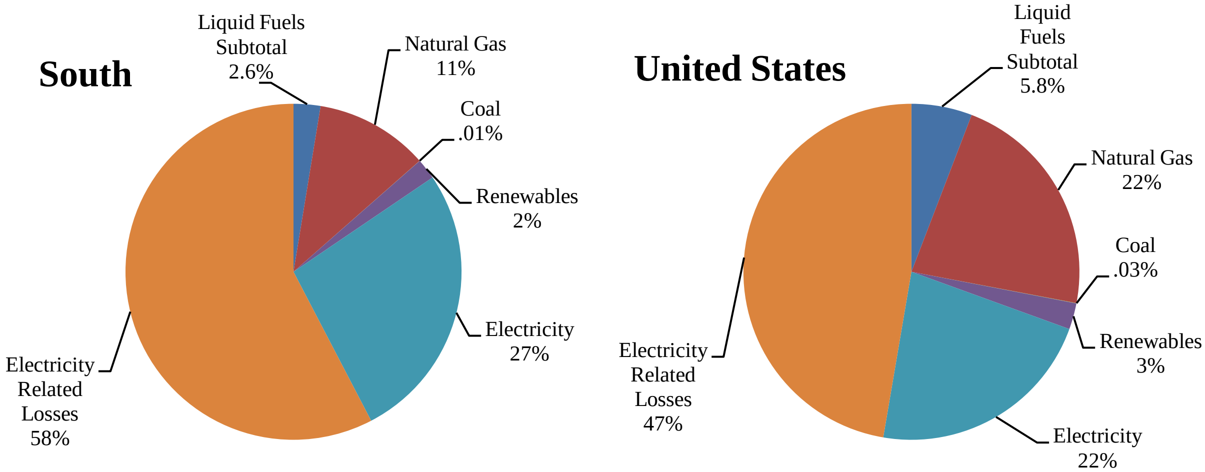

Figure 3.1 Residential Sector Consumption in the South and US, 2007 (EIA, 2009b)

The historical and projected energy consumption by the South's residential sector is shown in Figure 3.2. Historical consumption is shown from 1960 to 2007 (EIA, 2009d). The projected consumption is shown from 2007 to 2030 and is expected to increase 18% from 2010 to 2030 (EIA, 2009).

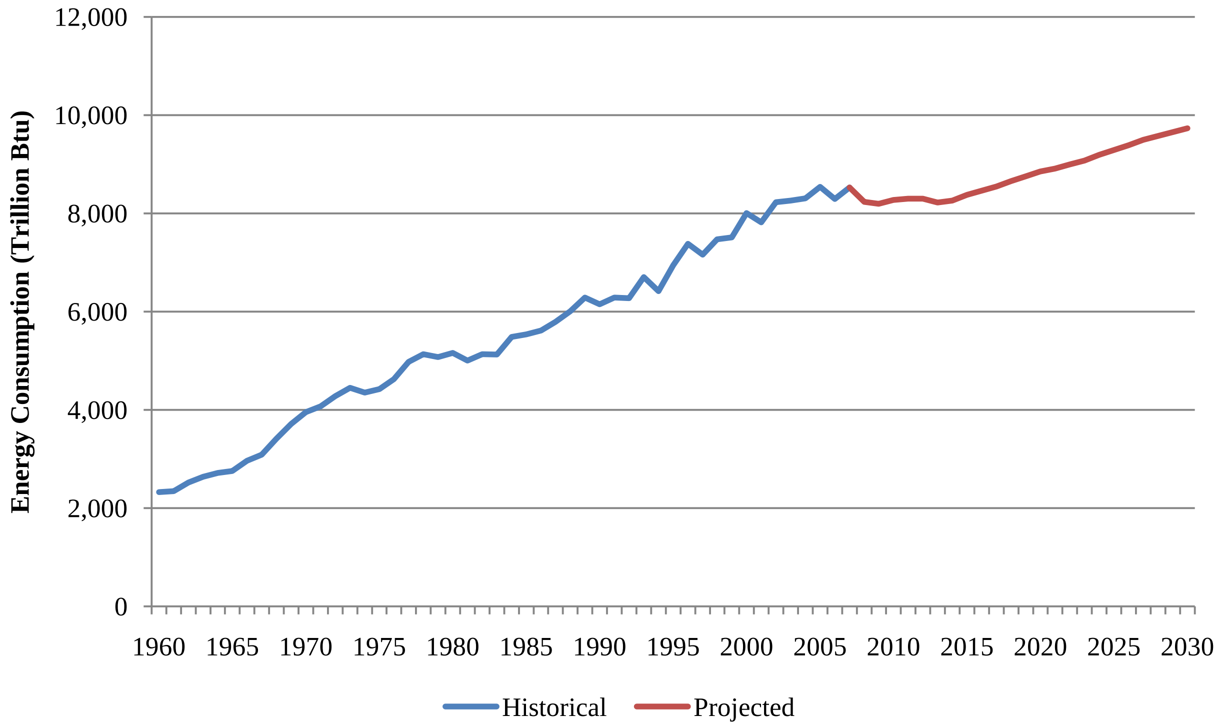

Figure 3.2 Southern Residential Sector Historical and Projected Energy Consumption (EIA, 2009; EIA, 2009d)

The South has the newest stock of housing in comparison to the rest of the nation. In 2005, 32% of Southern homes had been constructed in or after 1990. In the Northeast, Midwest, and West Census Divisions, the newest homes composed 12%, 23%, and 21% of the stock respectively (US DOE, 2009c). In 2007, over 51% of new homes built in the U.S. were also located in the South (US DOE, 2009a; Table 2.2.7). While new buildings may be more efficient than older ones, the type of homes built should also be examined.

3.2 BARRIERS TO RESIDENTIAL ENERGY EFICIENCY AND POLICY OPTIONS

3.2.1 Barriers to Energy-Efficient Homes in the South

Energy efficiency retrofits of older homes and improved home construction practices are often seen as two of the most cost-effective strategies for cutting energy costs and curbing carbon emissions (McKinsey & Company, 2009, p. xii). However, numerous market failures and barriers impede investments in these opportunities.

The ***large, diverse, and fragmented*** nature of the buildings industry is the source of some of these barriers. The numerous participants in the decision-making process have distinct interests, they impact the process at different points in design, construction and use, and they often act as decision-making intermediaries who do not represent the long-term interests of building owners and occupants (CCCSTI, 2009; Brown et al., 2009a). The involvement of intermediaries in the purchase of energy technologies leads to an under-emphasis on life-cycle costs. As a result, homeowners cannot see beyond the ***relatively high initial costs*** of energy-efficient appliances and building construction practices. Similarly, many builders adopt green building practices because they do not know if higher up-front expenditures will translate into increased sale values.

Information barriers occur when decision-makers do not possess enough usable information to make investments that are in their own best interest. Consumers have been found to be largely unaware of the relationships between their lifestyles, energy consumption, and the environment (Garrett and Koontz, 2008). Behavioral-related studies have shown that individuals do not know how much energy appliances or their homes use, do not know where energy comes from, assume new appliances are efficient, do not consider energy when they make purchasing decisions, and focus on up-front costs (Lutzenhiser, 2009; DEFRA, 2007; McKeown, 2007). Sometimes information barriers are compounded by a ***lack of trusted, actionable information*****.** While a bounty of facts and data is available to consumers, the information is often presented in terms that are not specific enough to the consumer to be useful or to drive change.

Outdated building codes and appliance standards represent ***regulatory barriers*** to energy-efficient residential buildings. For example, seven states in the South either do not have statewide residential building codes, or have outdated codes from 2003 or earlier. Building standards can also be distortionary, in spite of their numerous positive influences. Because codes and standards take a long time to adopt and modify, the best performing materials and technologies are not readily deployed, thereby inhibiting innovation and encouraging obsolete technology (Brown, et al., 2009a).

Even when states surpass older building codes, their ***code compliance is often limited***. The continuous updating of existing codes, adoption of new codes, and expansion of code programs to improve compliance and achieve real energy and financial savings appear to be difficult for many states because they lack consistent code enforcement and support programs (Yang, 2005; Zing Communications, 2007, p.23). Building code compliance is difficult to determine, especially given performance-based standards, where information is not readily available and determination of measures require unavailable resources that many times may be prohibitively expensive (Smith and McCullough, 2001; Yang, 2005).

3.2.2 Policy Options

To address these barriers and to support energy efficiency in the residential sector, this study models four policy packages: residential building energy codes with third party verification, expansion of the Weatherization Assistance Program, incentives for existing home retrofits with equipment standards, and improved appliance standards and incentives.

High initial costs, regulatory barriers, and code compliance are addressed by the modeled policies. Incentives for retrofit equipment and appliances lower the relatively high initial costs of energy efficient equipment and appliances. The residential building energy codes remove regulatory barriers by implementing more efficient and updated codes, while third party verification also improves building code compliance. All standards and regulations also assist in overcoming the building industry's fragmented structure and the information shortfalls that impede voluntary consumer adoption.

The four policy packages are only some of many policy alternatives that may improve residential energy efficiency and address barriers. Table 3.1 lists examples of policy actions including those that are modeled, which are presented in italics. Some of the presented policies could be used as substitutes to the modeled packages, or as complementary actions.

Table 3.1 Policy Actions that Support Residential Energy Efficiency

Actions	Retrofit Incentives and Equipment Standards	Residential Building Codes with Third-Party Verification	Appliances Incentives and Standards	Expanded Weatherization Assistance Program
Research, Development, and Demonstration	Development of new insulation, heating, and cooling technologies for local climates	Support for R&D in advanced building processes and materials	Support for research and development for innovation in appliance performance	Development of new insulation, heating, and cooling technologies for local climates
Financing	Low or No-Interest Loans for Incremental Cost of Improvements for Existing Buildings	Low or no-interest loans for incremental costs of new construction improvements Support for Energy-Efficiency Mortgages (EEMs)	Low or No-Interest Loans for ENERGY STAR® Appliances	N/A
Financial Incentives	*Retrofits rebates* Tax credits for efficient purchases	*Incremental cost rebates to builders for homes that meet or exceed building energy code* Permit fee or property tax reductions for efficient homes	*Efficient appliance rebates* Tax credits for efficient purchases Appliance Buyback Programs	*Grants or publicly funded provision of retrofits*
Pricing	N/A	N/A	N/A	N/A
Voluntary Agreements	N/A	Agreement between major builders in the area to meet or exceed code	N/A	N/A
Regulations	Allowing third party compliance inspection Resale energy rating and labeling *National efficiency standards for retrofit equipment*	*Model Building Energy Code legislation* *Allowing third party compliance inspection* Energy-efficiency rating and labeling	Broad appliance standards with tighter requirements Standby Efficiency Standards *National efficiency standards for appliances*	National standards on minimum efficiency for retrofit equipment and appliances

Table 3.1 Policy Actions that Support Residential Energy Efficiency				
Actions	**Retrofit Incentives and Equipment Standards**	**Residential Building Codes with Third-Party Verification**	**Appliances Incentives and Standards**	**Expanded Weatherization Assistance Program**
Information Dissemination & Training	Training architects and contractors Public Awareness campaigns to inform consumers of the benefits of conservation and efficiency measures Advanced metering (interior, real-time, with price signal)	*Training architects, builders, contractors, and code enforcement officials*	Public Awareness campaigns to inform consumers of the benefits of conservation and efficiency measures Advanced metering (interior, real-time, with price signal)	Training contractors, weatherization officials, and community providers Public Awareness campaigns to inform consumers of the benefits of conservation and efficiency measures
Procurement	N/A	N/A	Government efficient appliance lead by example programs	N/A
Market Reforms	Enable On-bill Financing for Retrofits	N/A	N/A	N/A
Planning Techniques	N/A	Evaluation and monitoring for feedback	N/A	N/A
Capacity Building	Centers for energy efficiency to train next generation of architects, builders, retrofitters	Centers for energy efficiency to train next generation of architects, builders, retrofitters	Centers for energy efficiency to train next generation of architects, builders, retrofitters	Centers for energy efficiency to train next generation of architects, builders, retrofitters

Lighting efficiency policies were not included in this report. Such policies are typically considered appliance efficiency standards, but the SNUG-NEMS logic handles it separately. Most of the savings possible through energy-efficient lighting have already been accounted for in the American Recovery and Reinvestment Act (ARRA) and in the SNUG-NEMS Reference Scenario (Personal Correspondence with John Cymbalsky, October 1, 2009). The Energy Independence and Security Act of 2007 (EISA) called for an increase in incandescent bulb performance and required the Secretary of Energy to consider implementing a minimum standard of 45 lumens per watt for general service lamps by 2014 (EISA 2007). This effectively phases out incandescent bulbs, which only produce about 15 lumens per watt. The implementation of the ARRA in NEMS was done by phasing out inefficient incandescent bulbs starting in 2012, thereby leading to increased adoption of compact fluorescent light bulbs (CFLs) and light emitting diodes (LEDs) for this bulb type (Personal Correspondence with John Cymbalsky, October 1, 2009). In addition to this measure, the American Clean Energy and Security Act (ACESA) calls for the creation of lighting efficiency standards for outdoor light sockets in 2012 (ACESA, 2009).

The Department of Energy (DOE) has announced new lighting standards that address fluorescent tubes and recessed can lighting fixtures, which contain reflector lamps (Mufson, 2009). The more efficient T8 lamps will replace T12 lamps in fluorescent lamps, while both incandescent and halogen bulbs in reflector lamps will be replaced by highly efficient halogen infrared reflector bulbs (ACEEE, 2009). While the performance standards for general service incandescent lamps required by the 2007 Energy Independence and Security Act (EISA) are already accounted for in the 2009 baseline, the new standards will be implemented by the EIA in the 2010 Annual Energy Outlook (AEO) (Personal communication with John Cymbalsky, October 1, 2009). Therefore, the savings from the new lighting standards for the year 2010 are an example of many small savings opportunities that were not captured in our report.

Lastly, if solid-state lighting (SSL) is successfully commercialized such that it achieves its price and performance levels for full-spectrum white LEDs, it could displace general illumination by 2027 while saving about 1.2 quads in that year alone, which is equivalent to the annual output of 44 large power plants (EERE 2007). This is also one of the opportunities for energy savings that has not been taken into account in this report.

3.3 ENERGY EFFICIENCY POLICIES IN RESIDENTIAL BUILDINGS

3.3.1 Residential Building Codes with Third-Party Verification

Most states adopted residential energy codes in the 1970s but implementation and enforcement are not consistent across or between states, which is in part due to the fact that energy codes rank below health and safety codes as a priority for enforcement (Yang, 2005). As a consequence, the energy and cost savings potential from building code implementation is not fully achieved. Figure 3.3 shows a commercially available home with an airtight high-R exterior insulation finish system (EIFS) that is resistant to moisture and saves more energy than brick, concrete, stucco, or fiber cement siding (Lapsa, 2009).

Figure 3.3 Exterior Insulation Finish System (Lapsa, 2009)

DOE evaluates states that have the International Energy Conservation Code (IECC) and the ASHRAE Standard or an equivalent code for residential buildings (US DOE, 2009e). No state in the South has adopted the IECC 2009 code, its equivalent or better. Florida, the District of Columbia, Georgia, Kentucky, Louisiana, Maryland, North Carolina, South Carolina, and Virginia have adopted the IECC 2006 code or better. Arkansas, Tennessee and West Virginia have adopted the IECC 2003 code, while Texas has adopted the IECC 2001-1998 code. Meanwhile, Mississippi, Alabama and Oklahoma have adopted no statewide code (US DOE, 2009e). Figure 3.4 presents a map of residential building code adoption in the South.

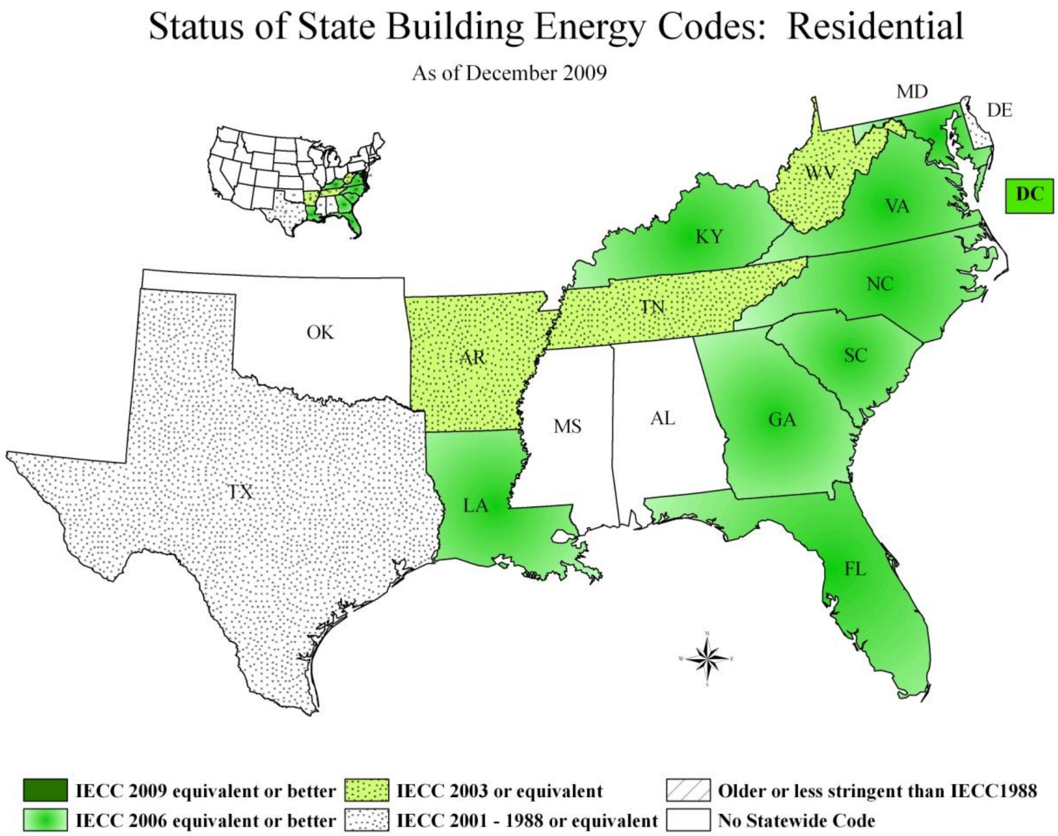

Figure 3.4 Residential Building Codes in the South as of December 2009

Policy Description and Modeling. The policy for reducing energy consumption through more stringent building codes was modeled by providing a 30% subsidy in the installation costs for appliances that were covered by the most stringent building codes in NEMS namely. The most stringent building codes are subsidized by 30% of installation costs for building equipment. Updated and improved building codes were assumed to be implemented every six years by eliminating the least stringent code and allowing only the more stringent ones to remain. See Appendix C-2.1 for further details.

Technology Demand Shifts. As shown in Table 3.2, more aggressive building codes with increased enforcement can cause a shift in the types of cooling, heating, and water heating equipment that are bought. The building code policy results in the virtual elimination of new purchases of room air conditioners and a sizeable increase in the purchase of electric heat pumps with their inherently high efficiencies. Similarly, electric radiators see a significant decline in purchase with the building code policy, with electric heat pumps accounting for nearly half of heating equipment purchased in 2030. For water heating, the building code policy causes a shift away from natural gas units and toward electric water heating.

Interestingly, the residential code upgrades do not create a large demand for geothermal heat pumps or solar water heating. Other types of policies (or revised building codes) are needed to encourage a shift to these renewable alternatives.

Table 3.2 Technology Demand Shifts from Building Codes with Third Party Verification Policy*							
		Efficiency		**Reference**		**Policy**	
End Use	**Equipment Class**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**
Cooling	Central A/C - SEER	14-23	15-23	52%	50%	53%	57%
	Electric heat pumps - SEER	13-20	13-21	18%	22%	43%	41%
	Geothermal heat pumps - EER	19-30	19-31	0%	0%	2%	2%
	Room A/C - EER	11-13	11-13	31%	28%	1%	1%
Heating	Electric heat pumps - HSPF	8-11	8-11	27%	33%	44%	49%
	Electric radiators	---	----	33%	29%	20%	7%
	Geothermal heat pumps - COP	3.9-5.1	3.9-5.1	0%	1%	2%	2%
	LPG furnaces - AFUE	81-96%	82-96%	5%	5%	5%	6%
	Natural gas furnaces - AFUE	81-96%	82-96%	27%	26%	27%	35%
	Natural gas radiator	----	----	4%	4%	1%	1%
Water heating	Electric water heating - EF	0.92-0.95	0.92-0.95	58%	58%	70%	71%
	LPG water heating - EF	0.63-1.4	0.86-1.4	2%	2%	4%	4%
	Natural gas water heating - EF	0.80-0.85	0.80-0.86	40%	39%	26%	26%
	Solar water heating - EF	0.8-4.8	0.8-4.8	0%	0%	0%	0%

*These refer to the percentage of new appliances purchased in the reference case and in the policy scenario in each year.
*SEER = Seasonal Energy Efficiency Ratio
*EER = Energy Efficiency Ratio
*HSPF = Heating Seasonal Performance Factor
*COP = Coefficient of Performance
*AFUE = Annual Fuel Utilization Efficiency
*EF = Energy Factor

Energy Savings. Figure 3.5 displays the percentage reduction of primary savings by census region showing that the energy savings in 2020 and 2030 are greatest in the South Atlantic, followed by the West South Central and East South Central divisions. The primary savings for this program by census division are shown in Table 3.3 where the cumulative primary energy savings in 2030 are also highest in the South Atlantic division, followed by the West South Central and East South Central. The SNUG-NEMS output shows that from 2010 to 2030, 441,667 homes are affected by the policy, which is equivalent to an incremental cost of about $9,000 per home in public costs.

The building envelope improvements resulted in significant savings for heating, cooling, and water heating end-uses.

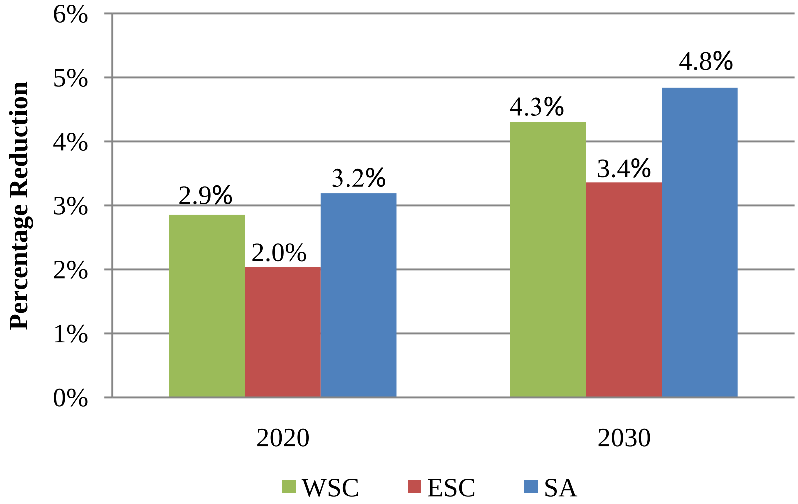

Figure 3.5 Primary Energy Savings for Residential Building Codes

Table 3.3 Primary Energy Savings for Residential Building Codes (TBtu)				
	WSC	ESC	SA	Total
2020	56.2	22.8	104	183
2030	92.5	40.3	174	307
Cumulative to 2030	1,090	469	1,970	3,520

*Primary energy savings is the energy required to generate the avoided energy.

Energy Bill Savings. See Figure 3.6 for the percentage of energy bill savings from the Residential Building Codes with Third-Party Verification policy. Energy bill savings range from about 4% in the West South Central to about 6% in the South Atlantic Division in 2030.

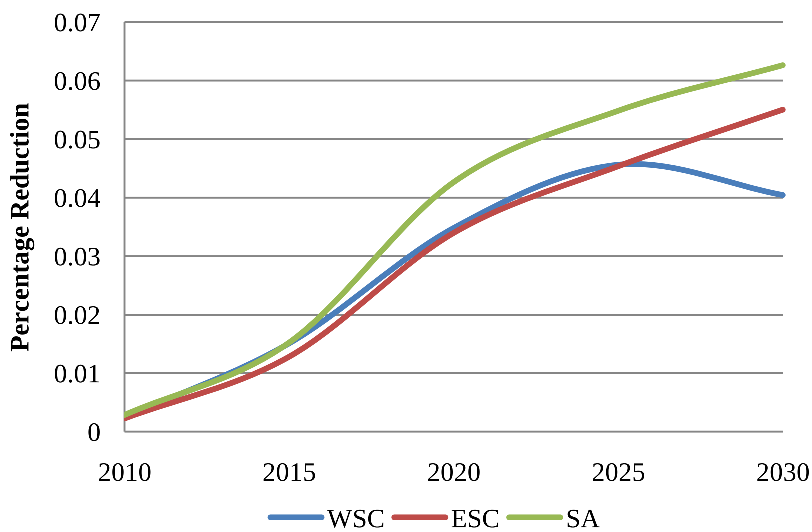

Figure 3.6 Energy Bill Savings for Residential Building Codes with Third-Party Verification

Economic Test. Energy bill savings measure the private household benefits, but the costs associated with the residential building codes policy include both public and private costs. The policy is evaluated for a twenty year period beginning 2010. Investment costs occur during this same duration, while energy bill savings continue beyond this period due to the lifetime of the measures installed in the latter years of the policy. The energy bill savings exceed the public and private investment costs for much of the time, suggesting the policy is highly cost-effective (Figure 3.7). Appendix C.3 summarizes the cost and savings calculations for the policy.

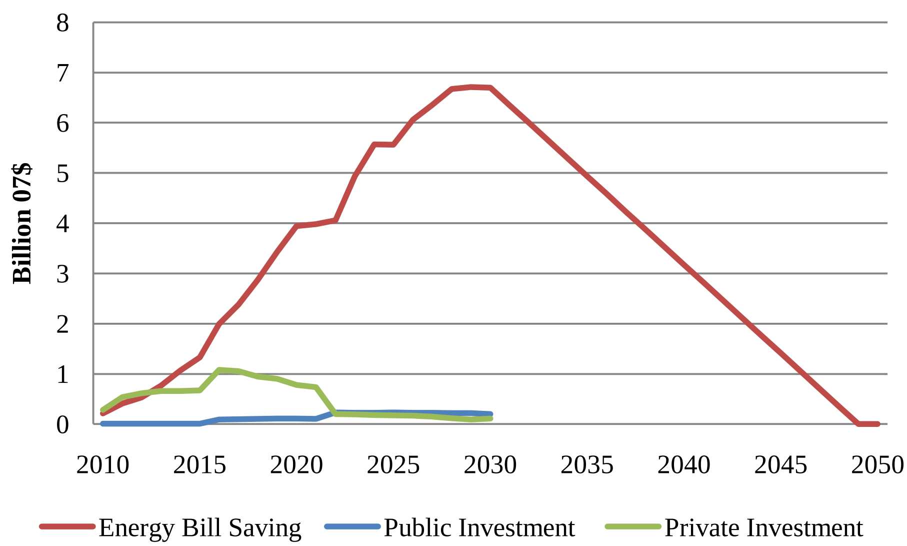

Figure 3.7 Cost and Savings from Residential Building Codes with Third-Party Verification Policy

Levelized Cost of Energy Efficiency. The levelized cost reflects the cost to achieve a particular amount of energy savings through the implemented policies. Table 3.4 presents the levelized costs from the Residential Building Codes with Third-Party Verification policy.

Table 3.4 Levelized Cost of Energy Efficiency from Residential Building Codes with Third-Party Verification Policy in 2020

Energy Type	Cost of Efficiency
Electricity (¢/kWh)	3.4
Natural Gas (¢/therm)	9.2
Total Energy ($/MMBtu)	10.8

Economic Test. Administrative costs are based on one administrator per state at a salary of $150,000 per annum and an employee at $75,000 per annum. It also includes an additional employee for the verification of every 100,000 homes in the state at $75,000 per year (ARC report, 2009). The investment cost is calculated by subtracting the new investment in the policy scenario from the new investment under the basic stimulus plan and then summing up this difference in investment from 2010 to 2030. The values are provided in the NEMS output files. The savings are extrapolated to 2050 in order to account for the extra savings that accrue through the lifetime of the appliances adopted in 2030. Prices used in the calculation are from the SNUG-NEMS price forecasts to 2030.

Table 3.5 displays some details of the total resource cost test for this policy. The benefit-cost ratio is 5.6, which shows that the benefits from the policy are nearly six times as great as the associated costs.

Table 3.5 Total Resource Test for Residential Building Codes with Third-Party Verification*

	(Million $2007)					B/C
	Public Costs		Private Costs	Total Discount Costs	Total Discount Savings	
	Annual Administration Cost	Annual Investment Cost	Annual (Investment & Other)	Cumulative Costs	Cumulative Savings	
2020	3.85	201	769	5,740	11,600	5.6
2030	3.83	305	21	7,280	31,100	
NPV	42	1,550	5,690	7,280	40,900	

*Cumulative Costs and Savings beginning in 2011. NPV included savings post 2030.

3.3.2 Appliance Incentives and Standards

Appliance efficiency standards require that certain appliances meet minimum energy efficiency levels. They are cost effective, increase consumer bill savings, reduce air and water pollution, and improve electric system reliability by reducing peak demand (Eldridge, deLaski et al., 2006). The first states began adopting residential appliance standards in the 1970s, but as of October 2008, only the District of Columbia and Maryland have passed state appliance efficiency standards in the South. Other states follow national standards (ASAP, 2009a; DSIRE, 2009). Federal standards for residential products such as refrigerators, freezers, clothes dryers, ranges and ovens, dishwashers, and clothes washers exist. Many were implemented by the National Appliance Energy Conservation Act of 1987 (ASAPa, 2009).

The American Clean Energy and Security Act of 2009 calls for the provision of financial incentives to retailers selling large quantities of "best-in-class" appliances and makes several improvements to the current standard-setting process at the Department of Energy (Waxman and Markey, 2009). The electric heat pump clothes dryer is an example of an appliance that can increase residential energy efficiency (See Figure 3.8 below). It can achieve a cumulative energy reduction of 34 trillion Btu in the South from 2009 to 2030 (EPRI, 2009b).

Figure 3.8 Heat Pump Clothes Dryer (PriceInspector, 2009)

Policy Description and Modeling.
Due to the long lead time in the development of new technologies, it is necessary to implement policies to increase the adoption of more efficient technologies. Such policies also addresses the slow rate of turnover for many of these appliances and helps generate significant long term savings (Philibert 2007).

This policy is defined as a 30% subsidy for the capital cost of the most efficient appliance available. The subsidy focuses on the following equipment classes: dishwashers, cooking, clothes washers, food refrigeration, and food freezing.

In addition, a federal appliance standard, assumed to be adopted by all states as required by federal rule, was also implemented for refrigerators, freezers, and clothes washers. The standards are assumed to be renewed every ten years, where more efficient appliances are mandated. The lowest efficiency appliance in each equipment class was removed in the year that the respective standard is assumed to come into effect. See Appendix C.2.3 for additional details.

A federal subsidy for efficient appliances has been modeled by altering an SNUG-NEMS residential input file detailing appliance efficiencies and costs. Only equipment classes with an efficiency improvement during the study period received the subsidy for the highest efficiency appliance within the class. For these appliances, a 30% reduction in their cost was given.

An additional sensitivity analysis was conducted to determine the effect of clothes washers and refrigerators on the appliance policy’s savings and economics. In the modeled appliance policy, these two appliances cost the most per energy saved. The sensitivity run removed clothes washers and refrigerators from both the appliance standards and the incentives. This allowed a range to be estimated for the appliance policy, given a varied policy design.

Technology Demand Shifts. This policy causes a shift towards higher efficiency equipment, as would be expected, for heating, cooling, and water heating end-uses. Table 3.6 lists the appliances, their efficiencies, and their percentage of use in the reference and policy scenarios for a few examples. See Appendix C.2.3 for additional technologies. The numbers listed in the efficiency column are derived from the SNUG-NEMS input file. Some numbers exceed one since they includes traditional efficiency numbers and efficiency as rated by usage. Due to the discrepancy of the efficiency numbers in SNUG-NEMS presented as efficiency and as rated by usage, in some cases the efficiency increases in numeric value with increased efficiency (like LPG and natural gas stoves). In other cases, the efficiency is presented as rated by usage and decreases in numeric value with increased efficiency (like dishwashers).

Table 3.6 Total Technology Demand Shifts from Appliance Incentives and Standards Policy

Description	Efficiency	Reference		Policy	
		2020	2030	2020	2030
Dishwasher	0.65	52%	52%	0%	0%
	0.35*	0%	0%	100%	100%
LPG Stove	0.399	75%	74%	30%	0%
	0.420*	25%	26%	70%	100%
Natural Gas Stove	0.399	82%	82%	29%	0%
	0.420*	2%	18%	71%	100%

*****These are the high efficiency models.

Energy Savings. The primary savings for this policy by census region are shown in Table 3.7, which indicates that the highest savings can be obtained in the South Atlantic, followed by the West South Central, and then the East South Central division (Figure 3.9).

Table 3.7 Primary Energy Savings from Appliance Incentives and Standards Policy (TBtu)

	WSC	ESC	SA	Total
2020	13	7	32	53
2030	28	15	59	102
Cumulative to 2045	509	268	1,110	1,880

*Primary energy savings is the energy required to generate the avoided energy.

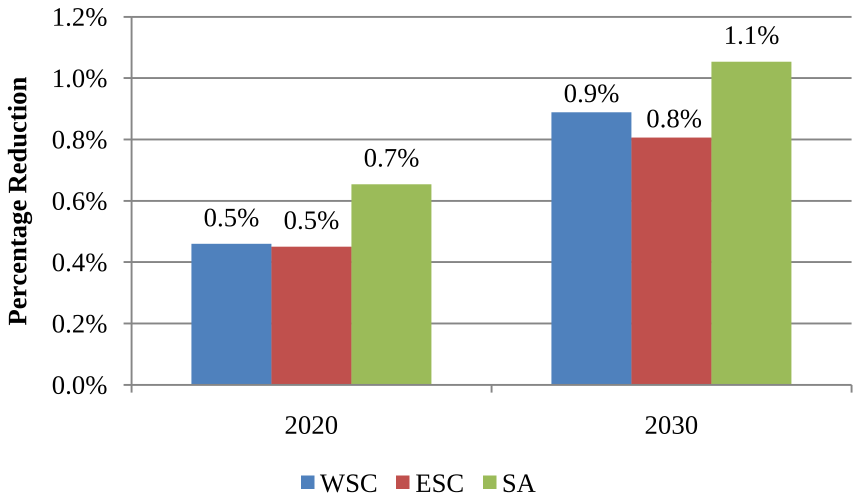

Figure 3.9 Primary Energy Savings for Appliance Incentives and Standards

The sensitivity analysis found that the removal of clothes washers and refrigerators from the policy decreased total cumulative energy savings by 43%. A total of 1,080 TBtu of energy savings were realized cumulatively to 2045 in the sensitivity case.

Energy Bill Savings. Energy bills are reduced with the policy, varying from zero to about one percent savings (Figure 3.10). The energy bill savings around 2022 dip significantly for all three census divisions. During this time, the policy scenario prices increase above the reference scenario prices.

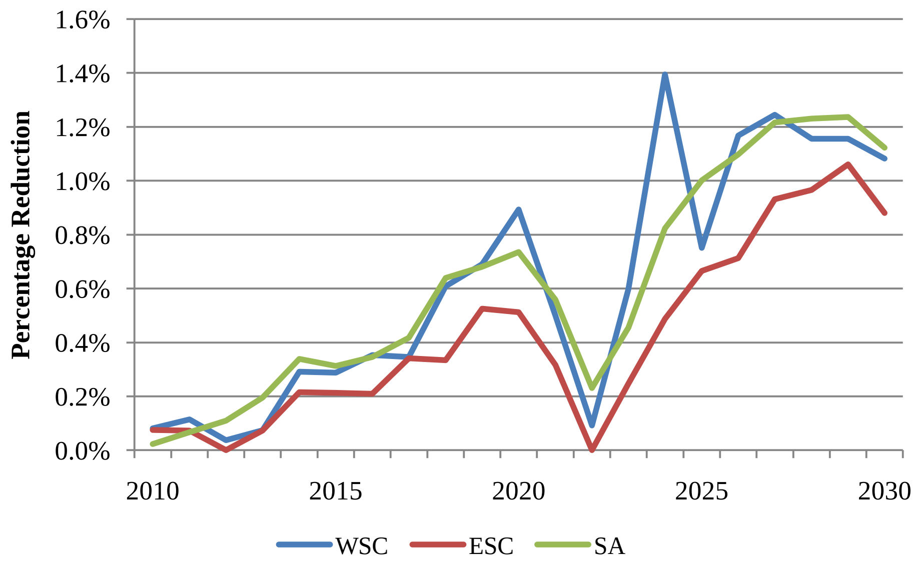

Figure 3.10 Energy Bill Savings from Appliance Incentives and Standards

Levelized Cost of Energy Efficiency. The levelized cost reflects the cost to achieve a particular amount of energy savings through the implemented policies (Table 3.8).

Table 3.8 Levelized Cost of Energy Efficiency from Appliance Incentives and Standards in 2020	
Energy Type	Cost of Efficiency
Electricity (¢/kWh)	15
Natural Gas (¢/therm)	60
Total Energy ($/MMBtu)	42

The levelized cost for electricity is above residential market prices, while the levelized cost for natural gas is below market prices. This may suggest that the policy may be either at or below cost beneficial.

The sensitivity analysis removed clothes washers and refrigerators from the policy. These two appliances were the most expensive per unit energy saved in the appliance policy. With their removal, the levelized cost for total energy decreased to $14.5 per MMBtu. This decrease shows that the levelized cost is variable, depending on the appliances that receive standards and incentives.

Economic Test.
Energy bill savings measure the private household benefits, but the costs associated with the residential appliance policy include both public and private costs. The policy is evaluated for a twenty year period beginning 2010. Investment costs occur during this same duration, while energy bill savings continue beyond this period to 2045 due to the lifetime of the measures installed in the latter years of the policy.

In general, the public investment cost for this policy is higher than the private investment costs and energy bill savings. Energy bill savings decrease around 2022, likely due to the relative fuel price increase projected for the policy scenario in comparison to the reference scenario. Private investment costs are negative for the first four years (Figure 3.11). Along with possible free rider issues, it is possible the policy may be providing too generous of a subsidy which is inflating public investment costs and depressing private investment cost. Appendix C.3 summarizes the cost and savings calculations for the policy.

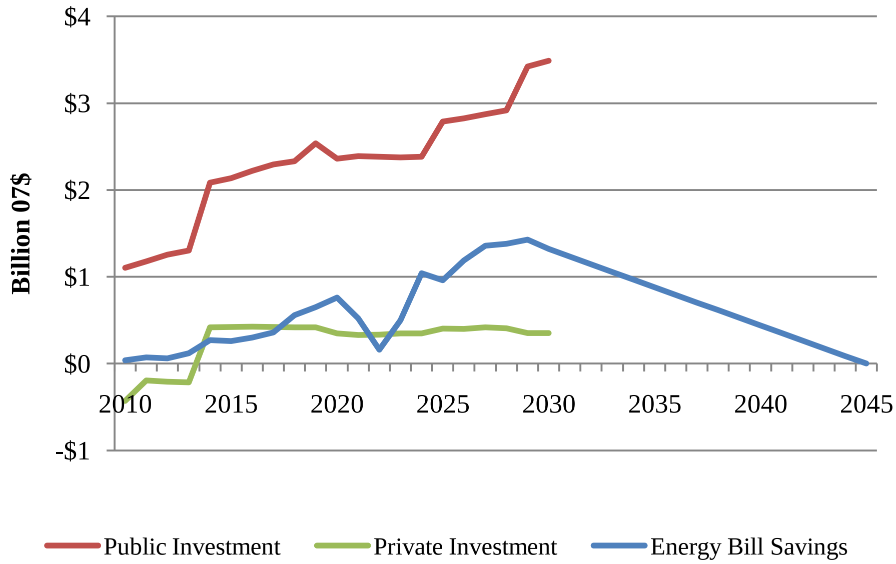

Figure 3.11 Costs and Savings from Appliance Incentives and Standards Policy

Table 3.9 Total Resource Test for Appliance Incentives and Standards*						
	(Million $2007)					B/C
	Public Costs		Private Costs	Total Discount Costs	Total Discount Savings	
	Annual Administration Cost	Annual Investment Cost	Annual (Investment & Other)	Cumulative Costs	Cumulative Savings	
2020	6.86	2,360	348	14,500	2,100	0.3
2030	13.3	3,480	352	25,500	5,350	
NPV	63.8	22,900	2,590	25,500	7,060	

*Cumulative Costs and Savings beginning in 2011. NPV included savings post 2030.

The benefit-cost ratio of the policy is 0.3, showing that the benefits actually less than the cost of the policy. This ratio is lower than expected. It is likely that the 30% subsidy for appliances is too generous, which causes the public costs to be much higher than necessary for the estimated energy efficiency potential. Also, due to the limited selections of appliances in SNUG-NEMS, the most efficient technology that received the subsidy in some cases was also the only technology available due to the implementation of the standards. This likely forced the public cost to be higher in these cases, due to a free rider effect as consumers who were going to buy the appliances regardless also collected the subsidy.

The cost per energy savings varied for each appliance that was included in the policy. In the sensitivity case, the removal of the two most expensive appliances (clothes washers and refrigerators) improved the benefit cost ratio. Total net present value costs reduced to $5,650 and total net present value benefits decreased to $4,080. This increased the benefit cost ratio to 0.7. Overall, the sensitivity run's cumulative costs were 22% of the appliance policy's cumulative cost. Its cumulative benefits were 58% of the appliance policy's cumulative benefits. Since some appliances may be more costly per energy savings, the appliances that should receive incentives and other policy actions should be selected judiciously. The sensitivity findings suggest that appliances included within the policy may significantly impact the cost benefit level. Additional exploration into the effect of individual appliances on the total economics must occur for greater insight into their effects on the overall policy.

3.3.3 Expanded Low-Income Weatherization Assistance

The Weatherization Assistance Program (WAP) is a federal block grant program implemented in 50 states, the District of Columbia, Puerto Rico, and other U.S. territories (Kaiser and Pulsipher, 2004; US DOE, 2009f). The program increases the energy efficiency of homes occupied by low-income individuals to reduce energy expenditures and increase health and safety. The program especially focuses on the elderly, the disabled, and families with children (US DOE, 2009g). Households at or below one and a half times the poverty level are eligible.

By 2005, the WAP had weatherized over 5.8 million low-income homes since inception (DOE, 2009j). Improvements in energy savings from weatherization measures have increased in the WAP since its original inception. These additional savings were largely due to improved technologies in determining infiltration leakages, the use of energy audits, and better program design. Insulation measures were also more commonly used in recent years (McCold et al, 2008).

In a study by Schweitzer, the average cost for weatherizing a natural gas heated home was $2,913 in 2003 dollars. The lifetime benefits associated with weatherizing a house was estimated to be $3,466 in 2003 dollars. This generated a benefit to cost ratio of 1.34 for lifetime energy savings. A benefit to cost ratio of 2.53 was found when both energy and non-energy benefits were included (2005).

According to the Census, Southern states have a higher proportion than the national average of individuals and families who qualify for WAP (See Table 3.10). This means it has a larger population that can benefit from the policy we call Expanded Weatherization Assistance Program.

Table 3.10 Below 150% Poverty by Southern State, 2008			
(Census, 2009c)			
		% Individuals	**% Families**
Nation		23	18
South Average		25	20
South Atlantic	DC	26	23
	DE	20	16
	FL	23	18
	GA	24	20
	MD	16	13
	NC	25	20
	SC	26	22
	VA	17	14
	WV	25	20
East South Central	AL	25	19
	KY	27	21
	MS	33	27
	TN	28	24
West South Central	AR	27	23
	LA	30	24
	OK	24	19
	TX	28	24

The American Recovery and Reinvestment Act of 2009 (ARRA) provides $5 billion dollars to the Weatherization Assistance Program, with a presidential goal of weatherizing 1 million homes per year (DOE, 2009h). Under the American Recovery and Reinvestment Act of 2009 (ARRA), the amount of funding for each state varies from a low of about $4 million for Hawaii to $394 million for New York (DOE, 2009i). The southern state with the highest amount of funding is Texas with over $326 million dollars, while the lowest amount of funding goes to the District of Columbia, about $8 million dollars (DOE, 2009h). See Figure 3.12 shows the stimulus funding for all the southern states.

Figure 3.12 ARRA Weatherization Assistance Program Funding for Southern States

The ARRA revises several program statutes. First, any household at or below 200% of poverty is now eligible for the program. Second, the maximum that can be spent per dwelling was raised to $6,500 from $2,500. Third, the Secretary may encourage states to prioritize certain activities, such as attic insulation, if he believes such changes would increase program effectiveness. Fourth, up to 20% of total funds can be for training and technical assistance. Lastly, assistance for previously weatherized dwellings are eligible for weatherization again if they were weatherized before September 30, 1994, instead of September 30, 1979 (ARRA, 2009).

The Weatherization Assistance Program was touted as one of the best programs to create green jobs and stimulate the economy during this economic downturn. Recently, it has become the focus of criticism. As of February 2010, only an estimated 8% of the five billion dollars appropriated to the program was spent (Ling, 2010). This limited the program's effectiveness, inhibiting a larger contribution to economic revitalization. As is true with all programs, the Weatherization Assistance Program cannot be effective if the necessary funds are not received. Though funding dispersal may have temporarily affected the number of homes weatherized by the program, the Department of Energy is resolving the issue (Ling, 2010). It is unlikely that the program's effectiveness in achieving energy efficiency, once the needed funds are in hand, has been affected by the temporary funding setback.

Over the years, the Weatherization Assistance Program has increased the cost effectiveness of implemented measures due to advanced diagnostics, like blower-door guided air sealing and improved methods for weatherization measure selection (US DOE, 2009j). Other diagnostics such as infrared cameras to detect heat loss and duct blowers to measure duct air leakage can also be used (Energy Star, 2009a).

New innovations in retrofit technologies that not only improve energy efficiency, but also decrease costs, will also improve the effectiveness of the Expanded Weatherization Assistance Program. For instance, cellulose insulation has a high insulation factor and low cost since it can be made from recycled content such as newspapers. Use of such insulation can also increase fire safety. Cellulose insulation was found to have the highest fire resistance when compared to rock fiber and fiberglass insulation (Kodur and Sultan, 2006).

New developments, such as cellulose insulation with 20% phase change material (PCM), can bring additional efficiency. This new generation dynamic insulation uses the PCM, a substance like paraffin wax, to absorb thermal energy when hot and to release it when cold to better regulate the home's temperature (Advanced Fiber Technology, nd). This material is appropriate for retrofitting and for new homes and is currently commercially available (Lapsa, 2009). Application of the new insulation can use existing cellulose insulation technology (Advanced Fiber Technology, nd; Lapsa, 2009). Figure 3.13 shows magnified pictures of the PCM within cellulose insulation and Figure 3.14 shows cellulose insulation with 20% PCM being applied.

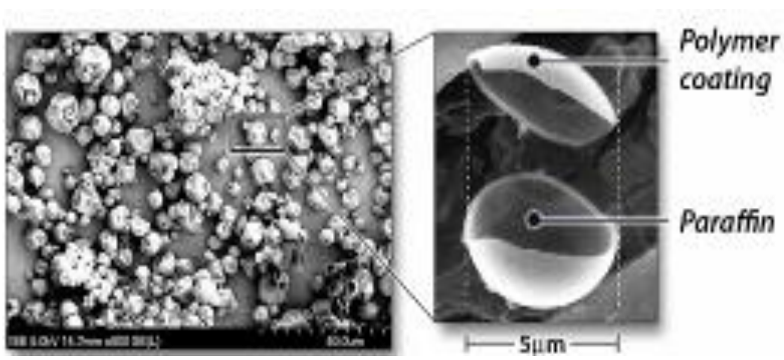

Figure 3.13 Phase Change Material in Dynamic Cellulose Insulation (Lapsa, 2009)

Figure 3.14 Implementation of Dynamic Cellulose Insulation with Phase Change Material (Lapsa, 2009)

Policy Description and Modeling. The expanded Low Income WAP assumes that the increase in funding to the WAP from the ARRA will continue, but decline to a national budget allocation of 1.7 billion dollars per year (2007 dollars) through 2030. This policy only considers assistance provided by DOE funding. A lifetime of 20 years is assumed for the weatherization measures. During this time, the efficiency of the weatherization measures is assumed to decrease by 30%. Single family, multi-family, and manufactured housing were all included within the policy scenario. The $6,500 investment per home allowed by the ARRA is assumed to decline. The investment cost per home in 2010 was assumed to be $2,600. Thereafter, it is assumed to decrease by 1% per year due to improved technologies, diagnostics, and knowledge. From 2010-2030, an 18% increase in the number of home weatherized per year is achieved with these assumptions with a cost of $2,127/home in 2030.

A table of new values was calculated to replace the existing values in an SNUG-NEMS input file (See Appendix C-1.2). Afterwards, SNUG-NEMS was run to project the savings from the expanded WAP alone. See Appendix C-2.4 for additional details on expanded WAP in SNUG-NEMS.

Energy Savings. The primary energy savings values vary from census division to census division (Table 3.11). The energy savings are largest for the South Atlantic, followed by the West South Central, and the East South Central census regions. These energy savings follow population trends.

Table 3.11 Primary Energy Savings from Expanded Weatherization Assistance Program Policy (TBtu)

	WSC	ESC	SA	Total
2020	7.25	5.56	13.0	25.8
2030	8.45	6.01	8.66	23.1
Cumulative to 2050	227	167	312	707

*Primary energy savings is the energy required to generate the avoided energy.

The primary energy savings by census division is small because the program participants are a small fraction of all households (See Figure 3.11). The percentage reduction in energy consumption from expanded WAP is greatest in the East South Central census division, which has a larger low-income population.

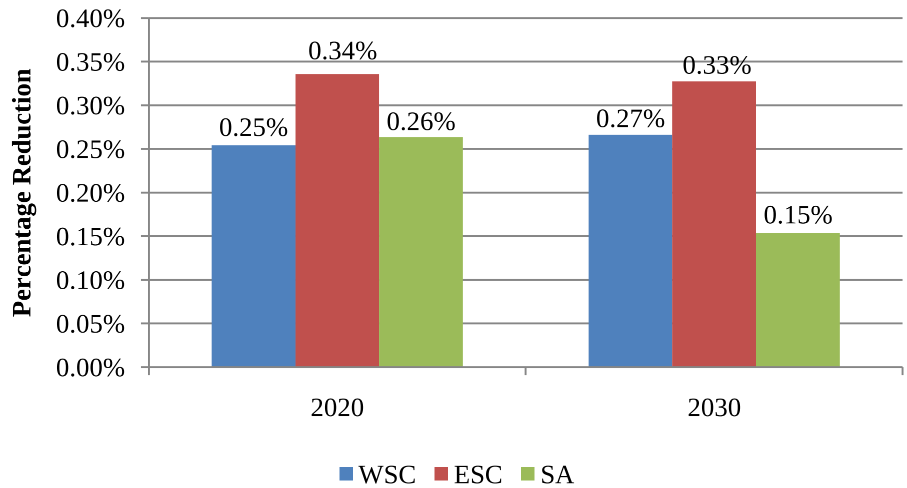

Figure 3.11 Percentage Reduction of Primary Energy from Expanded Weatherization Assistance Program Policy

From 2001 to 2006, about 97,900 households were weatherized annually in the country using DOE funds (WAPTAC, 2009). The expanded Weatherization Assistance Program policy weatherizes about 4.35 million low income households or over 217,000 per year in the South from 2010-2030. This is about six times as many households that may normally be weatherized in the South by DOE funds per year. The number of households served by the expanded program is estimated to be 0.51-0.65% of the South's total households projected by SNUG-NEMS. Assuming the average percentage of households below 150% poverty remains at 2008 levels for all three census divisions, the policy serves about 2.8-2.9% of the low-income households in the South.

The cumulative primary energy savings from these households are over 700 trillion Btu. From 2010-2030, the average primary energy savings per household varied from 123, 160, and 130 million Btu in the South Atlantic, East South Central, and West South Central census divisions respectively.

Energy Bill Savings. Figure 3.12 shows the percentage reduction of the energy bill savings from the expanded program. As mentioned above, the percentage reduction is small because the number of households weatherized per census division is small in comparison to all households. The energy bill savings around 2022 dip significantly for all three census divisions. In the South Atlantic census division, the energy bills actually increase for about two years during that time. These are likely due to the increase in projected energy prices for the policy scenario during this period when compared to the reference scenario.

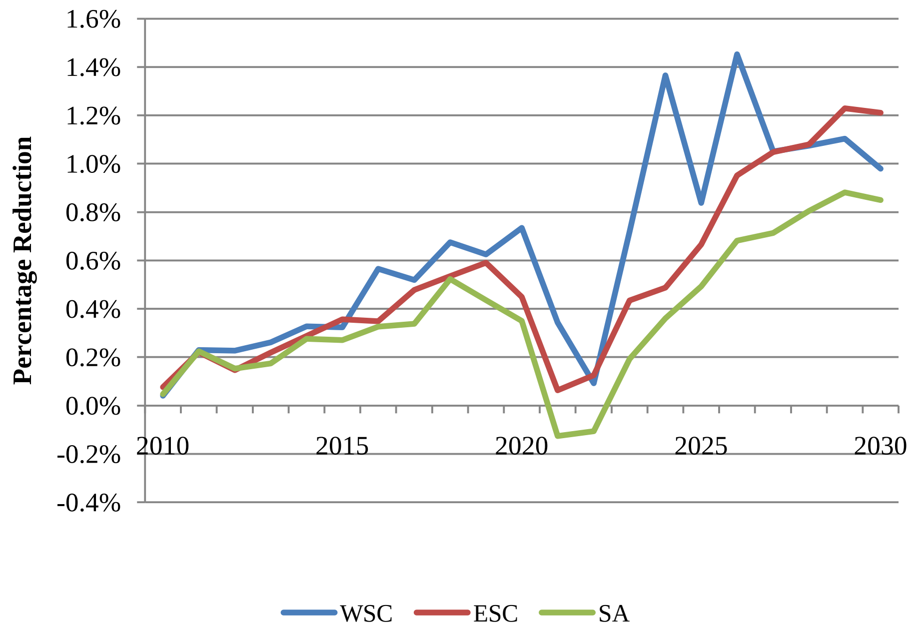

Figure 3.12 Energy Bill Savings from Expanded Weatherization Assistance Program Policy

Levelized Cost of Energy Efficiency. The levelized cost reflects the cost to achieve a particular amount of energy savings through the implemented policies (Table 3.12).

Table 3.12 Levelized Cost of Energy Efficiency from Expanded Weatherization Assistance Program Policy in 2020 (2007$)	
Energy Type	Cost of Efficiency
Electricity (¢/kWh)	8.6
Natural Gas (¢/therm)	230
Total Energy ($/MMBtu)	24

The electricity levelized cost for this policy is 8.6¢/kWh in 2007 dollars, which is lower than most residential retail electricity prices seen in the South, which averaged 8.5-10.5¢/kWh by census division in 2007 (EIA, 2009g). Since the levelized cost for electricity efficiency is lower than most retail costs, the electricity efficiency potential from the Expanded Weatherization Assistance Program policy can be achieved with modest savings in most savings. In 2007, only four states in the South had retail electricity prices that were lower than the levelized cost for electricity efficiency. These states were: West Virginia (6.73¢/kWh), Kentucky (7.34¢/kWh), Tennessee (7.84¢/kWh), and Oklahoma (8.58¢/kWh) (EIA, 2009g).

The natural gas levelized cost for this policy is 230¢/therm, which is also higher than residential retail natural gas prices seen in the South. In 2007, Southern residential retail prices varied from 120-206¢/therm in the states and DC (EIA, 2009g). The levelized cost of natural gas efficiency for the expanded Weatherization Assistance Program is higher than all of these prices, suggesting that the natural gas measures implemented by the policy would not be cost effective immediately.

As electricity efficiency comprises 50-66% of the total efficiency potential while natural gas comprises 26-37%, the savings from implementing electricity efficiency measures will likely offset the costs associated with natural gas efficiency measures.

Economic Tests. The energy bill savings from the policy exceeds the public and private investment costs associated with the program for the much of their duration (See Figure 3.13). Due to the relative price increase of the policy scenario around 2022 in comparison to the reference scenario, the energy bill savings decrease around that duration. Appendix C.3 summarizes the cost and savings calculations for the policy.

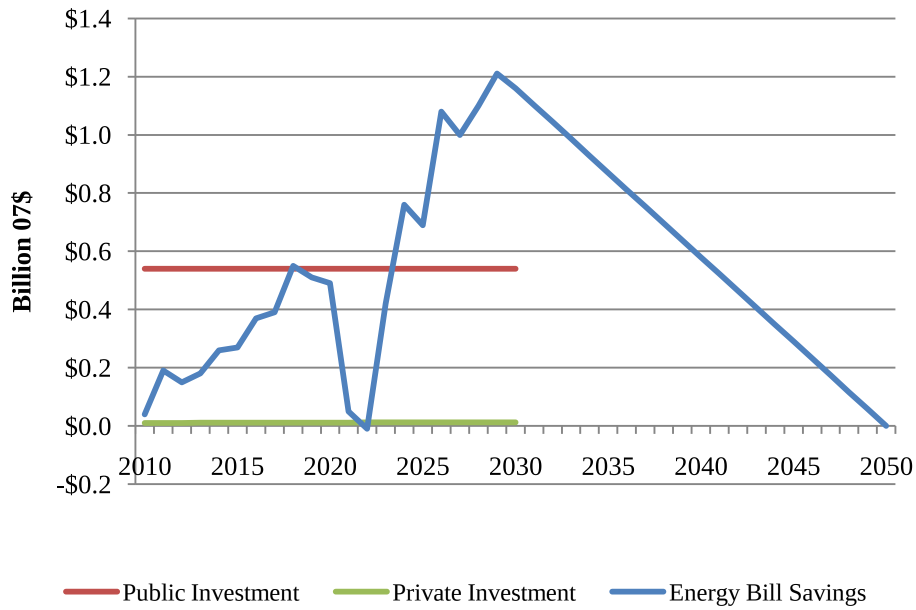

Figure 3.13 Costs and Savings from Expanded Weatherization Assistance Program Policy

The benefit cost ratio of the net present value benefits and costs is 1.1 for this test. For the approximate 5.31 million low income households served by the Expanded Weatherization Assistance Program, the average total discounted cost per home was $1,340 while the total discounted savings per home was about $1,600. Outside of the calculated savings and costs, non-energy benefits also accrue from the program and are not included in this calculation.

Table 3.13 Total Resource Test for Expanded Weatherization Assistance Program Policy*

	(Million $2007)					B/C
	Public Costs		Private Costs	Total Discount Costs	Total Discount Savings	
	Annual Administration Cost	Annual Investment Cost	Annual (Investment & Other)	Cumulative Costs	Cumulative Savings	
2020	54	486	11.6	3,870	2,180	1.1
2030	54	486	12.8	5,840	4,560	
NPV	572	5,150	121	5,840	6,420	

*Cumulative Costs and Savings beginning in 2011. NPV included savings post 2030 to until 2050, when the lifetime of weatherization measures installed in 2030 cease.

Some non-energy benefits experienced by weatherized households include property value benefits and water and sewage savings. There are also health, safety, and comfort benefits accrued by residents. Other social, environmental, and economic benefits accrue to society in general from the weatherization assistance program. For instance, the reduction of bad debt write-off, fewer service calls, reduction in electricity transmission and distribution losses and other benefits that reduce utility costs and should indirectly benefit rate payers. Schweitzer and

Tonn calculated the societal benefit cost ratio to be 3.7, with a range from 2.0 and 52.5, when including low and high non-energy benefit estimates (2002). Naturally, the benefit to cost ratio would be even higher than 1.1 if these non-energy benefits were included.

3.3.4 Residential Retrofit Incentive with Equipment Standards

A retrofitting policy can offer greater savings than the weatherization assistance program, since all new homes are eligible. The Middle Class Task Force found that residential retrofitting may reduce energy consumption by up to 40% per home (Recovery through Retrofit, 2009). Residential standards exist for products pertaining to the modeled residential retrofit. These include central air conditioners, room air conditioners, heat pumps, furnaces, boilers, and water heaters. Standards for these products were implemented by the National Appliance Energy Conservation Act of 1987 (ASAP, 2009a).

When households retrofit heating, cooling, or water heating equipment, they have the opportunity to reduce their monthly costs by increasing their efficiency. New products emerging on the market can provide greater energy savings without sacrificing performance. For instance, heat pump water heaters (Figure 3.14) available in late 2009 can cut annual energy costs for water heating by over 50% (Energy Star, 2009b). These water heaters pull heat from the air to heat the water. They can be standalone units, like the one shown in Figure 3.14, or they can be added to existing conventional storage water heaters as a retrofit measure (DOE/EERE, 2009d). The higher upfront costs for a standalone unit are estimated to be paid back by energy savings in about three years (Energy Star, 2009b).

Figure 3.14: Heat Pump Water Heater (Lapsa, 2009)

Policy Description and Modeling. This policy includes a retrofit program for heating, cooling, and water heating, as well as standards for furnaces, heat pumps, air-conditioners, and water heaters. The retrofit program includes an incentive measure for 30% of capital cost for the most efficient technologies available.

The residential subsidy for efficient retrofit appliances was implemented by making changes to a residential input file in SNUG-NEMS detailing appliance efficiencies and costs. Only equipment classes that have a projected efficiency improvement during the study period received the subsidy for the highest efficiency equipment within the class. For these, a 30% reduction in their capital cost was given.

A federal equipment standard is assumed to be adopted by all states as required by federal rule. This standard was implemented in SNUG-NEMS in the same input file as the incentives. When a standard was implemented, the least efficient grouping of equipment was removed from the market. Every ten years, the lowest efficiency equipment remaining was removed (See Appendix C-2.2 for additional information on standard implementation).

Table 3.14 lists the equipment affected by the incentives, standards, and the year of standard implementation. See Appendix C-2.2 for additional information on the equipment incentives, standards, and dates.

Table 3.14 Equipment Affected by Residential Retrofit Incentives and Equipment Standards*

Equipment Classes	30% Incentive	Equipment Standard Implementation Year*
Electric Heat Pump	Heat Pump 4	Heat Pump 1 & 2 (2014)
Natural Gas Furnace	Furnace 5	Furnace 1, 2, & 3 (2014)
Natural Gas Radiator	Radiator 3	Radiator 1 & 2 (2013)
Kerosene Furnace	Furnace 3	Furnace 1 & 2 (2015)
LPG Furnace	Furnace 5	Furnace 1, 2, & 3 (2015)
Distillate Furnace	Furnace 3	Furnace 1 & 2 (2015)
Distillate Radiator	Radiator 3	Radiator 1 & 2 (2013)
Geothermal Heat Pump	Heat Pump 2	Heat Pump 1 (2014)
Natural Gas Heat Pump	---	Heat Pump (2014)
Room Air Conditioner	Room ACs 2 & 3*	Room AC 1 (2006)*
Central Air Conditioner	Central AC 4	Central AC 1 & 2 (2014)
Natural Gas Water Heater	Water Heater 4	Water Heater 1 & 2 (2013)
Electric Water Heater	Water Heater 5	Water Heater 1, 2, & 3 (2013)
Distillate Water Heater	Water Heater 3	Water Heater 1 &2 (2013)
LPG Water Heater	Water Heater 4	Water Heater 1 & 2 (2013)

*See Appendix C.2.2 for additional details.

Technology Demand Shifts. The Residential Retrofit Incentives and Equipment Standards Policy causes demand changes for energy efficient technologies. The policy causes a shift towards higher efficiency equipment, as can be expected, in heating, cooling, and water heating end-uses. Table 3.15 lists examples of equipment, their efficiencies, and their percentage of use in the reference and policy scenarios to show how technology demand has shifted. See Appendix C.2.2 for additional technologies. The numbers listed in the efficiency column are derived from the SNUG-NEMS input file.

Table 3.15 Total Technology Demand Shifts from Residential Retrofit Incentives and Equipment Standards Policy						
Description	**Efficiency**		**Reference**		**Policy**	
	2020	**2030**	**2020**	**2030**	**2020**	**2030**
Central Air	4.69	---	29%	33%	35%	0%
	6.74	---	6%	7%	65%	100%
Natural Gas Furnace	0.90	0.90	40%	35%	41%	0%
	0.96	0.96	12%	12%	59%	100%
Electric Water Heater	2.30	---	4%	10%	40%	0%
	2.40	---	0%	0%	60%	100%

Energy Savings. The policy saves over 26,800 trillion Btu of primary energy over the duration of the implemented measures, which last until 2050. Table 3.16 shows the primary energy savings in trillion Btu from the policy by census division. These values vary from division to division, with the largest savings attributed to the South Atlantic census division, which includes the most states. Retrofit measures are assumed to have a lifetime of 20 years, so even though investsments discontinue after 2030, the savings from the investments persist until 2050.

Table 3.16 Primary Energy Savings from Residential Retrofit Incentives & Equipment Standards Policy (TBtu)				
	WSC	ESC	SA	Total
2020	211	107	421	739
2030	355	177	777	1,310
Cumulative to 2050	7,380	3,720	15,700	26,800

*Primary energy savings is the energy required to generate the avoided energy.

Figure 3.15 shows the percentage reduction of primary energy savings attributed to the policy in each census division in 2020 and 2030. The percentage reduction due to the policy increases from over time. For the South Atlantic region, it rises from 8.56% in 2020 to 13.8% reduction in 2030.

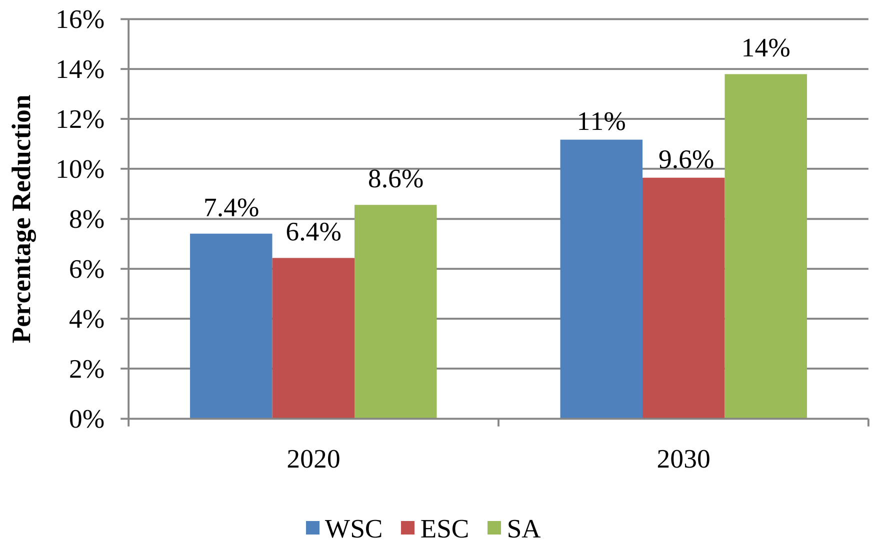

Figure 3.15 Primary Energy Savings for Residential Retrofit Incentives and Equipment Standards Policy

The SNUG-NEMS modeling of this policy applies to both retrofit and new homes. Though the policy is mostly applied to retrofits, about a quarter of the efficient equipment attributable to the policy are not retrofit applications. The results presented here does not separate the savings between retrofit and new applications. Because of this, the savings and costs attributed to the Retrofit Incentives and Equipment Standards policy may be inflated.

Levelized Cost of Energy Efficiency.
The electricity levelized cost for this policy is 3.4¢/kWh (noted in Table 3.17), which is lower than the residential retail electricity prices seen in the South. In 2007, Southern residential retail prices averaged 8.5-10.5¢/kWh by census division (EIA, 2009g). As the levelized cost for electricity efficiency is much lower than the retail cost, the electricity efficiency potential from the residential retrofit policy can likely be achieved economically.

Table 3.17 Levelized Cost of Energy Efficiency from Residential Retrofit Incentives and Equipment Standards Policy in 2020

Energy Type	Cost of Efficiency
Electricity (¢/kWh)	3.4
Natural Gas (¢/therm)	110
Total Energy ($/MMBtu)	11

The natural gas levelized cost for this policy is 110¢/therm, which is also lower than residential retail natural gas prices seen in the South. In 2007, Southern residential retail prices ranged from 120-206¢/therm by state (EIA, 2009g). This indicates that every therm of natural gas saved through the efficiency measures from this policy is and will likely continue to be cheaper to implement than continuing previous consumption habits by using that therm. In general, this policy can provide energy efficiency savings economically since natural gas and electricity efficiency potential dominate the efficiency potential from the policy.

Energy Bill Savings. Figure 3.16 shows the percentage reduction in energy bill savings from this retrofit policy. The percentage reduction increases over time, going from zero in 2010 to about 16-18% reduction in 2030, depending on the census division.

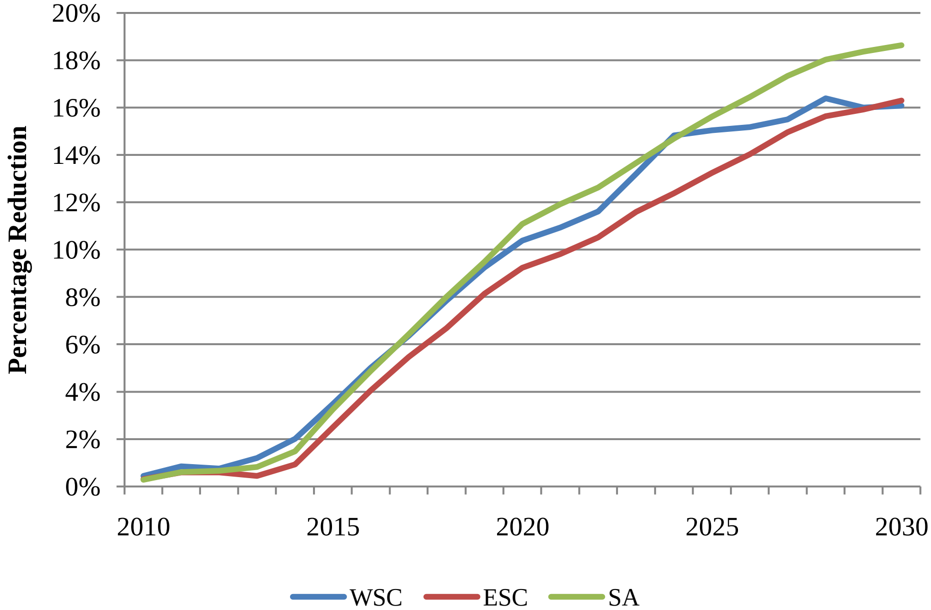

Figure 3.16 Energy Bill Savings from Residential Retrofit Incentives and Equipment Standards Policy

Economic Tests. Energy bill savings due to this policy increase steadily over the duration of the policy and are assumed to decrease linearly until 2050, after the 20 year lifetime assumed for retrofit measures. Figure 3.17 shows the public and private investment trends from retrofits, which are similar up to about 2025 when public costs then jump upwards. Larger public subsidy outlays for increased purchases of highly efficient equipment occur around 2025, prompted by equipment standards that remove cheaper, but less efficient models from the market. The energy bill savings from the policy exceeds the public and private investment. Appendix C.3 details the cost calculations for the policy.

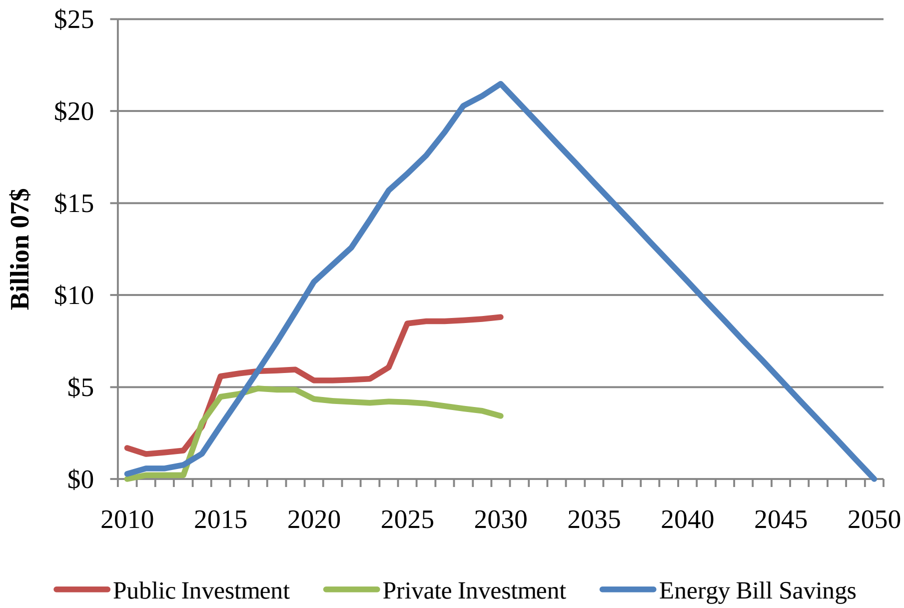

Figure 3.17 Costs and Savings from Residential Retrofit and Equipment Standards Policy

The equipment implemented by the program is estimated to have a twenty year life. Therefore, savings from the program continue to accrue until 2050 even though all costs cease in 2030. The benefit cost ratio is 1.4, suggesting that benefits from this policy are 1.4 times greater than the associated costs.

Table 3.18 Total Resource Test for Residential Retrofit and Equipment Standards Policy*

	(Million $2007)					B/C
	Public Costs		Private Costs	Total Discount Costs	Total Discount Savings	
	Annual Administration Cost	Annual Investment Cost	Annual (Investment & Other)	Cumulative Costs	Cumulative Savings	
2020	1.43	5,360	4,350	46,700	26,100	1.4
2030	1.43	8,800	3,420	86,600	84,400	
NPV	15.1	52,300	34,300	86,600	119,000	

*Cumulative Costs and Savings beginning in 2011. NPV included savings post 2030 to until 2050, when retrofit measures implemented in 2030 reached the end of the assumed 20 year life.

3.4 INTEGRATED RESIDENTIAL POLICIES

The remainder of this chapter describes the analysis of combining all the residential policies: Residential Building Codes with Third Party Verification, Appliance Incentives and Standards, Expanded Weatherization Assistance Program, and Residential Retrofit Incentives and Equipment Standards. Due to the synergistic effects of SNUG-NEMS modeling, the integrated results will not be the sum of the previous single policy results.

Energy Savings. The residential energy savings by policy in the integrated policies case was estimated (See Figure 3.18). The percentages are calculated using the savings from each individual policy run and is an estimate of the actual savings each policy provides in the integrated residential policy package. The savings contribution from each policy may range from 1-4% for expanded Weatherization Assistance Program, 1-9% for the Appliance Incentives and Standards policy, 2-4% for the Residential Codes and Third-Party Verification policy, and 5-7% for the Residential Retrofit Incentives and Equipment Standards policy. Additional study is needed to determine the contributions of each policy on the integrated residential policy savings.

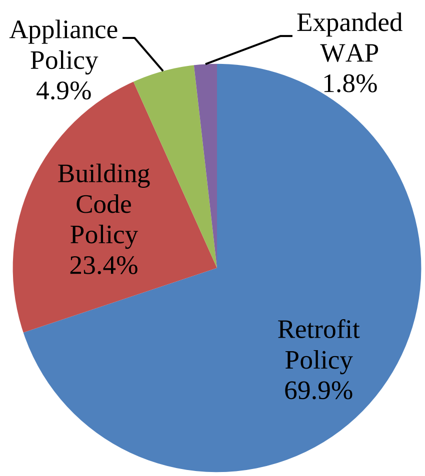

Figure 3.18 Estimated Residential Energy Savings by Policy

The results from the individual policy runs for the residential sector are summarized in Table 3.19, as are the integrated policy run. The integrated residential policy bundle generates greater primary energy savings than any one policy alone.

Table 3.19 Residential Primary Energy Savings (TBtu)

	Year	WSC	ESC	SA	Total
Building Codes with Third Party Verification Policy	2020	56.2	22.8	104	183
	2030	93	40	174	307
Appliance Incentives and Standards Policy	2020	13	7	32	53
	2030	28	15	59	102
Expanded Weatherization Assistance Program	2020	7.25	5.56	13	25.8
	2030	8.45	6.01	8.66	23.1
Retrofit Incentives and Equipment Standards Policy	2020	211	107	421	739
	2030	355	177	777	1,310
Integrated Policy Bundle	2020	271	134	509	914
	2030	448	224	895	1,570

The dotted lines in Figure 3.19 provide a sensitivity analysis for the integrated residential policies to determine whether a generic carbon constraint, called the Carbon Constrained Future (CCF), would dramatically affect their effectiveness. From this analysis, it is seen that the residential policies generate energy efficiency potential regardless of whether they are implemented in the reference or the CCF case. Table 3.20 shows the primary energy savings from the residential energy efficiency policies by census division.

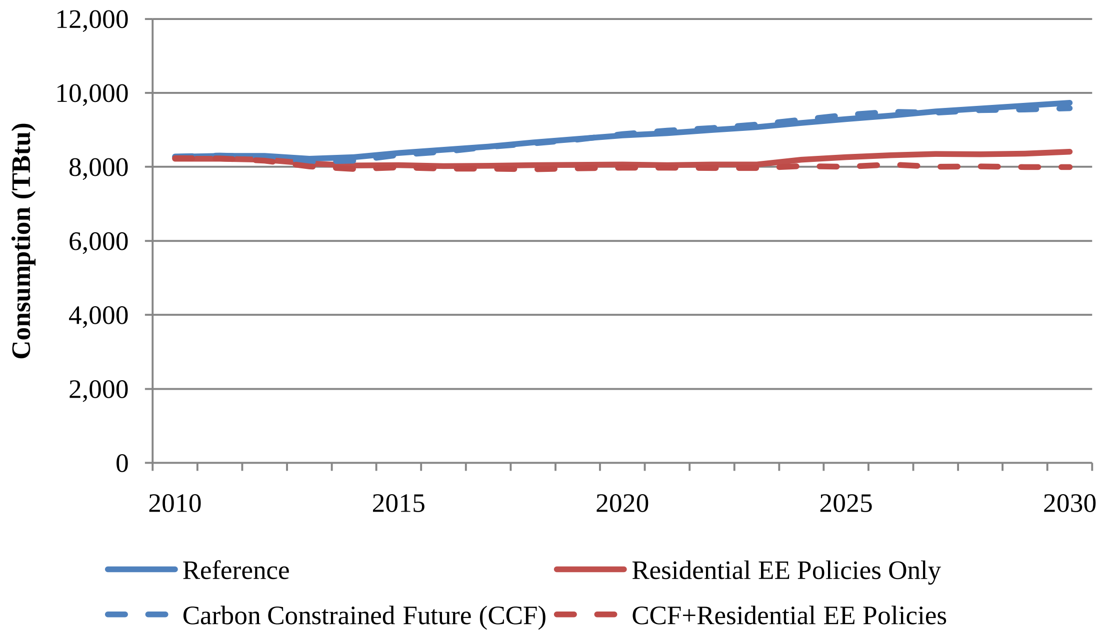

Figure 3.19 Primary Energy Consumption in the South with Residential Policies

In terms of actual Btu avoided, the South Atlantic has the greatest savings in both 2020 and 2030, as it is shown in Table 3.20. The percentage energy saving from the combined policies is very similar to that from Residential Retrofit and Equipment Standards Policy, which is the main contributor to energy savings. The South Atlantic census division shows the largest relative saving of 10% in 2020 and 16% in 2030 (Figure 3.20).

Table 3.20 Primary Energy Savings from Integrated - Residential Policies (TBtu)

	WSC	ESC	SA	Total
2020	271	134	509	914
2030	448	224	895	1,570
Cumulative to 2050	9,480	4,760	18,500	32,800

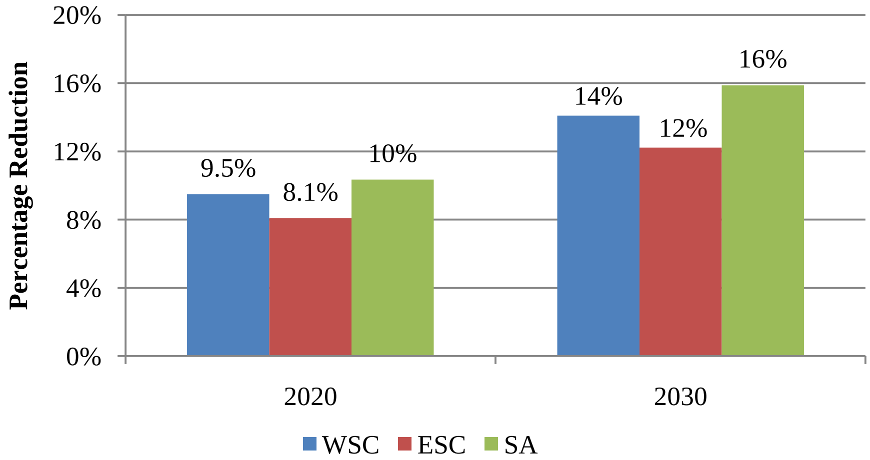

Figure 3.20 Primary Energy Savings for Integrated Residential Policies - Reference Scenario

Energy Bill Savings. The energy bill savings for the integrated residential policies are shown in Figure 3.21. Energy bill savings from the combined residential policies range from 19-21%, depending on census division.

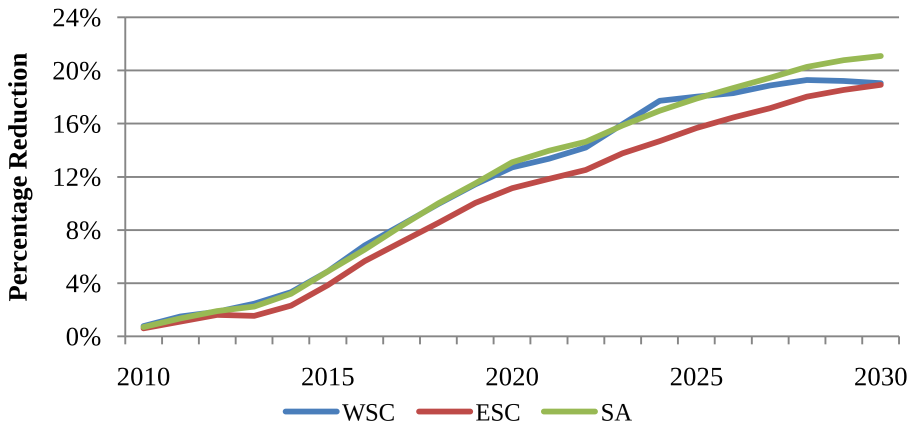

Figure 3.21 Energy Bill Savings for Integrated Residential Policies

Economic Tests. Energy bill savings increases steadily over the duration of the policy and are assumed to decrease linearly until 2050, after the 20 year lifetime assumed for measures. Even though appliances were assumed to have 15 year lifetimes, a 20 year lifetime was assumed for the integrated policies since all other policies assume a 20 year lifetime. Figure 3.22 shows the public and private investment trends from all residential policies. The increase in public costs around 2024 is likely due to the larger public subsidy outlays for increased purchases of highly efficient equipment and appliances at that time, prompted by standards that remove cheaper, but less efficient models from the market. The cost benefit ratio of the residential policy package is 1.3, indicating that the benefits exceed the costs associated with the program (Table 3.21).

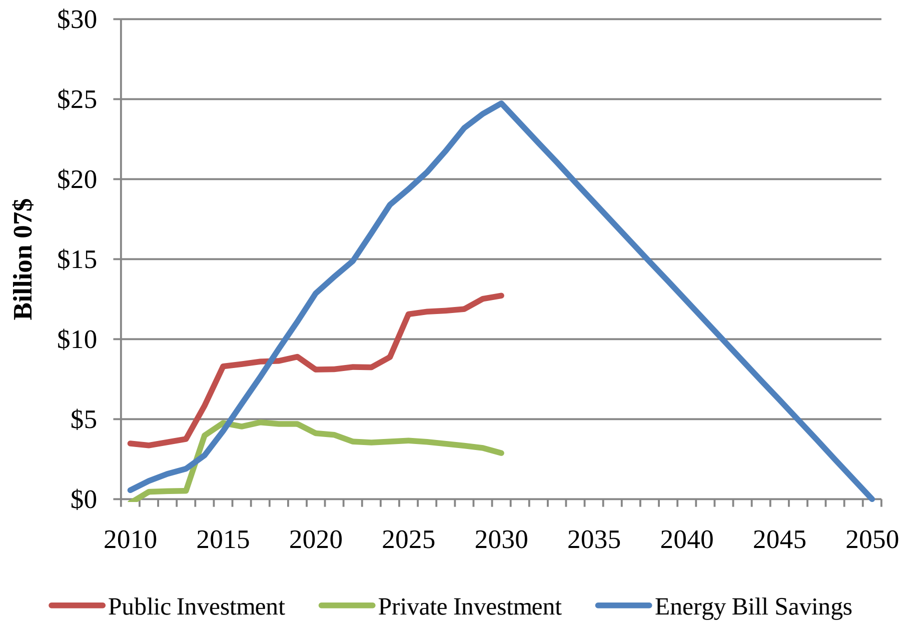

Figure 3.22 Costs and Savings from the Integrated Residential Policies

Table 3.21 Total Resource Test for Integrated Residential Policies*

	(Million $2007)					B/C
	Public Costs		Private Costs	Total Discount Costs	Total Discount Savings	
	Annual Administration Cost	Annual Investment Cost	Annual (Investment & Other)	Cumulative Costs	Cumulative Savings	
2020	548	7,540	4,120	65,600	35,900	1.3
2030	648	12,100	2,870	115,000	104,000	
NPV	5,760	75,300	33,600	115,000	143,000	

*Cumulative Costs and Savings beginning in 2011. NPV included savings post 2030.

3.5 SUMMARY AND DISCUSSION OF RESULTS FOR THE RESIDENTIAL SECTOR

This analysis of residential efficiency potential suggests that the South could save 9.7% of the energy it is forecasted to consume in the residential sector in 2020 and 15% in 2030 by implementing this collection of four policies. Table 3.22 gives a summary of the net present cost, benefit, and benefit cost ratio from the residential policies and integrated policy bundle.

Table 3.22 Total Resource Cost Tests by Sector (Million 07$)

Residential Sector Policies					
	Building Codes with Third-Party Verification	Appliances Incentives & Standards	Expanded Weatherization Assistance Program	Retrofit Incentives & Equipment Standards	Integrated Residential Policies
NPV Cost	$7,280	$25,500	$5,840	$86,600	$115,00
NPV Benefit	$40,900	$7,060	$6,420	$119,000	$143,000
B/C Ratio	5.6	0.3	1.1	1.4	1.3

3.5.1 Comparison with Other Studies

Over the past decade, numerous state and regional studies have examined the potential for energy efficiency improvements in the South (the results of several key studies are summarized in Figure 3.23). Based on a review of 19 of these, focusing on estimates for 2020, Chandler and Brown (2009) concluded that 800 TBtu of residential energy (or 9% of the residential consumption forecast for 2020) could be cost-effectively avoided with aggressive, but feasible policies. Since that study was published, McKinsey and Company (2009) completed a national analysis of the "NPV-positive potential for energy efficiency," including a breakdown of results for the South and individual sectors. The estimate of energy efficiency potential in the South's residential sector in 2020 from the McKinsey study is 26%.

This study's estimate for residential efficiency potential is essentially identical to the estimate for Appalachia (Brown, et al., 2009), which included many of the Southern states and involved a similar analytic approach. Our result is comparable to the moderate scenario in the IWG (2000) study of the nation, but is substantially less than that study's advanced scenario. A significant portion of the residential savings from both the McKinsey and IWG studies are attributable to improved lighting technologies (about 16% in the case of McKinsey). Yet lighting was excluded from the residential estimate in this study because most of its potential savings have now been legislated through lighting standards and have been subtracted from the baseline forecast of future consumption. It is likely if lighting had been included in this study, the estimated energy efficiency potential within the residential sector might have increased by 1-2%.

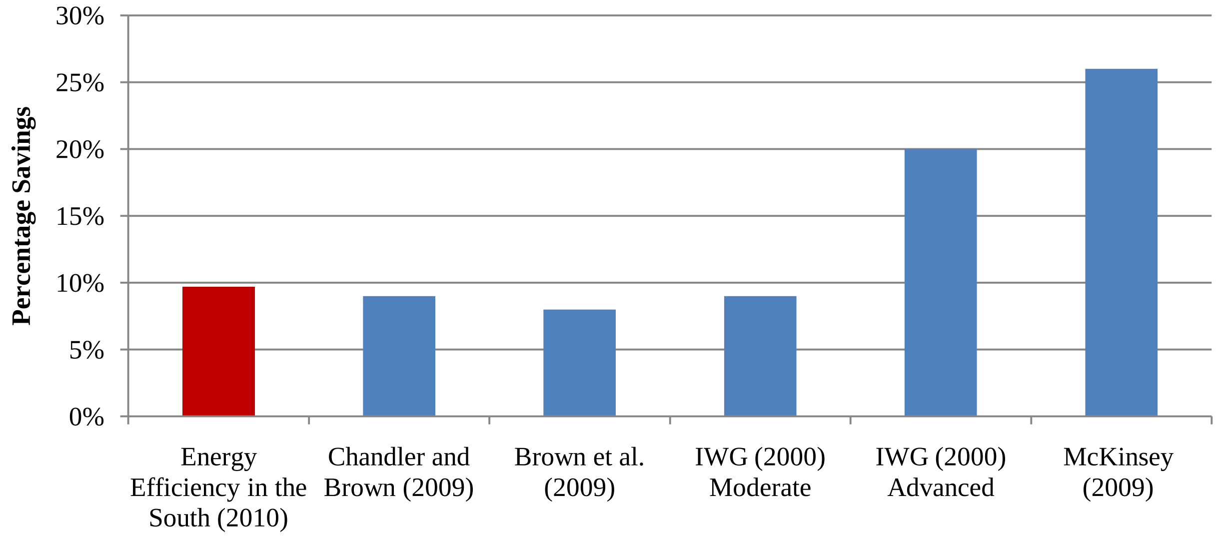

Figure 3.23 Comparison of Residential Energy Savings Estimates Across Studies

EPRI (2009) provides an estimate of residential electricity efficiency potential for the South in 2030. The realistic potential for efficiency is estimated to be 5%, and the maximum potential is larger at 8%. These estimates are considerably smaller because they only take into account the reduction in electricity consumption that could occur as the result of programs run by electric utilities. As a result, they do not include the potential savings from building codes or appliance standards (Personal Communication with Ammi Amarnath, Electric Power Research Institute, December 10, 2009). No comparison of overall estimates in 2030 was conducted due to the limited number of studies that provided estimates for that year.

3.5.2 Limitations and Needs for Future Research

This analysis of energy efficiency potential in the residential sector in the South has several limitations that require further analysis and research than was possible in this project. Specifically, the analysis could be improved in several ways.

A. **Include more technology options, especially emerging technologies, to better model the energy efficiency potential.** The technology profiles included in the SNUG-NEMS input files are limited and in some cases do not reflect the most recent advancements. For instance, integrated heat pump systems are not included in the residential technologies, despite existing commercialization activities. This limits the technology options available for incentives and standards. The residential retrofit policy only incentivized 13 technologies and only implemented standards for 18 technologies. Greater technology options would allow for more realistic modeling of the energy efficiency potential.

B. **Account for household behavioral effects to identify a wider range of energy efficiency potential.** SNUG-NEMS employs price elasticities of demand that result in limited demand sensitivity for some technologies. It employs a price elasticity of zero for clothes washers, dish washers, stoves, refrigerators, and freezers. The price elasticities of the remaining residential technologies, such as TVs and computers, are set at -0.15. This set of modeling assumptions may accurately reflect past consumer behavior in periods of energy price volatility, but it might not accurately reflect consumer behavior in the present or future, should energy prices continue to rise in real terms. With the growing appreciation of how energy consumption impacts environmental quality and national security, future consumer behavior could further enlarge the savings estimate as the demand for energy efficient technologies grows. Though SNUG-NEMS does include a rebound effect in estimating energy demand for heating and cooling, the inclusion of additional behavioral effects would provide a more precise efficiency potential estimate.

C. **Internalize all cost analyses.** The private and public costs for residential retrofit incentives and equipment standards, appliance incentives and standards, and building codes with third party verification policies were all obtained from SNUG-NEMS model outputs. However, the costs for the expanded Weatherization Assistance Program and all administrative costs were calculated off-line since SNUG-NEMS does not report these values. Future work could internalize these costs within the SNUG-NEMS model.

D. **Further sensitivity analyses would strengthen results.** For instance, sensitivity on fuel prices and discount rates could provide a range of efficiency estimates under various scenarios, which might better bracket the range of future energy-efficiency potential possibilities. More detailed sensitivity analysis could also be conducted on policies that have been bundled, such as appliance incentives and standards, to examine the individual effects of the components through integrated sector runs. This would allow an understanding of the impact of incentives, separately from appliance standards.

E. **Benefits beyond the scope of this report should be acknowledged.** This study only examined the benefits of the energy savings from the policies. Energy efficiency not only saves energy, but also can reduce environmental impacts and improve human health. For example, greater energy efficiency can reduce water used for power generation. This in turn can improve water quality and aquatic habitats. The societal benefits accrued from the non-energy benefits of energy efficiency may be significant and worthy of additional consideration.

F. **Other policies may expand the energy efficiency estimate for the South.** In addition to the modeled residential policies, other policies exist that may have further increased the efficiency potential. Due to time and modeling limitations, a lighting efficiency policy was not included even though additional efficiency potential would be expected from LEDs and recessed can lighting.

These limitations suggest the presented estimate of residential energy efficiency potential is conservative because it does not include certain behavioral effects, estimates for lighting, the full range of technologies, environmental benefits, and other possible policies.

4. ENERGY EFFICIENCY IN THE COMMERCIAL SECTOR

4.1 INTRODUCTION TO COMMERCIAL BUILDINGS IN THE SOUTH

The commercial sector in the South consumed 6,800 Trillion Btus of primary energy in 2007, while the total non-renewable energy expenditures were nearly $62 billion. EIA projects that the total energy consumption in the South will increase to 8,9 Trillion Btus by 2030, growing at an annual rate of 1.2% (EIA, 2009). According to this forecast, energy consumption in the commercial sector is increasing more rapidly than in any other sector. Electricity and electricity related losses represent more than 80% of the primary energy consumption in this sector, and natural gas accounts for another 11% (EIA, 2009). One nation-wide study indicates that a deployment of all cost-effective efficiency improvements in the commercial sector could achieve a 29% energy consumption reduction by 2020 (McKinsey Global Energy and Materials, 2009).

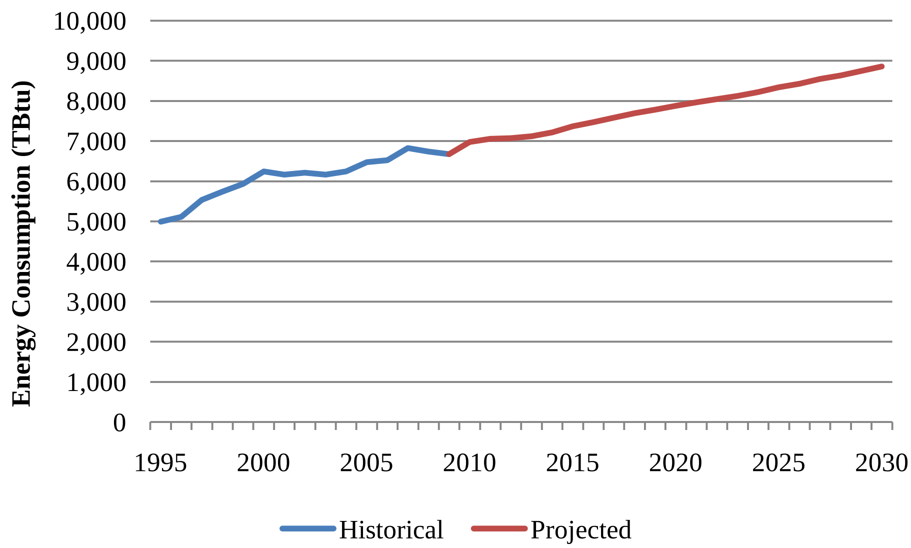

Figure 4.1 Primary Energy Consumption in the South

Compared to the rest of the country, the commercial sector in the South currently uses a larger proportion of electricity (Figure 4.2). Commercial buildings in the South are newer compared to the rest of the country. However, in terms of both number of commercial buildings and floorspace, the South's building stock is the largest and accordingly it presents a large potential for increasing energy-efficiency.

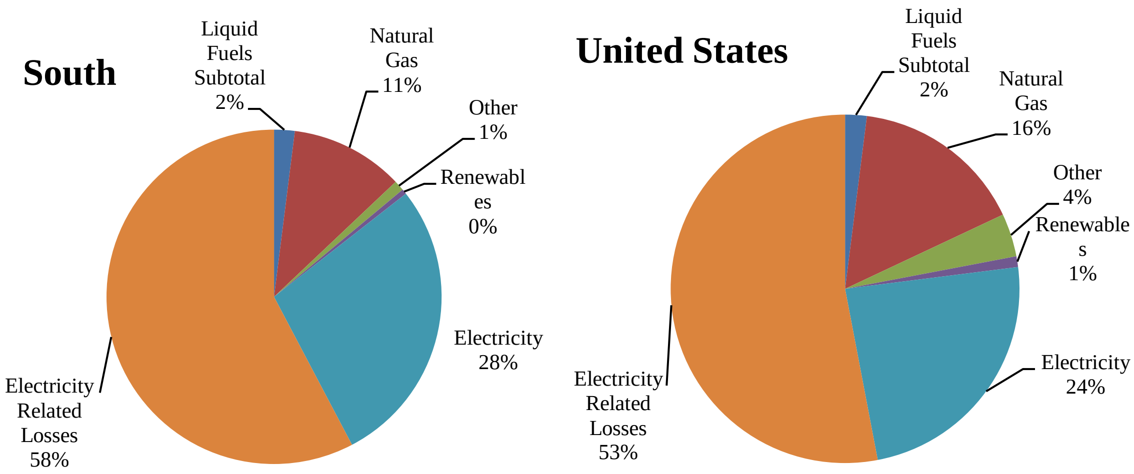

Figure 4.2 Commercial Energy Source by Fuel in 2007 (EIA,2009)

A number of commercial efficiency programs exist in the South. Maryland and Washington DC have adopted state-specific commercial appliance standards for equipment that is not covered by federal standards. Several states, such as Alabama, Florida, North Carolina, and Virginia have policies that promote energy efficiency in public buildings through retrofitting programs (U.S. Environmental Protection Agency 2008). Table 4.1 shows the number of commercial building and floorspace that they represent in the South.

Table 4.1 Commercial Buildings in the South by Building Type, 2003

	Number of Buildings (thousands)	**Total Floorspace (million square feet)**
Principal Building Activity	156	3,983
Education	94	487
Food Sales	127	764
Food Service	48	1,277
Health Care	100	2,970
Lodging	295	5,094
Mercantile	545	8,877
Office	92	1,174
Public Assembly	15	373
Public Order and Safety	158	1,498
Religious Worship	198	1,358
Service	277	3,966
Warehouse and Storage	21	Q
Other	88	701

(CBECS, 2003)

4.2 BARRIERS TO COMMERCIAL ENERGY EFICIENCY AND POLICY OPTIONS

4.2.1 Barriers to Energy-Efficiency in Commercial Buildings

Energy-efficient commercial buildings are seen by many experts to be one of the most cost-effective strategies for cutting energy costs and curbing carbon emissions (McKinsey & Company, 2009, p. xii; National Academy of Sciencs, 2009). However, for a variety of reasons, developers, building owners, and tenants typically under invest in these "NPV-positive" improvements.

The ***large, diverse, and fragmented*** nature of the buildings industry helps explain some of this underinvestment. Developers, architects, engineering firms, leasing agents, and many others influence the design and construction of commercial buildings, and they often do not represent the long-term interests of building owners and occupants (CCCSTI, 2009; Brown et al., 2009). This market structure results in an overemphasis on minimizing first costs, meaning that owners and occupants are saddled with higher operating costs, including energy bills.

Once a commercial building is built, the ***landlord-tenant relationship*** becomes a disincentive for energy upgrades (Murtishaw and Sathaye, 2006). When the tenants pay the energy bill, the landlord is not incentivized to invest in efficient equipment. The situation that favors the purchase of efficient equipment (when the landlord pays the utility bill) leads to a disincentive for the tenants to use energy wisely (Ottinger and Williams, 2002). Since 51% of nongovernment-owned commercial buildings are rented or leased (DOE, 2008, Table 1.3.8), commercial buildings are particularly prone to this problem of misplaced incentives.

In the buildings industry, there is also a ***workforce training gap***. Many architects, engineers, builders and tradespeople do not have access to sufficient training in new technologies, new standards, new regulations, and best practices. Lowe and Oreszczyn (2008) describe this lack of knowledge as a remnant of the shift of the construction industry from one of apprenticeship to one of labor, and they suggest that the industry will need to become a producer of human capital in order to support a new generation of buildings. Local government authorities tend to face this gap as well with building code officials working without skills necessary to evaluate compliance with building energy codes.

The result of these (and many other) market barriers and obstacles is a large reservoir of lost opportunities for improving the energy efficiency of U.S. buildings.

4.2.2 Policy Options to Improve Energy-Efficiency in the Commercial Sector

This study evaluates two policies[15] to improve energy efficiency in commercial buildings and appliances in the South: Aggressive Commercial Appliance Standards, wherein more stringent

[15] Originally, there was a third policy, Commercial Building Codes, which has been advocated for in a number of studies. However, after preliminary modeling, the energy efficiency gains from reduced heating were fully offset by increased cooling. After discussing this with a number of experts (North Carolina State Energy Office, Oak Ridge National Laboratory, and Energy Information Agency), we determined that using SNUG-NEMS to model tighter commercial building shells would not show efficiency improvements because of the increased internal heat gains from lighting and electronic equipment that would require air conditioning.

appliance standards are implemented; and Incentivizing HVAC Retrofits, where customers are encouraged to upgrade their current appliances with higher efficient ones. These polices, as with most of those in other chapters, are envisioned as being more aggressive than existing programs but are anticipated to be no cost or low cost. For the purposes of this study, these policies are implemented across the South uniformly. However, the way these policies would actually be implemented may vary and would conform to the specific goal and capacity of each policy making body (local, state, or federal). Table 4.2 shows some supporting actions and policies that states may wish to pursue in conjunction with or instead of the policies described in this report.

The relevance of this analysis should extend beyond the potential of implementing these particular policies. Rather these policies are general enough that a range of potential implementations could attain the energy and economic effects by reaching similar levels of avoided energy consumption.

Table 4.2 Policy Actions that Support Commercial Energy Efficiency

Actions	HVAC Retrofit Policy	Aggressive Commercial Equipment Standards
Research, Development, and Demonstration	Development of new insulation, heating, and cooling technologies useful for the local climate	Support for research and development for innovation in appliance performance
Financing	Low or no-interest loans for incremental cost of improvements for existing buildings Efficiency Grants Enable performance contracting	Low or no-interest loans for ENERGY STAR equipment Enable performance contracting
Financial Incentives	*Incremental cost incentives for efficient retrofits* Tax credits for efficient purchases	Incentives to use efficiency features and lower consumption Tax credits for efficient purchases Equipment buyback programs
Regulations	NA	*Tighter office equipment standards* *Tighter equipment standards* *Standby efficiency standards*
Information Dissemination & Training	Training Architects, Builders, Contractors, and Building Managers *Public awareness campaigns to inform consumers of the benefits of conservation and efficiency measures.* Awareness campaigns to inform executives of the benefits of efficiency measures Advanced metering or billing methods	Awareness campaigns to inform executives of the benefits of conservation and efficiency measures Advanced metering and billing
Procurement	Government lead by example procurement programs	Government lead by example procurement programs
Capacity Building	Centers for energy efficiency to train next generation of architects, builders, retrofitters	N/A

This table describes policy actions available that could further the savings from the policy packages modeled in this study. The policy actions shown in *italics* are modeled in this study, while the others are not.

There are many advanced technologies whose adoption would lead to higher efficiency in commercial buildings. One example is centrifugal chillers. Centrifugal chillers are large chillers that use a centrifugal compressor (Figure 4.3). They produce water that is used in building space cooling equipment. It is the most efficient chiller in the mechanical compression family, which also includes reciprocating and screw chillers. High efficiency centrifugal chillers are designed to have enhanced controls, enlarged and improved condensers and high efficiency compressors (FEMP, 2006).

Chiller efficiency is measured in electric use per ton of cooling (kW/t). The best available centrifugal chillers have a full-load efficiency of 0.47 kW/t[16] (DOE, 2004). A typical 500 ton centrifugal chiller managed at full load can achieve an annual saving of 210MWh compared to a base model with a full load efficiency of 0.68 kW/t. Assuming the electricity rate is $0.06/kWh, one high efficiency centrifugal chiller can help reduce annual electricity bill by $12,600 per year. Based on its estimated 23 years lifetime, lifetime energy cost savings could be as high as $170,000 (DOE, 2004). Though the upfront cost is relatively high for high efficiency centrifugal chillers, this technology provides promising economic benefits both through replacement and retrofitting.

There is no federal standard for centrifugal chillers. Though it is not mandatory, 18 states in the nation have adopted the more stringent code of 0.58 KW/t in ASHRAE 90.1-2004 standard. In SNUG-NEMS, there are different vintages of centrifugal chiller and the highest efficiency level reflects the best available technology.

Figure 4.3 High Energy Efficiency Centrifugal Chiller

Lighting is the largest consumer of energy in commercial buildings. Lighting technology has been innovating a great deal in the past few decades making bulbs more energy efficient and environmentally friendly. The 60 LED light bulb, for example uses only 6 Watts but has the equivalent luminescence of a traditional 60 Watt incandescent bulb, which means it uses only 10% as much electricity. Currently, it is one of the most efficient bulbs, has a light output of 300

[16] Full load efficiency is measured in peak load condition described in ARI standard 550/590-98

lumens and a warm light temperature of 3000K. Though the upfront cost to replace regular bulbs with this high efficiency one is relatively high, it has a long lifespan of 35,000 hours of Pharox 60 (compared to an average of 1,000 hours of incandescent bulb), which may make the payback attractive for some segments of consumers.

Figure 4.4 High Energy Efficiency LED light Bulb
(Source: www.inhabitate.com/2009)

4.3 MODELED ENERGY EFFICIENCY POLICIES FOR COMMERCIAL SECTOR

4.3.1 Commercial Appliance Standards

Minimum energy efficiency standards for many major appliances were first established by the U.S. Congress in Part B of Title III of the Energy Policy and Conservation Act (EPCA), as amended by the National Energy Conservation Policy Act, by the National Appliance Energy Conservation Act, by the National Appliance Energy Conservation Amendments of 1988, by the Energy Policy Act of 1992, by the Energy Policy of 2005 (DOE, 2009a) and by Energy Independence and Security Act of 2007. These laws and regulations set energy conservation standards for commercial heating, air conditioning, and water heater equipment (42 U.S.C. 6313(a)). Specifically, the statutes set standards for small, large, and very large commercial package air conditioning and heating equipment, packaged terminal air conditioners, packaged terminal heat pumps, warm-air furnaces, packaged boilers, storage water heaters, and unfired hot water storage tanks. For these types of equipment, the laws and regulations established federal energy conservation standards that generally correspond to the levels set in the American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) Standard 90.1 (DOE, 2009b)

EPCA directs DOE to consider amending the existing federal energy efficiency standard for each type of equipment listed, each time ASHRAE Standard 90.1 is amended with respect to such equipment (42 U.S.C. 6313(a)(6)(A)). For each type of equipment, EPCA directs that DOE must adopt amended standards at the new efficiency level in ASHRAE Standard 90.1 (DOE, 2009c). The latest version of ASHRAE Standard is ASHRAE Standard 90.1-2007, and it was approved for distribution and officially released to the public on January 10, 2008. Federal energy efficiency standards generally preempt state laws or regulations except in the case that DOE grants a waiver of Federal preemption (DOE, 2008) for a particular state law. As of 2009, the only state that has filed a petition is California. However, states are allowed to develop their own commercial appliance standards for any equipment that is not covered under federal standards.

Commercial Appliance Standards in the South. Required by federal rule, all states adopt federal energy efficiency standards. California has successfully petitioned to implement standards that are more stringent than federal standard for five commercial appliances. In the South, state standards are not as vigorous as in other regions such as New England.

Maryland and Washington DC are the only southern entities which have adopted their own standards for commercial appliances. Maryland has standards for Reach-In Refrigerators and Freezers, Commercial Air Conditioner, Commercial Clothes Washers, Unit Heaters, Hot Food Holding Cabinets and Water Dispensers. Washington DC has its own commercial appliance standards for Walk-In Refrigerators and Freezers, Hot Food Holding Cabinets and Water Dispensers (ASAP, 2009b). However, these standards have been superseded by or will be superseded by federal standards that are scheduled to be put in place in the next few years. Compared to residential appliance standards, federal standards for commercial appliances are less well developed. As there is ample opportunities to achieve meaningful energy efficiency savings through improving commercial appliances standard. This study develops a set of stringent commercial appliance standard to cover many commercial end uses where there is no existing federal standard.

Aggressive Commercial Appliance Standards. The definition of our standard policy is the aggressive implementation of cost effective commercial appliance standards in the South. Previous studies of similar policies, though with different geographical focus, show significant energy and energy bill savings and indicate the cost-effectiveness of appliance standards. With a national model of energy savings using appliance and equipment standards, Rosenquist et.al identified 12,000 Trillion Btu nationwide of cumulative primary energy saving during the 2010-2030 period. They note that potential energy bill savings from commercial sector standards have a greater net present value than those from the residential sector (Rosenquist et.al., 2005). Another analysis, *Energy Efficiency in Appalachia*, identified an energy saving potential in 2030 of 143 trillion Btu in the Appalachian region just from implementing commercial appliance standards (SEEA, 2009)

This appliance standard policy focuses on ten end uses: space heating, space cooling, water heating, ventilation, cooking, lighting, refrigeration, office equipment (PCs), office equipment (non-PCs), and miscellaneous. Table D.1.1 in Appendix D.1 lists about thirty technologies that were identified as candidates or proxies for standards.

SNUG-NEMS Modeling. Aggressive standards are implemented through making changes to the commercial technology input file in SNUG-NEMS. This is done by eliminating the most inefficient appliances and thereby accelerating the switch from less efficient appliances to more efficient ones. There are nine for most appliance technologies, different types become availabe each decade (usually at least three). This policy generally eliminates the least efficiency option each decade. Table 4.3 uses the example of water heaters to illustrate how this policy stimulates the switch from lower efficiency appliances to higher ones. In the reference forecast, most businesses have purchased the lowest efficiency equipment installed. Appendix D.5 shows the forecasted energy consumption changes for six commercial end uses.

Table 4.3 Energy Consumption Changes Due to Standards Policy*

Technology Description	Energy Efficiency Factor	Reference		Standards Policy	
		2020	2030	2020	2030
HP Water Heater	2.30	100%	100%	0%	0%
	2.40	0%	0%	100%	100%
Gas Water Heater	0.78	55%	53%	0%	0%
	0.93	45%	47%	100%	100%
Oil Water Heater	0.78	60%	55%	0%	0%
	0.80	40%	45%	100%	100%

* These refer to the percentage of new appliances purchased in the reference case and in the policy.

This policy also includes a 2% annual efficiency improvement for the three other end uses not included in the technology input file: office equip-PCs, office equip-non PCs, and all other uses[17]. This is done directly as there are no technology choices for these end uses. SNUG-NEMS has a separate input file which contains annual energy efficiency improvement for these services. Appendix D.2 describes the changes made to SNUG-NEMS input files.

These three end-uses compromise a significant share of the commercial sector's energy consumption. In the *Annual Energy Outlook 2009* reference case, it is forecasted that energy consumption from these three sectors will grow from 6,900 to 11,000 Trillion Btu between 2006 and 2030. This growth increases their share from 38% to 47% of total commercial energy consumption.

Standards Policy Results: Energy Savings and Efficiency. In the Reference future, after implementing standards, energy savings in the commercial sector is 9,790 trillion Btu in 2030 (Figure 4.5), which represents 17% reduction in commercial primary energy consumption relative to the reference case. West South Central and South Atlantic regions have larger energy savings than the East South Central in both 2020 and 2030 as is shown in Figure 4.6. They both reach 12% energy saving in 2020 and 18% in 2030. Table 4.4 shows the primary energy savings in Trillion Btu's from each of the three census divisions.

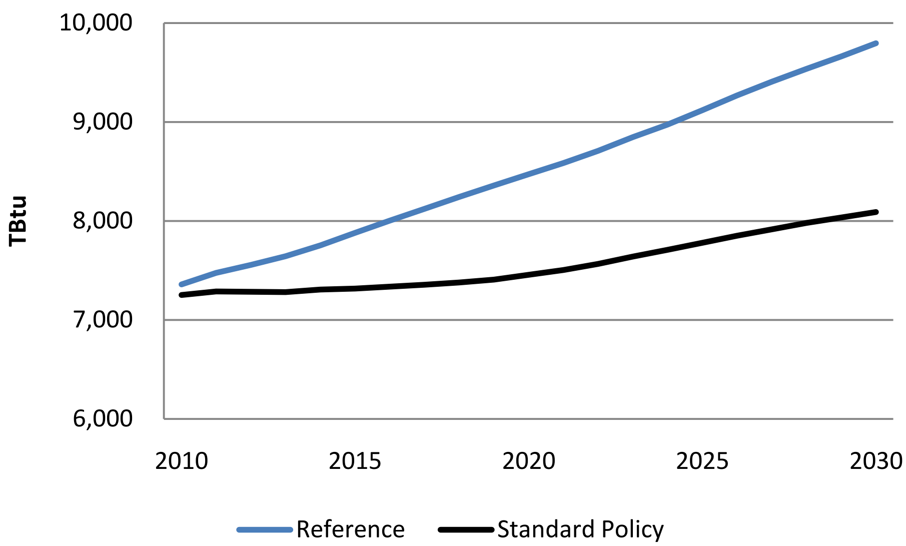

Figure 4.5 Commercial Primary Energy Consumption in the South

[17] Other uses includes miscellaneous uses, such as service station equipment, automated teller machines, telecommunications equipment, medical equipment, pumps, emergency generators, combined heat and power in commercial buildings, manufacturing performed in commercial buildings, and cooking (distillate), plus residual fuel oil, liquefied petroleum gases, coal, motor gasoline, and kerosene.

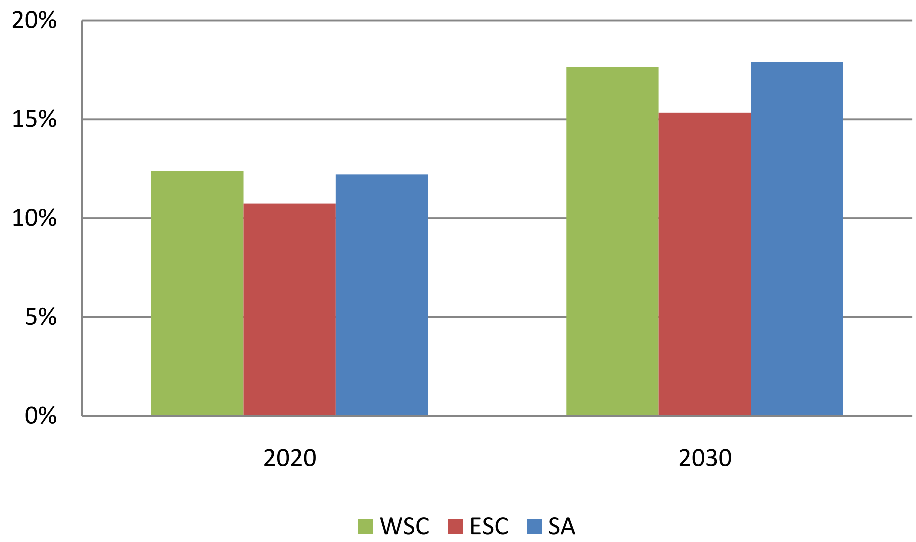

Figure 4.6 Energy Savings in 2020 and 2030 from Aggressive Standards

Table 4.4 Primary Energy Savings from Aggressive Standards (TBtu)

	WSC	ESC	SA	Total
2020	320	140	560	1,020
2030	520	220	960	1,700
Cumulative to 2049	10,910	4,720	19,760	35,390

Standards Policy Results: Energy Bill Savings. Aggressive standards will reduce energy bills in all three regions compared to the Reference case (Figures 4.7). Energy bill saving in 2030 in the three regions ranges from 17% (South Atlantic) to 20% (West South Central).

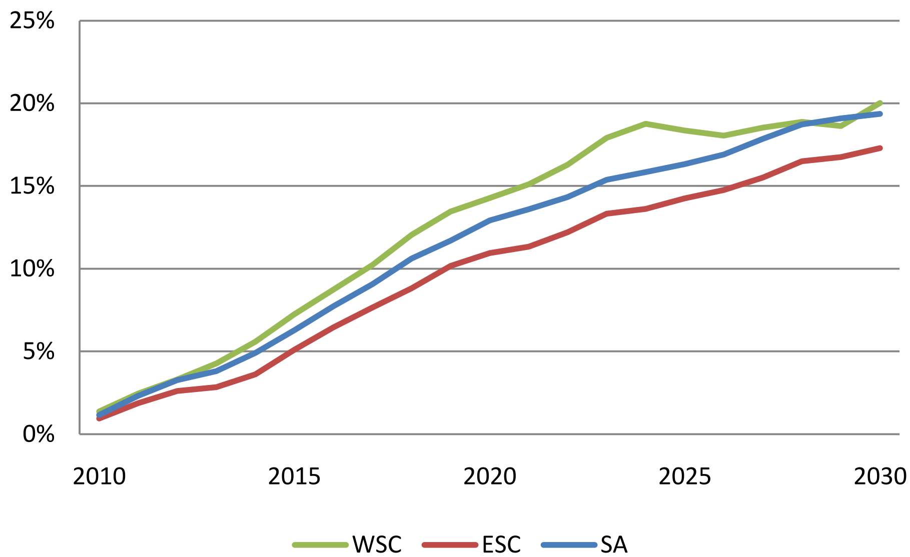

Figure 4.7 Energy Bill Savings from Aggressive Standards Policy

Standards Policy Results: Levelized Cost of Energy Efficiency. The levelized cost reflects the cost to achieve a particular amount of energy saving through commercial energy efficiency policies. Table 4.5 shows the levelized cost of electricity, natural gas and total energy efficiency for the standards policy. Both the electricity and natural gas numbers are lower than the current energy rates for commercial business in most southern states.

Table 4.5 Levelized Cost of Energy Efficiency from Standards Policy in 2020	
Electricity Efficiency (¢//kWh)	3.1
Natural Gas Efficiency (¢/Therm)	3.1
Total Energy Efficiency ($/MMBtu)	9.3

Standards Policy Results: Economic Test. While energy bill savings measures commercial benefits, the costs of implementing standards are both the private and public. Private parties invest in the more expensive but higher efficient appliances while the public costs are those associated with administrators incur administration and program.

These standards are being evaluated for 20 years starting in 2010 and the investments will occur during the same period, the energy savings will continue beyond this period, for the lifetime of the products installed through 2030. Figure 4.8 illustrates the costs ending in 2030, and extended benefits from the aggressive standards policy. The energy bill savings exceed the public and private investments by many times, indicating that the policy is highly cost-effective. An "Annual Cost and Saving" table in Appendix D.4 summarizes the cost and saving from standards policy as well as the HVAC retrofit policy and the commercial combined policy and it further emphasizes the dynamic nature of cost and savings pattern and the cost-effectiveness of the policy.

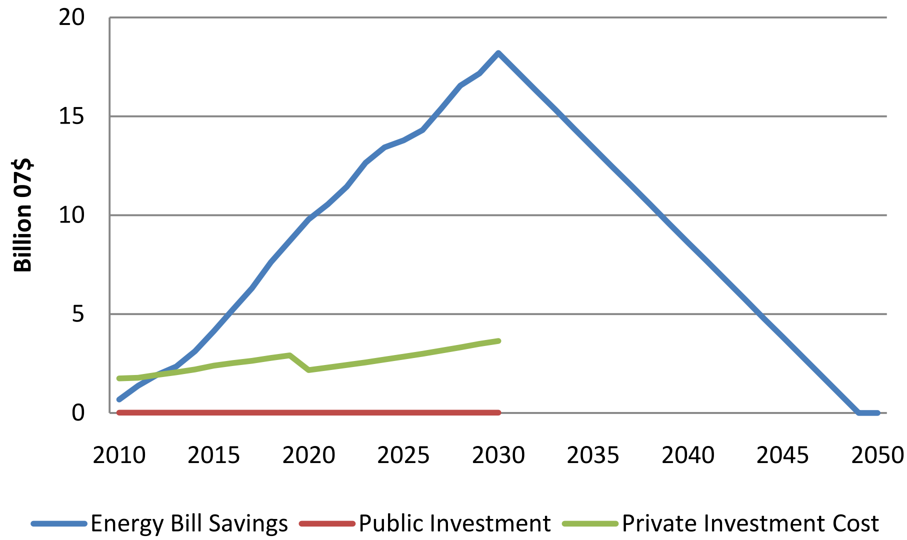

Figure 4.8 Costs and Savings from Aggressive Standard Policy

Table 4.6 shows the regional public and private cost in 2020 and 2030 and net present values calculated for the Total Resource Test. The benefit-cost ratio is one measure of the cost effectiveness of a program. A ratio greater than 1 indicates higher benefits than costs.

Table 4.6 Total Resource Test for Aggressive Standards Policy

	(Million $2007)					B/C
	Annual Public Costs		Annual Private Costs	Total Costs	Total Savings	
	Administration Cost	Investment Cost	Investment and Others*[1]	Cumulative Costs	Cumulative Savings *[2]	
2020	10	0	2,170	16,050	31,730	4.6
2030	10	0	3,620	26,270	81,320	
NPV	80	0	26,220	26,300	109,400	

*[1] A range of investment related to "Office Equipment (PC)" "Office Equipments (Non PC)" and "Other" end uses are estimated externally. Total resource test used the mid range value, which is considered as the best estimate. For more details, please reference to Appendix D.3

*[2] NPV of cumulative savings includes post 2030 savings

4.3.2 Commercial Building HVAC Retrofit

Background. New, high efficiency energy efficient heating and cooling technologies can reduce an energy bill up to 25% (Farrel et.al, 2007).To be effective, a commercial building HVAC retrofit program should provide information and incentives for property owners to replace lower efficiency HVAC systems with newer, more efficient ones.

Retrofitting in the South. Some southern states and utilities have begun to implement programs that encourage commercial building HVAC system efficiency upgrades. States can use Energy Efficiency Resource Standards to motivate utilities to work with energy services companies to upgrade performance of commercial building systems (Amann et al., 2005). These energy services companies, also known as ESCO's, can offer contracting services with financing options based on the payback period for the energy savings realized. Utilities may facilitate this process by offering incentives tied to reduction in energy demand.

States also can play an important role in encouraging energy efficiency by mandating minimum efficiency requirements in public buildings. According to the U.S. Environmental Protection Agency, several southern states, such as Alabama, Florida, North Carolina, and Virginia have policies that promote energy efficiency in public buildings (EPA, 2008). South Carolina requires that new and renovated public buildings attain LEED Silver certification, or the equivalent. The U.S. Green Building Council states that many local governments across the region require energy and green building certifications for public buildings (U.S. Green Building Council, 2009). States may choose to work closely with utilities and local governments to more effectively use available federal funding. Financial support could be in the form of efficiency grants, low interest loans, tax credits, or rebates. Providing flexible and widely available financial incentives can go a long way toward stimulating investment in high efficiency commercial building upgrades (World Resources Institute, 2009).

Commercial Building HVAC Retrofit Policy. The retrofit policy conceptualized in this study could be made up of a set of teams whose task is to evaluate commercial building space within their home state or region. These teams would distribute information about energy efficiency and the eligibility requirements for available financial incentives. Each team would also provide auditing services which identify potential energy savings achievable through individual technology or whole building system retrofits. Oversight of these teams would be managed by a program administrator.

SNUG-NEMS Modeling. The policy as modeled in this study reduces the capital costs for installation of nine higher efficiency technologies, each of which come from one of three end uses: space heating, space cooling and ventilation. Seven technologies are incentivized by 30%. A different incentive is applied to ventilation. The two ventilation technologies receive 9% incentive.[18] Appendix D.2 summarizes the incentivized technologies.

HVAC Retrofit Policy Results: Energy Efficiency. Primary energy consumption is reduced as a result of this policy (Figure 4.9). The total reduction of primary energy in 2030 is 316 TBtu.

[18] Ventilation has a lower incentive rate because the relative costs are closer among technology vintage classes and a larger incentive seemed to be more costly than necessary.

Table 4.7 shows the primary energy savings from each region in 2020, 2030 and overall. The West South Central has the largest relative saving in both 2020 and 2030 (Figures 4.10).

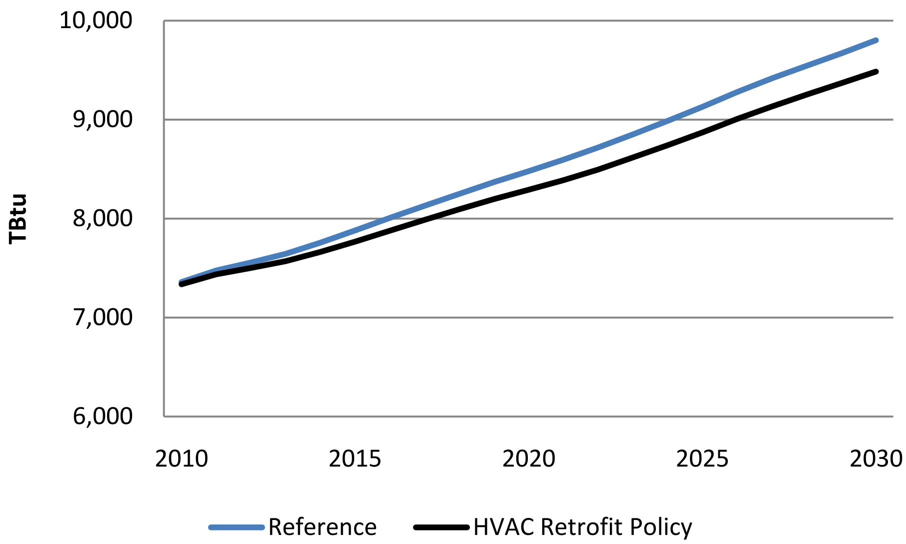

Figure 4.9 Change in Primary Energy Consumption in the South with the HVAC Retrofit Policy

Table 4.7 Primary Energy Savings with the HVAC Retrofit Policy (TBtu)				
	WSC	**ESC**	**SA**	**Total**
2020	63	28	98	189
2030	101	43	172	316
Cumulative to 2049	2,120	940	3,600	6,600

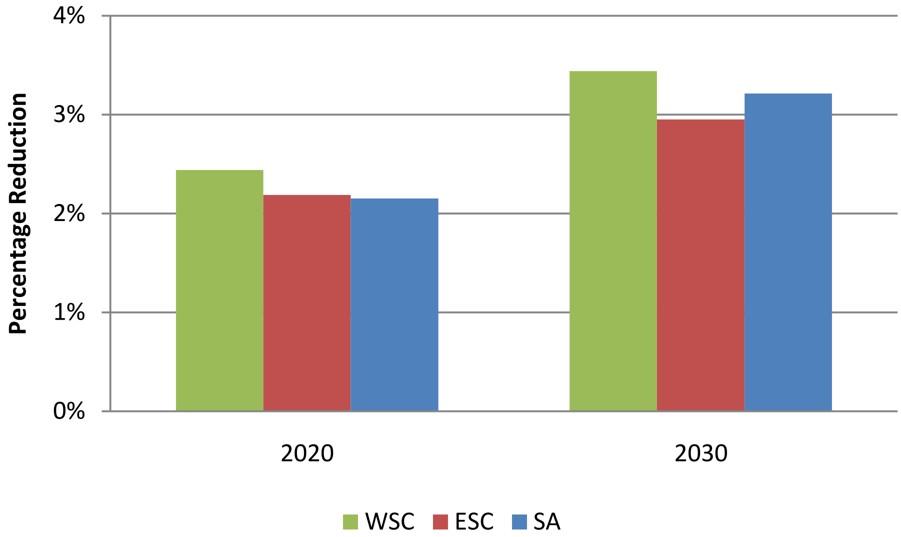

Figure 4.10 Primary Energy Savings in 2020 and 2030 with the HVAC Retrofit Policy

HVAC Retrofit Policy Results: Energy Bill. The commercial HVAC retrofit program modeled in this study achieves a reduction in commercial energy bill of 2 to 3% by the year 2020 (Figure 4.11). The WSC's energy bill saving is noticeably higher than the other regions after 2020.

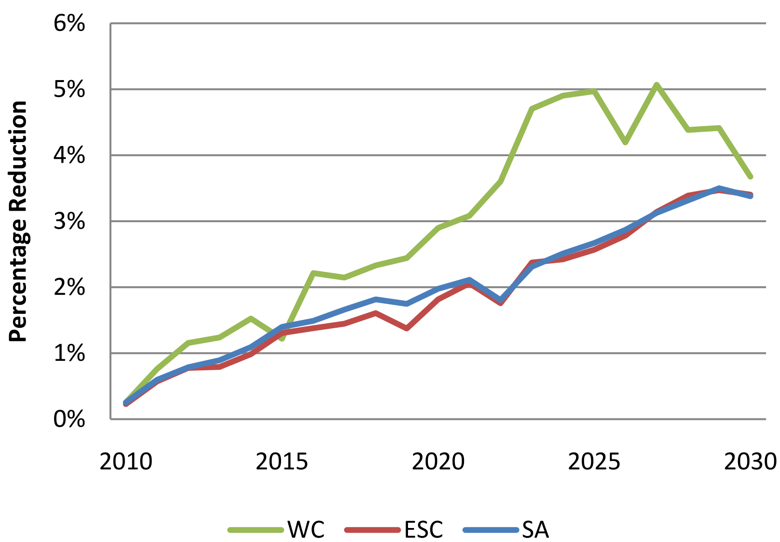

Figure 4.11 Energy Bill Savings from the HVAC Retrofit Policy

HVAC Retrofit Policy Results: Levelized Cost. The natural gas efficiency improvement modeled for this policy is smaller than 1% of the total energy efficiency from the same policy. Therefore, only the levelized cost of electricity efficiency and total energy efficiency are estimated. Compared with the standards policy, the HVAC retrofit policy is higher in cost (Table 4.8). However, the levelized cost of electricity is still lower than most of the commercial electricity rates in the southern States.

Table 4.8 Levelized Cost of Energy Efficiency from the HVAC Retrofit Policy in 2020	
Electricity Efficiency(¢//kWh**)**	4.2
Total Energy Efficiency ($/MMBtu)	12.3

Economic Tests. The private investment cost to carry out the HVAC retrofit policy is negative meaning business's pay less for the equipment that is incentivized than they would have paid for less efficient equipment without incentives. Note that this negative cost is offset by the cost of the subsidy, shown as public investment (Figure 4.12). Energy bill savings exceeds the costs of this program by almost 150%, which indicates the cost-effectiveness of the HVAC retrofit policy (Table 4.9). The annual savings and costs are shown in Appendix D.4.

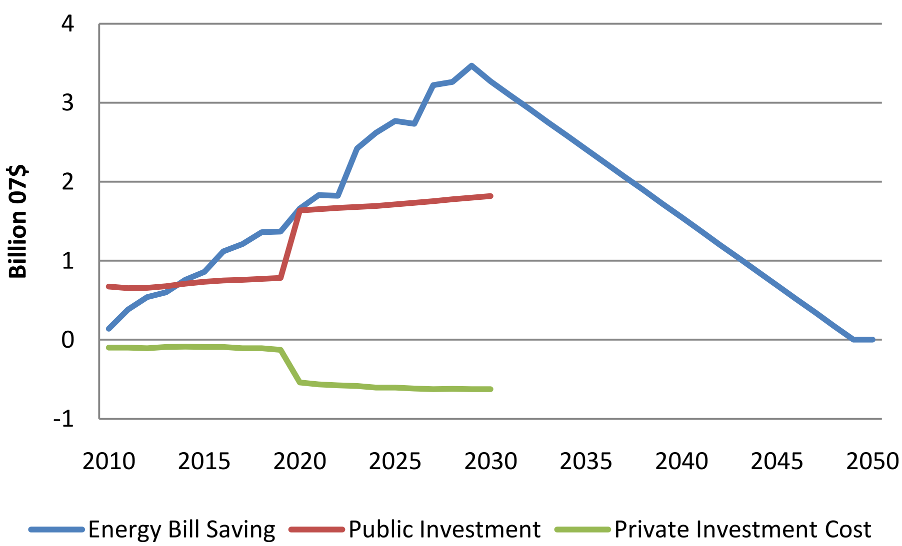

Figure 4.12 Costs and Savings from HVAC Retrofit Policy

Table 4.9 Total Resource Test for HVAC Retrofit Policy						
	(Million $2007)					B/C
	Annual Public Costs		Annual Private Costs	Total Costs	Total Savings	
	Administration Cost	Investment Cost	Investment and Others	Cumulative Costs	Cumulative Savings	
2020	50	1,580	-540	4,550	6,390	2.4
2030	50	1,760	-620	8,540	14,000	
NPV	570	11,050	-3,070	8,540	20,850	

4.4 COMBINED COMMERCIAL POLICIES, RESULTS

The rest of this chapter describes the analysis of combining the aggressive standards and HVAC retrofit policies. SNUG-NEMS modeling effects can be overlapping and synergistic so results will not add up to the sum of the previous results.

4.4.1 Energy Efficiency

By implementing the combined commercial policies, the annual energy efficiency gain in 2030 in the South is 1,980 trillion Btu in the reference scenario. This represents a 20% reduction in energy consumption compared to the reference case. (Figure 4.13) The dotted lines on this plot represent a sensitivity analysis for these policies. The sensitivity analysis was done to determine whether modeling a generic carbon constraint, called the Carbon Constrained Future (CCF)[19], would dramatically reduce or increase the effectiveness of these particular policies.

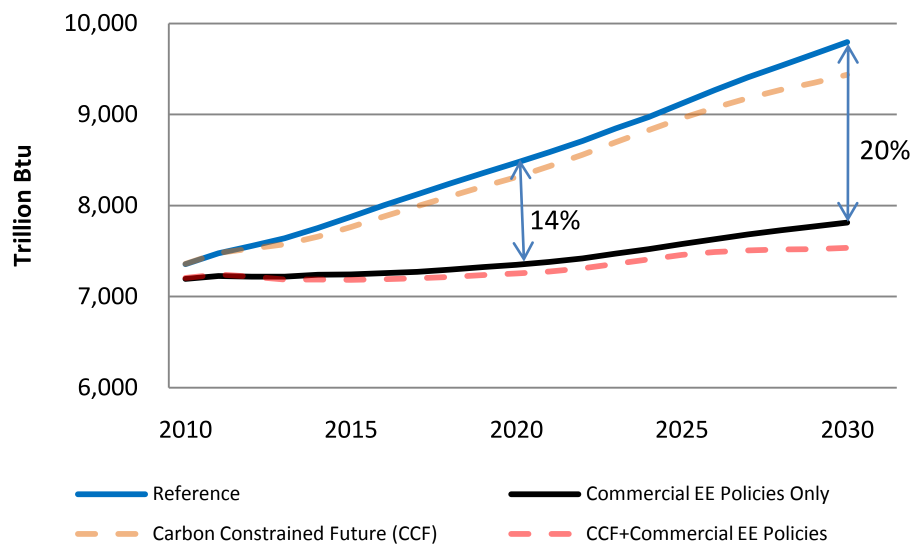

Figure 4.13 Primary Energy Consumption in South U.S. with Commercial Policies

[19] CFF is explained in detail in section 6.3.2

The percentage energy saving from the combined policies is very similar to that from aggressive standards alone because 83% of the total commercial energy savings come from the standard policy. The West South Central region shows the largest relative saving of 14% in 2020 and 21% in 2030 (Figure 4.14). In terms of actual Btu avoided, the South Atlantic has the greatest savings in both 2020 and 2030, as it is shown in Table 4.10.

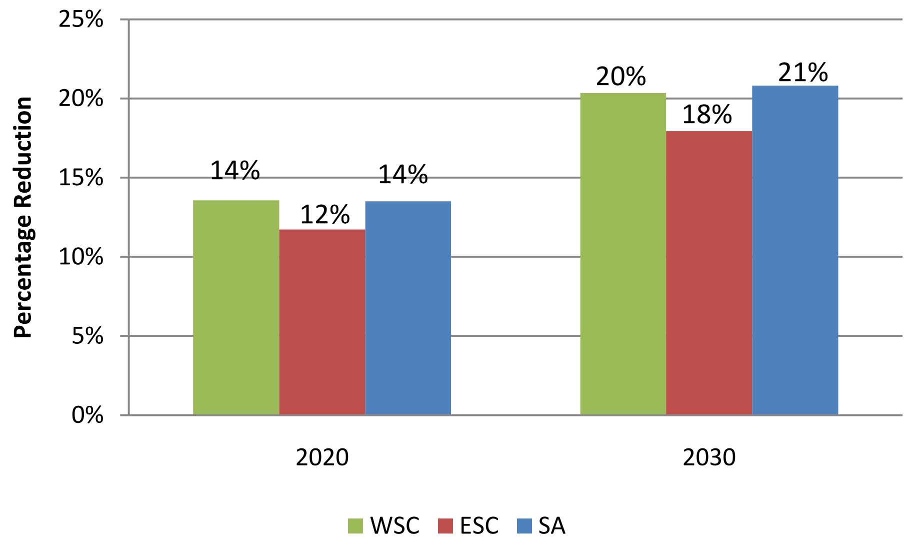

Figure 4.14 Energy Efficiency Potential in 2020 and 2030 with Commercial Policies

Table 4.10 Primary Energy Savings from Commercial Policies (TBtu)			
	WSC	**ESC**	**SA**
2020	360	150	620
2030	600	260	1,120
Cumulative to 2049	12,500	5,440	22,830

4.4.2 Energy Bill Savings

Commercial savings due to energy efficiency policies in all three regions exceed ten percent in 2020 and reach approximately 20% in 2030 (Table 4.11). Under the reference scenario, commercial consumers would pay an estimated $11 billion less in energy bills in 2020 and $21 billion less in 2030. Figure 4.16 shows how bill savings change over time.

Table 4.11 Energy Bill Savings (Billion 07$)				
	2020		**2030**	
WSC	$3.5	16%	$7.0	24%
ESC	$1.3	12%	$2.5	20%
SA	$6.1	14%	$11.7	22%
South Total	**$10.9**	**15%**	**$21.2**	**22%**

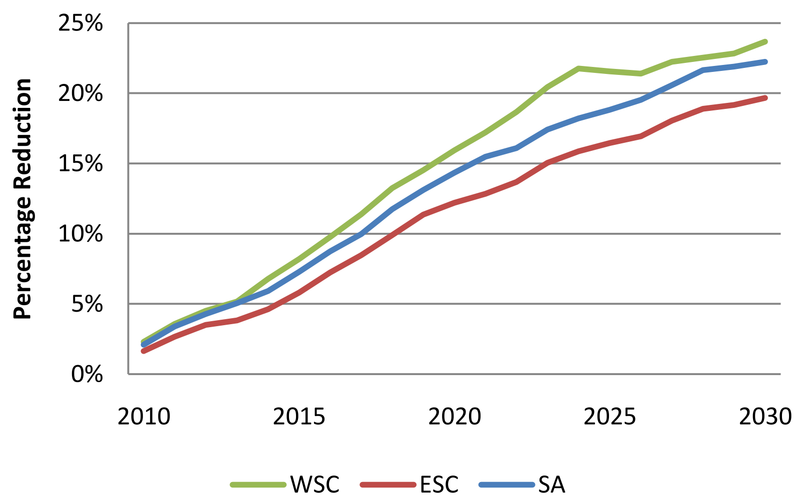

Figure 4.16 Energy Bill Savings from Commercial Policies – Reference Scenario

4.4.3 Economic Test of Combined Commercial Policies

According to the total resource test, these commercial sector policies are cost-effective (Table 4.12). Private investment on commercial energy efficiency measures drops by over 50% in 2020 while public investment is doubled in the same year (Figure 4.17). This is because most of the retrofitting starts in 2020 and the associated subsidies drive the changes in public and private investment after that year. Private investment is increasing over time related to office equipment and other end use purchases.

Table 4.12 Total Resource Test for Commercial Policies

	(Million $2007)						**B/C**
	Annual Public Costs		**Annual Private Costs**	**Total Costs**	**Total Savings**		
	Administration Cost	**Investment Cost**	**Investment & Other**	**Cumulative Costs**	**Cumulative Savings**		
2020	60	2,050	890	23,590	59,500		4.0
2030	60	2,350	2,180	31,530	94,100		
NPV	680	15,230	15,660	31,530	126,300		

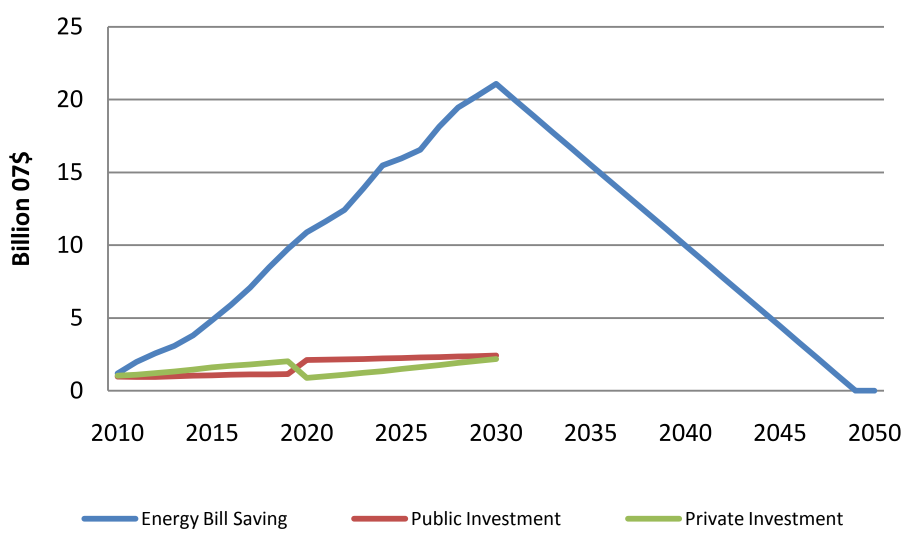

Figure 4.17 Costs and Savings from Commercial Policies-Reference Scenario

4.5 SUMMARY AND DISCUSSION OF RESULTS FOR COMMERCIAL SECTOR

The commercial energy efficiency policy bundle is forecasted to help the South achieve a 14% primary energy reduction in 2020 (1,200 TBtu saving from EIA's reference forecast) and a 20% reduction in 2030 (2,100 TBtu saving compared to EIA's projection). Aggressive standards, individually, could reduce the South's primary energy consumption by almost 18% in 2030 while commercial HVAC retrofit policy would reduce by nearly 3%, in 2030, relative to the reference scenario. Figure 4.18 shows most of the energy efficiency savings in commercial sector is from standards policy while HVAC retrofit policy is also significant. The levelized costs of electricity and natural gas efficiency are low for both commercial policies, compared to the energy rates that are currently charged in the South. Table 4.14 summarizes the energy savings potential by policy that has been discussed in this chapter.

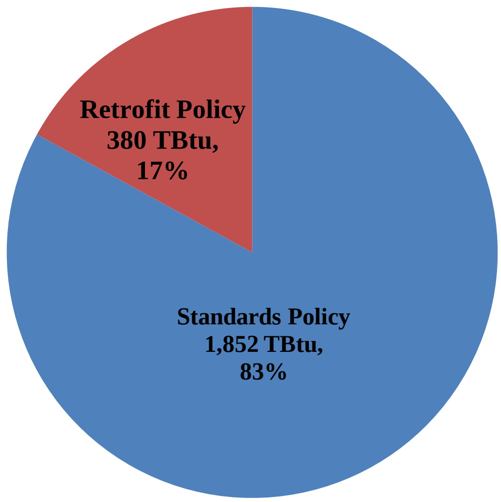

Figure 4.18 Commercial Energy Savings by Policy in 2030

Table 4.14 Commercial Primary Energy Savings - Reference Scenario (Trillion Btu)

	2020				2030			
	WSC	ESC	SA	Total	WSC	ESC	SA	Total
Aggressive Equipment Standards	360	150	630	**1,140**	560	250	1,050	**1,860**
HAVC Retrofit	100	40	160	**300**	130	50	200	**380**
Policy Bundle	370	160	650	**1,180**	630	280	1,170	**2,080**

These policies could generate over $20 billion in energy bill saving in 2030. While there are costs to public and private entities, these costs are relatively small compared to the benefits. Both policies are cost-effective as measured by the total resource test.

4.5.1 Comparison with Other Studies

A large number of studies have examined topics related to the energy efficiency potential in the South and the key results from some of them are summarized in Figure 4.19. In a recent review, Brown and Chandler (2009) examined 26 energy efficiency potential studies published over the past 12 years. They conclude that the energy efficiency potential for the South's commercial sector in 2020 is 1,400 TBtu which equals 14% of the region's commercial energy consumption forecast. Brown and Chandler's result is very close to the estimates from this study (14% and 1,200 TBtu in 2020). Another study, Brown et al. (2009), covering the Appalachian region showed somewhat a larger energy efficiency potential from the commercial sector. They estimated that the Appalachian region, which includes many of the Southern states, could achieve 22% savings from energy efficiency in the commercial sector in 2020. The discrepancy between this study and the Appalachia study may be attributed to the different policy coverage. In this study, the estimated commercial energy savings come from the policy bundle which includes only two policies, commercial appliance standards policy and HVAC retrofit policy. However, the Appalachia study also included building codes and commissioning of the existing building as part of their commercial policy package and the energy savings associated with these two polices are significant.

In the same year, McKinsey and Company (2009) released their estimates of national energy efficiency potential based on their "NPV-positive potential for energy efficiency" approach. This report includes results for each individual sector. McKinsey's commercial energy efficiency potential for the South is 32% in 2020, which means 3,000 TBtu of energy consumption could be avoided in a cost effective way. This estimate is more than twice as high as our result for at least three reasons. First, beyond commercial buildings and office equipment, McKinsey identified the potential from community infrastructure, such as water purification treatment, water distribution, street and traffic lights, as 13% of the national total energy efficiency, and these savings are not fully captured in our study. Second, McKinsey identified certain cost effective measures to improve energy efficiency of buildings and office equipments that are not modeled in our study, such as voluntary building standard for private commercial building and mandatory benchmarks or standards for government buildings. Finally, the McKinsey study focuses on "economic potential" and not "achievable potential", which takes into account the inability of policies to realize all of the cost-effective energy savings.

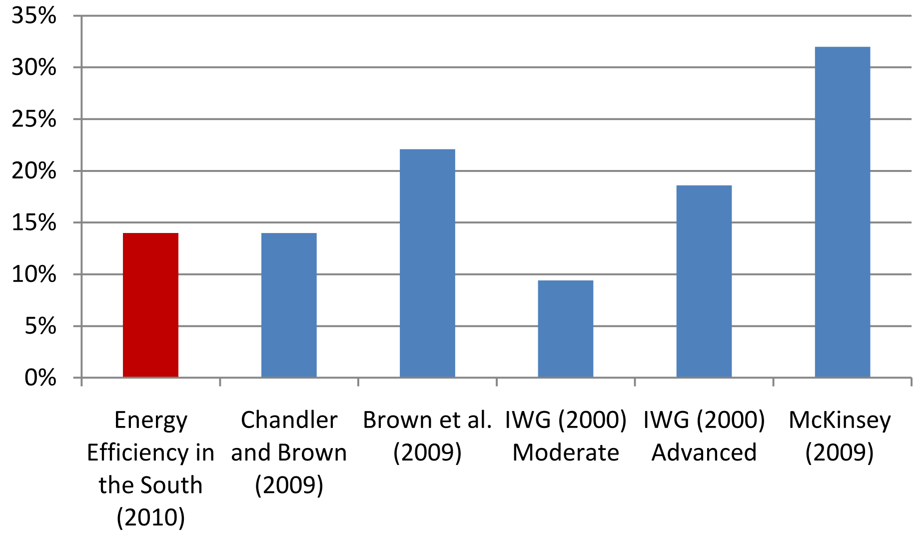

Figure 4.19 Comparison of Estimates of Commercial Energy Efficiency Potential in 2020 from Other Key Studies

In summary, our estimate falls in the middle of the range, it is higher than the Interlaboratary Working Group's (IWG) Moderate scenario estimate of 9.4% (equivalent to 1,700 TBtu avoided consumption) while lower than IWG (2000) Advanced scenario estimate of 19.1% (3,400 TBtu avoided consumption. Though the IWG analysis was a national level study, the gap between our estimates and IWG's is not due to regional idiosyncrasies. Rather, as with the McKinsey and Appalachia (2009) studies, a significant portion of the commercial sector energy efficiency potential estimated in IWG (2000) Advanced is attributed to new buildings through a building codes policy. As discussed in the next section, a commercial building codes policy was excluded from this study.

EPRI (2009) offers an estimate of commercial electricity efficiency from the utility point of view.[20] In 2020, the commercial sector realistic potential is estimated by EPRI to be 5% and maximum potential is 10%. They are both lower in comparison to our results. Because EPRI only considers the electricity efficiency potential that can be realized through utilities' programs, appliance standards as well as other approaches that are implemented by state and federal government regulations are not considered. This means that EPRI's electricity efficiency potential estimate covers only a portion of the overall commercial sector potential that other studies estimate.

4.5.2 Limitations and Needs for Future Research

This analysis of the energy efficiency potential in the South uses an integrated energy model (SNUG-NEMS) with many strengths and advantages over alternative approaches. However, the analysis could be strengthened in several ways.

[20] The EPRI estimate is not shown in Figure 4.19 because they estimate electricity not total energy efficiency potential.

A. **Include more technology options in both policies to identify more energy efficiency potential.** The number of technologies modeled in this study is limited. There are 59 different types of technologies in the commercial technology input file. Thirty seven of them were chosen to be subject to more stringent standards. In the HVAC retrofit policy, nine types of technologies are incentivized. Being selective in choosing technology subjects, we limited the number of technologies modeled, therefore underestimating the energy efficiency potential, especially for the retrofit policy.

B. **Account for real market behavioral shifting to identify a wider range of energy efficiency potential.** Due to the limitations in SNUG-NEMS, we assume there is no shifting across classes of equipment due to our policies. For instance, even if the retrofit incentives make the rooftop Air-Source Heat Pumps more economically desirable than a Rooftop Air Conditioner for heating, consumers who have a Rooftop Air Conditioner cannot switch to purchase a rooftop Air-Source Heat Pump. Instead, their purchase decision is limited to alternatives within their existing technology class. In practice, however, this is not true because consumers have freedom to choose between different types of technologies in a free market. Accounting for behavior shifting that is currently limited by SNUG-NEMS, could identify more energy efficiency potential.

C. **Internalize the cost estimates.** Most of our analysis is conducted inside the SNUG-NEMS model so that we can fully capture the interplay between different factors. There are only two exceptions. The administrative cost of the two policies and the private investment costs associated with the office PCs, non-PC office equipment and other equipment are estimated externally because SNUG-NEMS does not report these costs. Appendix D.3 explains the method developed in this study to calculate the administrative costs and investment costs associated with office equipments and miscellaneous end uses. Future work that would refine this analysis includes internalizing the costs in SNUG-NEMS modeling process.

D. **Additional sensitivity analysis could add more nuance to the results.** For example, with more time, a wider range of standards, standards customized by end-use, or more retrofit policies could have been evaluated. That would allow us to explore greater energy potentials in the South's commercial sector. In addition, sensitivity analyses on fuel prices and discount rates would offer a range of energy efficiency potential under different future scenarios.

E. **Certain benefits are beyond the scope of this report, but should be acknowledged.** The savings discussed here are primarily energy bill savings. However, in the real world, energy efficiency could help achieve not only energy savings but also environmental and public health benefits by reducing pollution such as CO_2, SOx and NOx from being emitted. These benefits may have significant value to society making the pursuit of energy efficiency policies even more attractive. Public health and environmental benefits are extremely hard to monetize but we would be remiss not to mention them.

F. **Other policy options also have the potential to expand the energy efficiency potential in the South.** For example, new buildings were not a focus of our policies but are a fertile area to pursue energy efficiency. New building codes were initially thought of as likely to be cost effective, however, due to the difficulties in SNUG-NEMS modeling, it was excluded from our analysis. In SNUG-NEMS, the relevant building code input file considers only the wall and roof rather than a whole set of building envelope which could also include windows and doors. In that case, a tighter building code with new envelope standard in SNUG-NEMS leads to an increase in energy consumption because the decrease in heating demand in the winter is offset by the growing demand from cooling in the summer. As a result of this counterintuitive outcome, we did not include building codes as part of our commercial energy efficiency policy bundle. Therefore, our policies are primarily focused on the existing commercial buildings though the appliance standard policy applies to both existing buildings and new constructions.

5. ENERGY EFFICIENCY IN INDUSTRY

5.1 INTRODUCTION TO THE INDUSTRIAL SECTOR IN THE SOUTH

The industrial sector in the South consumed about 16,500 Trillion Btu (or 16.5 quad) of energy in 2007 (EIA, 2009), which comprises 50% of the total U.S. industrial energy consumption. According to the EIA's Annual Energy Outlook (AEO) 2009, industrial consumption will remain significant, but shows a decreasing trend into the future. The reference forecast of industrial energy consumption in the South region is illustrated in Figure 5.1. Two-thirds of the industrial energy consumption is normally used for production processes, while one third of the energy is consumed as feedstock in several industries, such as chemicals, petroleum refining, and plastics manufacturing. Industrial energy consumption in the South is expected to remain relatively consistent at around 14,000 Trillion Btu through 2030 (EIA, 2009).

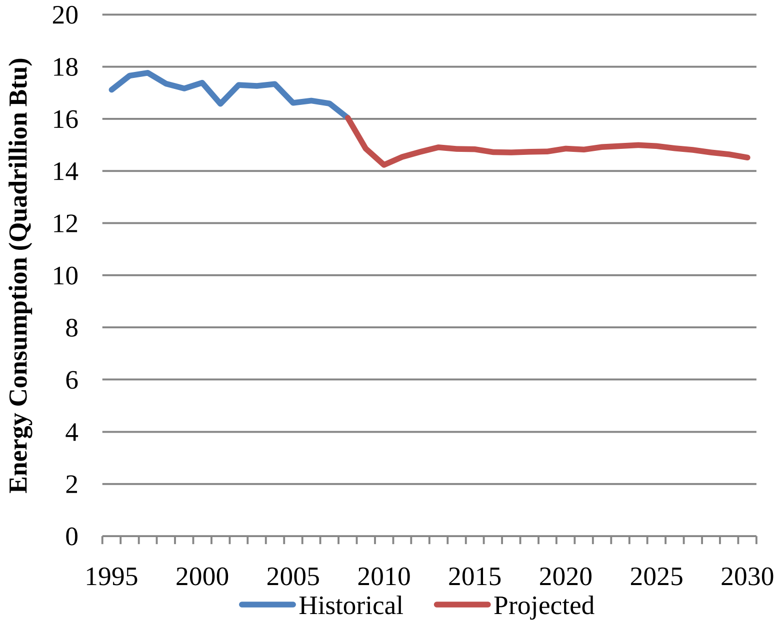

Figure 5.1 Energy Consumption Reference Forecast for Industry in the South (EIA, 2009)

Industrial energy users consume a wide variety of energy sources and use them to produce steam, heat, and electricity for operating equipment. Figure 5.2 illustrates the variety of fuels used by southern industries. Electricity and its related losses account for 28 percent of usage, while liquid fuels and natural gas respectively account for 36 and 24 percent.

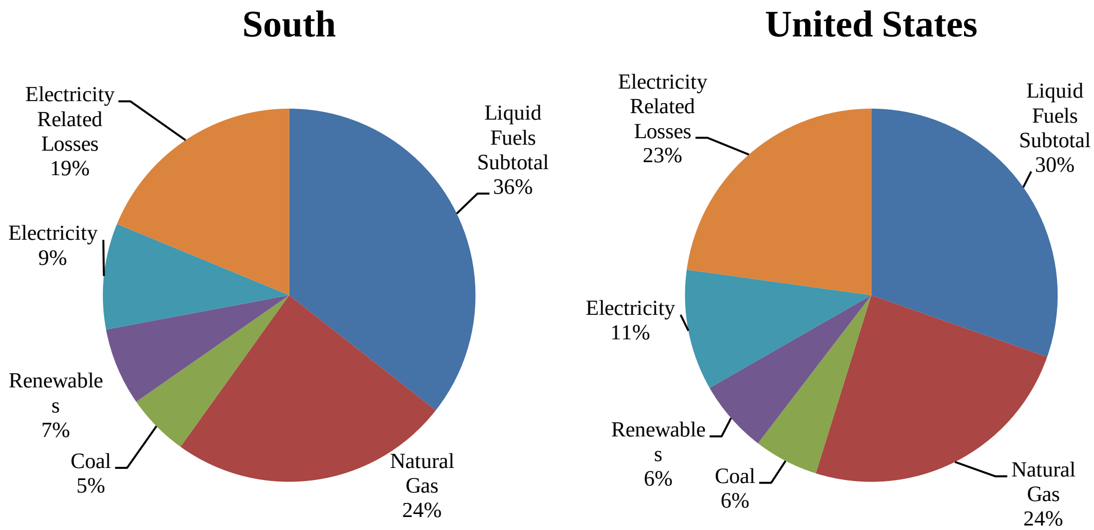

Figure 5.2 Industrial Energy Sources by Fuel, 2007 (EIA, 2009)

Although it accounts for more energy consumption than any other sector in the South, industry has fewer unique users; therefore, education and information dissemination can occur more rapidly and with less cost. Action at one industrial site can have more impact on energy consumption than action at a single residence or commercial enterprise. On the other hand, as industrial energy-efficiency improvements are often process or plant specific, it can be difficult to characterize technology specific potential for energy savings in this sector. Nevertheless, some policies can be discussed at a high level of aggregation.

In this study we have analyzed industrial energy efficiency policies from an energy savings perspective. Three promising regional policies that could contribute to reducing energy consumption in the future include: 1) expanded industrial assessment programs for plant utility upgrades, 2) accelerated industrial process improvement, and 3) technological development in combined heat and power (CHP) systems, combined with additional tax and subsidy programs for accelerating CHP development.

5.2 POLICY OPTIONS FOR INDUSTRIAL ENERGY EFFICIENCY

5.2.1 Barriers to Industrial Energy Efficiency in the South

The potential for greater industrial efficiency in the South results from the existence of numerous technical, corporate, regulatory, and workforce barriers to improvement. For example, companies must consider the ***technical risks of adopting a new industrial technology***. In today's manufacturing environment with 24/7 operations, reliability and operational risks represent major concerns for industry when adopting new technologies (National Academy of Sciences, 2009). ***Lack of specialized knowledge*** is a related impediment. To make optimal energy-efficiency decisions, plant managers must have working knowledge of a massive number of technologies (McKinsey and Company, 2008). Researching new technologies consumes time and resources, especially for small firms, and many industries prefer to expend human and financial capital on other investment priorities (Worrell and Biermans, 2005).

Relatively high initial costs for industrial energy-efficiency improvements result in longer payback periods than for traditional equipment. Senior managers often delay investing in costly refurbishments because they are uncertain about the longevity of their companies (McKinsey and Company, 2008, p. 9). Plant closures and production downturns in the textile industry in North Carolina and Georgia and in aluminum manufacturing in Kentucky and Tennessee illustrate that these are real concerns, particularly during the economic recession that began in 2008. Projects to improve energy efficiency have to compete for resources against projects that achieve other company goals and against familiar technologies. A large share of capital goes toward meeting government standards for health, safety, security, and emissions; the remaining discretionary capital is then allocated to other goals such as product improvement, production expansion, and (finally) cost savings such as energy efficiency. This ***lack of access to capital*** is one of the most significant barriers to energy efficiency improvements in industry (CCCSTI, 2009).

In the United States, existing ***fiscal policies are often unfavorable*** to investments in industrial efficiency. The current federal tax code discourages capital investments in general, as opposed to direct expensing of energy costs. Furthermore, outdated tax depreciation rules require firms to depreciate energy efficiency investments over a longer period of time than many other investments (Brown and Chandler, 2008). Existing ***regulations can also be unfavorable*** to industrial energy efficiency. The threat of triggering a New Source Review has prevented many upgrades from occurring (Brown and Chandler, 2008). Significant utility company interconnection fees, overly layered permitting processes, and the lack of net-metering policies provide disincentives for manufacturing plants to capture waste energy for the generation of electricity in combined heat and power systems. For example, many states have low limits for individual projects to receive net metering, such as 100 kW for commercial and industrial projects in Georgia, 30 kW in Kentucky, and 25 kW in West Virginia (Figure 5.3). Finally, ***policy uncertainty*** about the future cost of carbon emissions and the absence of an international climate agreement are leading to competitiveness concerns and reduced cooperation across firms (CCCSTI, 2009).

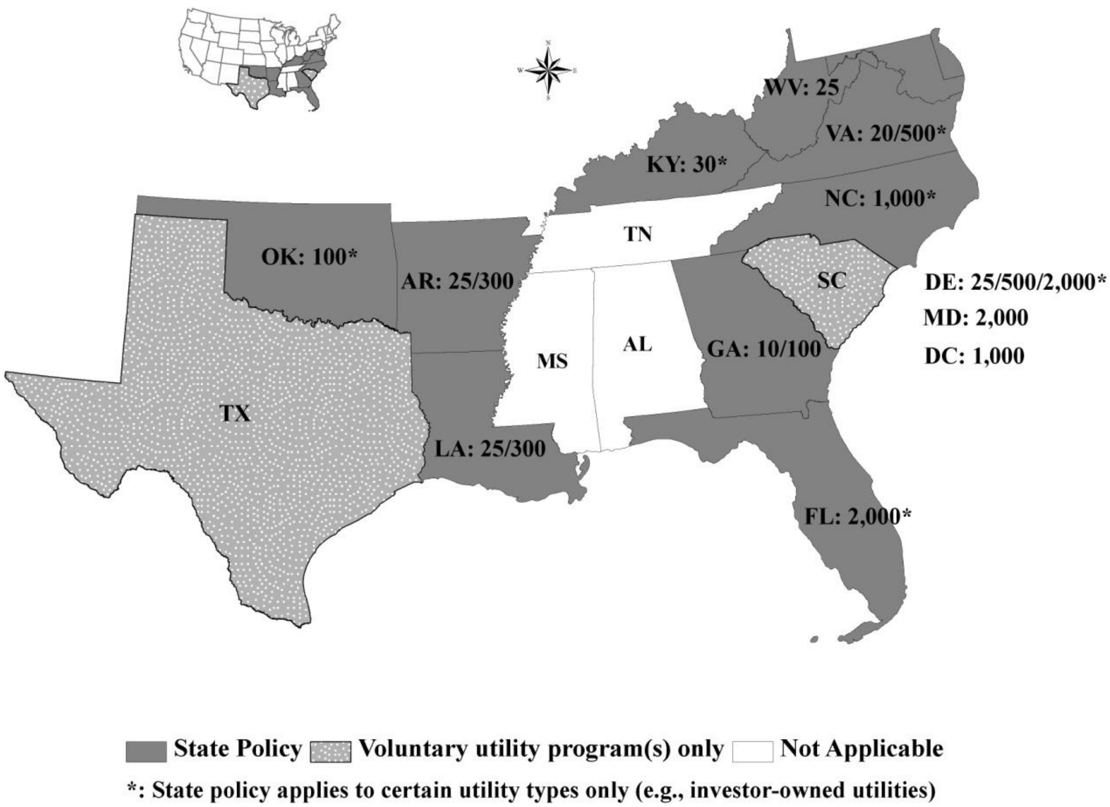

Figure 5.3 Geographic Variability of Net Metering (kW)

5.2.2 Policy Options

To address these barriers and support the expansion of industrial assessments in the South, several programs have been investigated. Three complementary policies were chosen to be modeled for energy efficiency potential. The first one is the Industrial Assessments of Plant Utility Upgrades, with the expansion of Industrial Assessment Centers (IACs), oriented to small and medium industrial sites, and increasing the scope of the Save Energy Now (SENA) program for large firms. These two programs of the DOE are oriented to monitoring the principal equipment that uses energy, such as motor and drive systems, pumps, steam systems, process heating and fans. This equipment requires regular maintenance to ensure optimal performance. The principal goal of these two programs is for specialists to visit the facilities and make recommendations in order to guarantee the efficient use of energy in consumptive equipment and identify replacements where needed. The second policy is to foster the acceleration of industrial process improvements. This policy ensures the implementation of most efficient technologies. The third policy option explored involves the stimulation of the installation of CHP units at industrial sites.

Table 5.1 lists complementary actions to these three policies. The policies and programs listed could be used as substitutions to the ones that were modeled in this study. The form of policies adopted in different parts of the South will depend on which critical barriers and market failures inhibit the market uptake of energy-efficient technologies and practices. These barriers vary across industries and census divisions of the South. The specific choice of policies will also reflect the goals and capacity of state and local agencies.

These three policies have the potential to reach nearly all southern industrial facilities by 2030. Policy-makers would need to provide resources for advertising and information dissemination in order to reach as many small to medium-sized industrial locations as possible. In addition, program personnel may need to travel to sites for in-person visits to discuss the benefits of industrial assessments. Once an industrial site requests an assessment, expert personnel should be available to act. In order to increase the number of industrial assessments within the Region, additional personnel should be added at current industrial assessment centers. The U.S. Department of Energy could ask additional universities to form IACs to keep up with new demand. This recommendation was taken into account in the last American Clean Energy Leadership Act of 2009.

Table 5.1 Policy Actions that Support Industrial Energy Efficiency

Actions	Industrial Assessments of Plant Utility Upgrades	Policies to Accelerate Industrial Process Improvements	Industrial Combined Heat and Power
Research, Development, and Demonstration	Increased equipment and system performance; reduced installed cost	*Increased equipment and system performance; reduced installed cost*	*Increased equipment and system performance; reduced installed cost*
Financing	Low or no interest loans for capital improvements	Low or no interest loans for capital improvements	Low or no-interest loans for CHP equipment purchase
Financial Incentives	*Assistance with energy audit costs*; grants and tax credits	Grants and tax credits	Grants, *tax credits, and subsidies* *- Extend the duration of existing Investment Tax Credit (ITC)* *- Subsidize a certain percentage of initial installation costs*
Pricing	Time-of-use rates	Time-of-use rates	Reduced rates for natural gas for CHP users
Voluntary Agreements	N/A	N/A	N/A
Regulations	Equipment standards	Equipment standards	Net metering and feed-in tariffs; equipment standards
Information Dissemination & Training	*Campaigns to inform small to medium-sized industrial sites of potential for energy and cost savings* *Training for on-site personnel during first*		Assessments to evaluate CHP feasibility at site; Campaign to inform industrial sites of the potential for energy and cost savings

Table 5.1 Policy Actions that Support Industrial Energy Efficiency			
Actions	**Industrial Assessments of Plant Utility Upgrades**	**Policies to Accelerate Industrial Process Improvements**	**Industrial Combined Heat and Power**
	assessment; *Software tools to perform Future assessments;* *Campaign to inform large industrial sites of the potential for energy and cost savings*		
Procurement	Assistance with equipment procurement to lessen lead times	Assistance with equipment procurement to lessen lead times	Assistance with equipment procurement to lessen lead times
Market Reforms	Public assistance fund	Public assistance fund	Public assistance fund
Planning Techniques	Outage management to facilitate energy-efficiency upgrades; zoning and land use planning	Outage management to facilitate energy-efficiency upgrades; zoning and land use planning	Outage management to facilitate energy-efficiency upgrades; zoning and land use planning
Capacity Building	*Increase the number of industrial assessment universities and personnel* Software development	Energy Service Company (ESCO) Incubators	
This table describes policy actions available that could further the savings from the policy packages modeled in this study. The policy actions shown in *italics* are modeled in this study, while the others are not.			

5.3 ENERGY EFFICIENCY POTENTIAL IN INDUSTRY IN THE SOUTH

This section describes the three policies evaluated to increase the industrial energy efficiency saving. In order to capture the potential energy saving of each industrial group, the authors collected a spreadsheet of state level data from the IAC and SENA programs which is presented in the following section.

5.3.1 Spreadsheet Analysis for Industrial Assessments for Plant Utility Upgrades

This policy is designed to stimulate current growth in industrial assessments to improve the plant's energy efficiency through the two DOE programs: IACs are oriented to save energy in small and medium-sized firms and SENAs are designed for relatively larger energy consumers. The information on energy use from these two programs had been analyzed below in order to obtain the source of potential energy efficiency necessary to modify and run the unit energy consumption in SNUG-NEMS.

Currently, there are 26 DOE Industrial Assessment Centers (IACs) located throughout the U.S. (DOE/EERE, 2009k), with 13 located in the South. These centers are university-based, and include teams comprised of both faculty and students who perform thorough energy analyses at small to medium-sized industrial facilities within the local region. These assessments suggest potential savings through improvements in energy efficiency, waste minimization, pollution prevention, and productivity. Table E.1 in the appendix illustrates the activities of this program in the South, including the number of assessments completed and the implementation rate of recommendations.

In order to estimate the potential benefits of increasing IAC capacity, findings from recent industrial assessments were evaluated. The resulting information was used with the state values of shipment by industrial groups to determine potential energy savings. The details of this spreadsheet analysis of IAC data are in Appendix E.1. The results of implementing increased IAC capacity are shown in Tables 5.2 and 5.3. Details of the IAC modeling, including baseline data, assumptions, and methodology are also detailed in Appendix E.1.

The IAC Program is estimated to reduce industrial energy consumption for small and medium companies by: 0.2% in 2010, 1.0% in 2020, and 1.4% in 2030, with a total of 0.207 Quads of savings in the South Region in 2030. The highest savings are expected to be in the West South Central division, with 47% of the total savings, followed by the South Atlantic and East South Central, with 31% and 22% respectively. Electricity constitutes a majority of the savings (0.129 Quads), while natural gas accounts for only 0.079 Quads of savings in 2030.

Table 5.2 Energy Savings from Increasing IAC Assessments and Training (TBtu), Spreadsheet Analysis

Region	Electricity Savings			Natural Gas Savings			Total Energy Saved		
	2010	2020	2030	2010	2020	2030	2010	2020	2030
WSC	18	42	61	3	24	36	22	66	97
ESC	3	24	35	1	8	12	4	31	46
SA	3	22	33	3	21	31	6	44	64
Total	45	88	129	7	54	79	32	141	208

(Source: DOE, IAC and Team Analysis)

These savings figures assume that IAC assessments are able to increase to completing assessments of nearly all small to medium-sized facilities by 2030 through an increase in the workforce and the number of centers located in or near the region. In 2006, the South was home to 14,112 small and medium manufacturing firms (50-250 employees). The energy savings could increase to 1.4 percent of the projected sector use, which represents 0.207 Quads of savings. This represents only part of the energy-efficiency gains possible in the region and is additive to the other industrial policy efficiency gains.

Table 5.3 Energy Use and Savings in 2030 Due to Increasing Industrial Assessment Centers (TBtu)				
Region	**Reference**	**Policy**	**EE Savings**	**Percentage Saving**
WSC	8,000	7,900	100	1.2%
ESC	2,910	2,870	40	1.6%
SA	3,640	3,580	60	1.8%
Total	14,550	14,350	200	1.4%

Like IAC assessments, SENA provides plant and facility managers with the tools they need to take control of their energy use, but these assessments take place at large industrial sites and only assess one system at a time (e.g. compressed air or steam). The impact of energy savings assessments on energy and economic savings has been documented by the SENA program. This program started in 2006 with a total of 200 plant assessments, almost 40% of which were conducted in the South Region. These assessments continued during the following years, as is shown in Table E.3 in the appendix.

Save Energy Now assessments conducted in 2006 included identification of ways to reduce natural gas and electricity use in steam and process heat. The assessments also focused on the on-site training of appropriate personnel to use the Save Energy Now software. In 2007, assessments included new areas, such as examining compressed air, fan, and pumping system.

Save Energy Now assessments were used to estimate the potential of energy savings for large energy consumption companies in the South Region (see Appendix E for details). The affect of expanding SENA are presented in Tables 5.4 and 5.5. This policy is estimated to reduce industrial energy consumption by: 1.1% in 2010, 3.6% in 2020, and 5.9% in 2030, with a total of 860 TBtu of savings in the South Region in 2030. Natural gas constitutes a majority of savings (560 TBtu), while electricity accounts for 300 TBtu of savings in 2030. Details of the SENA program modeling, including data, assumptions, and methodology are shown in Appendix E.

Table 5.4 Spreadsheet Estimate of Energy Savings from Increasing Save Energy Now Assessments (TBtu)									
Region	**Electricity Savings**			**Natural Gas Savings**			**Total Energy Saved**		
	2010	**2020**	**2030**	**2010**	**2020**	**2030**	**2010**	**2020**	**2030**
WSC	12	40	64	47	150	250	59	190	310
ESC	27	90	145	18	60	97	46	150	242
SA	16	54	86	40	140	220	58	190	305
Total	55	184	300	110	350	570	163	530	857

Table 5.5 Energy Use and Savings in 2030 Due to Increasing Save Energy Now Assessment (TBtu)				
Region	**Reference**	**Policy**	**EE Savings**	**Percentage Saving**
WSC	8,000	7,700	300	3.9%
ESC	2,910	2,670	240	8.3%
SA	3,640	3,330	310	8.4%
Total	14,550	13,700	850	5.9%

5.3.2 SNUG-NEMS Modeling of Industrial Assessments of Plant Utility Upgrades

The information obtained from this spreadsheet modeling was integrated into SNUG-NEMS by charging the values of the "unit energy consumption" and "technology possibility curve" reductions.[21] The results are shown in Tables 5.6 and 5.7 for industrial assessments for plant utility upgrades and for policies to increase the process improvement respectively. Because the industrial assessments program only included information about electricity and natural gas, these two energy sources were evaluated for this policy. The calculated energy savings for the IAC and SENA policies modeled in SNGU-NEMS were a total of 800 TBtu for the South in 2030, which include 450 TBtu of savings obtained from spreadsheet calculations for the oil refining industry, because oil refining is not part of the NEMS Industrial Demand Module. The potential savings for the refining industries were calculated based on information obtained from SENA assessments and extrapolated to the South (These savings were estimated from a spreadsheet analysis, for more details see Appendix E). More than 5% of the energy efficiency gains are expected in WSC and more than 3% in ESC and 2% in SA in 2030 (Figure 5.4).

[21] The technology possibility curve is an exponential growth trend corresponding to a given average annual growth rate, or technology possibility coefficient. The TPC defines the assumed average annual growth rate of the energy intensity of a process step or an energy end use.

Table 5.6 Total Energy Savings Industrial Assessment for Plant Utility Upgrades (TBtu)				
Year	**WSC**	**ESC**	**SA**	**Total**
2020	370	150	170	690
2030	430	170	200	800
Cumulative to 2050	10,500	4,400	5,000	19,900

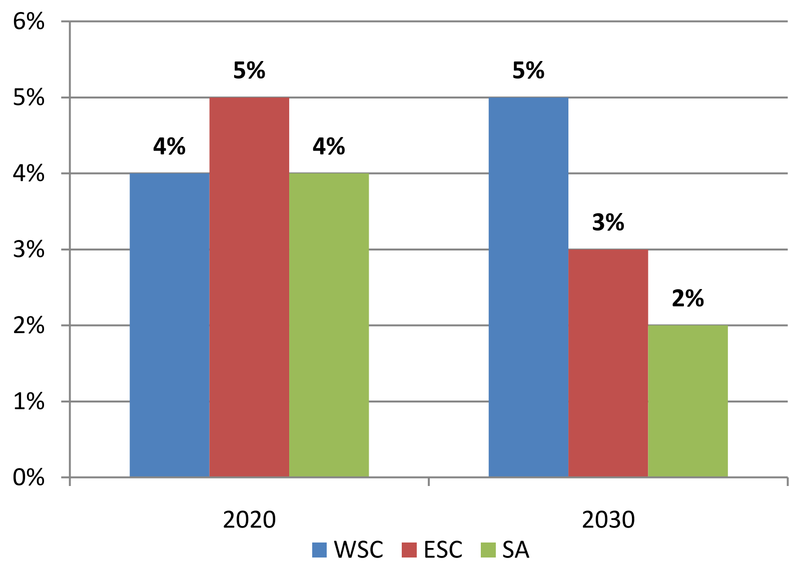

Figure 5.4 Primary Energy Savings for Plant Utility Upgrade Policy

The greatest electricity and natural gas savings in 2030 would occur in the chemical industry, although as a percentage reduction the values are not the highest because of the large energy budgets of this industry in 2010. The largest percentages of reductions are in paper and cement.

Table 5.7 Results from the Industrial Assessment for Plant Utility Upgrades in 2030 (TBtu)						
Industrial Sector	**Electricity Savings**			**Natural Gas Savings**		
	Reference Case	**Policy Case**	**% Difference**	**Reference Case**	**Policy Case**	**% Difference**
Chemicals	167	166	-0.4%	337	290	-14%
Paper	76	60	-20.7%	92	85	-8%
Cement	20	18	-4.0%	10	9	-8%
Oil and gas mining	91	81	-10.8%	226	165	-27%
Metal and other non-metal mining	39	35	-10.6%	14	10	-27%

Utility Upgrade Policy Results: Levelized Cost of Energy Efficiency. The levelized cost reflects the cost to achieve a particular amount of energy saving through our industrial energy efficiency policies. This study focuses on electricity efficiency potential, natural gas efficiency potential and total energy efficiency potential from each individual policy.

Table 5.8 shows the levelized cost of electricity, natural gas and the total energy efficiency in the Utility Upgrade policy. Both the electricity and natural gas numbers are lower than the energy rates charged to industrial business in most of the southern states.

Table 5.8 Levelized Cost of Energy Efficiency from Utility Upgrade Policy in 2020	
Electricity Efficiency (¢//kWh)	0.9
Natural Gas Efficiency (¢/Therm)	15.7
Total Energy Efficiency ($/MMBtu)	1.1

Economic Tests. The costs and savings for this policy are shown in Table 5.9. Investment costs are calculated from the cost information contained in the IAC and SENA programs. Both programs present detailed information about costs required to update plant utilities for increasing energy efficiency. All the investment costs are assumed to be made by the industry. Nevertheless, policy-makers could consider a public subsidy as part of the investment scenario, but that was not evaluated in this study. Administrative costs are assumed entirely by the public sector, which represents less than one percent of the total costs. The government role is to motivate industry to conduct energy efficiency assessments, through the creation of Champion programs. Additionally the public sector could establish a program for the diffusion of best practices in energy use for the 22 most significant industries, for small, medium and large firms (for more details about the calculation see Appendix E section).

Table 5.9 Total Resource Test -- Industrial Assessment for Plant Utility Upgrades Policy*						
	(Million $2007)					B/C
	Public Costs		Private Costs	Total Discount Costs	Total Discount Savings	
Year	Annual Administration Cost	Annual Investment Cost	Annual (Investment & Other)	Cumulative Costs	Cumulative Savings	
2020	10.6	0	750	8,600	17,100	
2030	9.3	0	590	10,800	38,700	
NPV	124	0	10,500	10,800	48,400	4.5

*Cumulative Costs beginning in 2010 and Savings beginning in 2011. NPV includes savings post 2030

Energy Bill Savings. This policy appears to be highly cost-effective. The energy bill savings exceed the public and private investments by many times. This policy's energy savings are is expected to decrease rapidly after 2030, since this is the last year when new assessments are modeled.

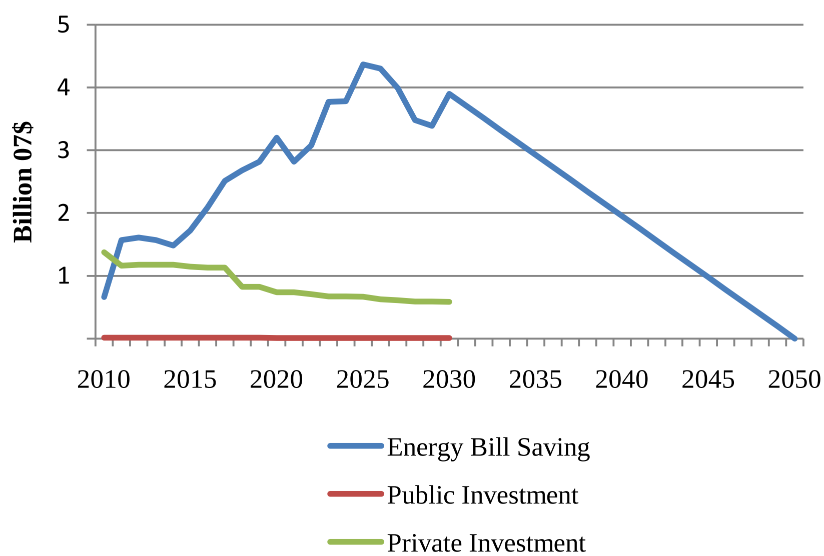

Figure 5.5 Energy Bill Savings for Plant Utility Upgrade policy

5.3.3 Policies to Accelerate Industrial Process Improvements

Several studies have shown high energy savings potential in the highly energy-intensive industries. A recent study of the National Academies (2009) recompiled these studies for 5 industries' potential energy savings in 2020: petroleum refining, iron and steel, cement, chemicals manufacturing, and pulp and paper. These five industries represent 83% of the total energy consumption in the South (EIA, 2006).

The petroleum refining industry's energy savings are presented in 3 studies; the lowest estimate of 0.3 quads, which represent 5% of energy consumption in 2020 came from McKinsey and Company (2008). The highest estimate is a range of 1.68 to 3.94 quads published in a DOE (2006j) report, with a range of 28-65% of reduction in consumption in 2020. The intermediate range of saving, between 0.73 to 1.46 quads in 2020, was shown by the study of LBNL (2005), with a range between 12 to 24%.

The iron and steel industry also presents an important opportunity for energy savings. McKinsey and Company (2008) identified 0.3 quads or 22% of energy consumption in 2020. The AISI study (2005) provided a higher level of energy savings at 0.79 quad, or 58% of energy use.

Three studies analyzed the cement industry, the lower estimation of energy savings is presented by Brown M., et al (2001) with 0.08 or 19% quads of saving in 2020, followed by McKinsey and Company with a 0.1 quads or 23%. The highest potential of savings is presented in the study of Worrell (2004), with 0.29 quads or 67% of energy saving in 2020.

The chemical manufacturing industry was analyzed by three studies: the lowest level of savings is presented in the NREL (2002) report with only 0.19 quads or 3.1% of energy use in 2020. A similar result was presented in McKinsey with a potential for savings of 0.3 quads or 5% in 2020. The highest amount of savings was shown by Energetics Incorporated (US DOE 2007), with a total of 1.1 quads or 18% of energy use in 2020.

Finally, the pulp and paper industry also represents a potential of energy savings through its process improvement, from 0.14 quads or 6.1% in the CEF study to 0.85 quads or 37% of energy use, in the study of Jacobs and IPST (2006).

Among the most prominent industrial process improvement technologies are super boilers, which present over 95 percent fuel-to-steam efficiency (Industrial Technology Program (ITP) DOE, 2008). This technology is able to improve heat transfer thanks to the use of advanced firetubes with extended surfaces that help achieve a compact design, reducing size, weight, and footprint. The advanced heat recovery system combines compact economizers, a humidifying air heater, and a patented transport membrane condenser. Many boilers used today are more than 40 years old, suggesting a large energy-savings opportunity (Gemmer, 2007). This technology provides compelling economic benefits to accelerate replacement of aging boilers (see Figure 5.6)

Figure 5.6 Gas-fired Super Boiler (Source: ITP 2008)

Table 5.10 lists each industry and business-as-usual (Reference) projected energy use. The different estimates for energy-efficiency potential savings is shown by the two rightmost columns.

Table 5.10 Estimated Energy Savings Due to Energy-Efficiency From Accelerated Industrial Process Improvements (in TBtu)

Industry	Energy Use in the Reference Case			Savings Over the Reference Case	
	2009	**2020**	**2030**	**2020***	**2030****
Petroleum Refining	4,950	5,640	6,720	300 610 to 1,210 1,400 to 3,280	5,490
Iron & Steel	1,310	1,220	940	210 to 790	740
Cement	330	430	420	80 290	320
Chemicals Manufacturing	5,540	5,280	4,490	300 190 to 1,100	1,150
Pulp & Paper	1,960	2,100	2,200	140 to 600 370 to 850	1,410

* Based on a review of studies for specific energy-using industries.

**Based on average of energy saving of 2020 savings projected to 2030

5.3.4 SNUG-NEMS Modeling to Accelerate Industrial Process Improvements

This policy as modeled in SNUG-NEMS resulted in a total savings of 1.38 quads in 2020 and 1.57 quads in 2030. This represents savings of 9% of energy in 2020 and 10% in 2030. The highest energy efficiencies are in the West South Central region with 89% of the total savings (see Table 5.11). Figure 5.7 shows energy efficiency gains by region, and WSC has the largest potential.

Table 5.11 Primary Energy Savings Industrial Process Improvements (TBtu)

Year	WSC	ESC	SA	Total
2020	1,230	90	60	1,380
2030	1,350	150	70	1,570
Cumulative to 2050	36,000	3,180	1,840	41,100

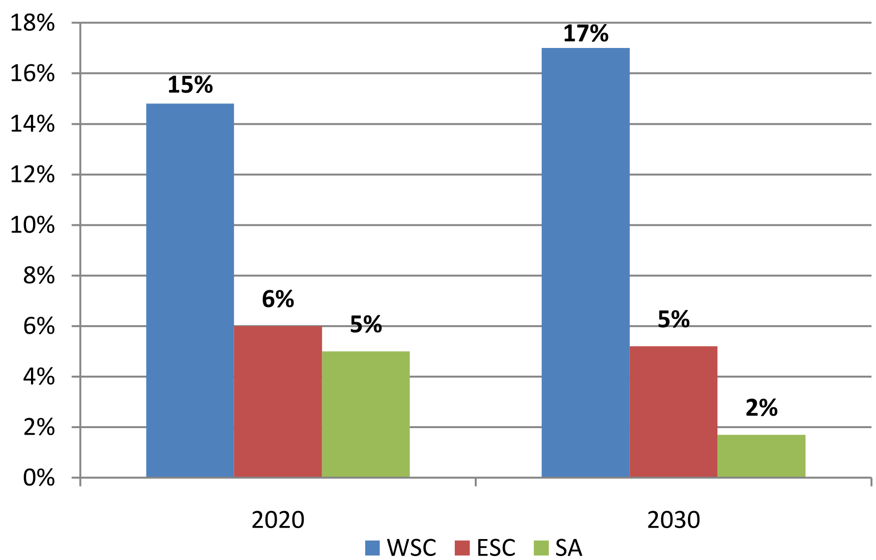

Figure 5.7 Primary Energy Saving in the Industrial Process Improvement Policy

Table 5.12 shows the levelized cost of electricity, natural gas and the total energy efficiency (including savings from liquid fuels with 344 TBtu in 2020) for this policy. Both the electricity and natural gas numbers are lower than the energy rates charged to industrial business in most of the southern states.

Table 5.12 Levelized Cost of Energy Efficiency from Process Improvement Policy in 2020	
Electricity Efficiency (¢//kWh)	2.4
Natural Gas Efficiency (¢/Therm)	23.8
Total Energy Efficiency ($/MMBtu)	3.6

Economic Tests. The costs and savings for the industrial policy to increase the process improvement are shown in Table 5.13. The investment costs are calculated based an estimation of the costs previously presented for the Plant Utility Upgrade policy. Considering that the adoption of new technologies to improve energy efficiency is more costly, this study assumed that the Plant Utility Upgrades policy represented 40% of the total investment cost of the Policy to accelerate industrial process improvements. All the investment costs are assumed to be made by the private-sector industry. Nevertheless, policy-makers could consider a public subsidy as part of the investment scenario, but that was not evaluated in this study. Administrative costs are assumed entirely by the public sector, which represents less than one percent of the total costs. It is designed to motivate the industry to conduct process improvement, through the acquisition of newest technologies. (See more details about the calculations in Appendix E section)

Table 5.13 Total Resource Cost Test for Process Improvement Policy

Year	(Million $2007)					B/C
	Public Costs		Private Costs	Total Discount Costs	Total Discount Savings	
	Annual Administration Cost	Annual Investment Cost	Annual (Investment & Other)	Cumulative Costs	Cumulative Savings	
2020	6.5	0	1,700	20,000	57,300	-
2030	10.6	0	1,400	36,000	108,700	-
NPV	65.4	0	24,800	36,000	128,800	3.6

*Cumulative Costs beginning in 2010 and Savings beginning in 2011. NPV included savings post 2030

Energy Bill Savings. The Process Improvement Policy appears to be cost-effective. The energy bill savings exceed the public and private investments by many times (see Figure 5.8). Energy savings is expected to rapidly decrease returns after 2030.

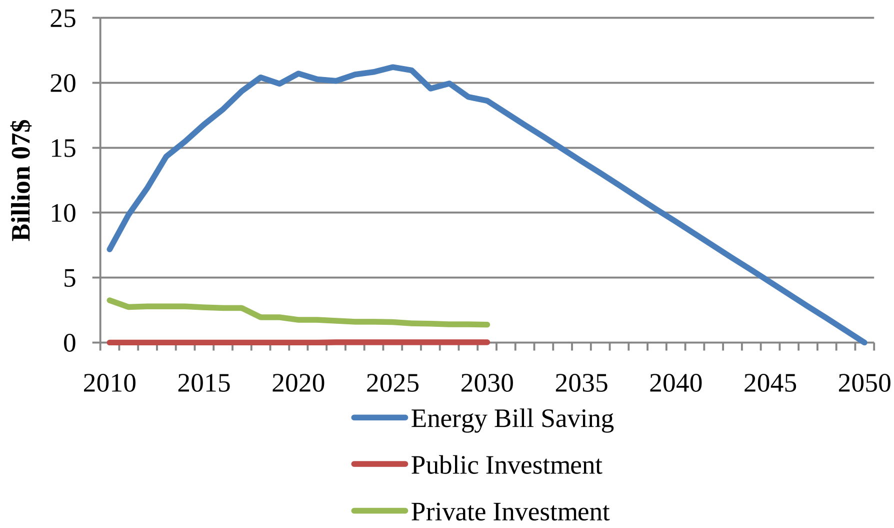

Figure 5.8 Energy Bill Savings from Industrial Process Improvements

5.3.5 Supporting Industrial Combined Heat and Power (CHP) with Incentives

Cogeneration, in other words combined heat and power (CHP), is the use of a heat engine or a power station to simultaneously produce both electricity and useful heat. The key technology in CHP systems is the prime mover, which generates electricity from the exhaust heat and steam. The proliferation of the CHP system could contribute to future energy savings by recycling the waste heat exhausted from other production processes. According to recent studies, the nation could produce about 19 or 20 percent of U.S. electricity with heat that is currently wasted in industrial processes (ORNL, 2008).

Figure 5.9 Heat Recovery Steam Generator

Previous studies on the effectiveness of CHP also estimate that 15 to 20 percent of industrial electricity demand could be met by CHP systems by 2030 (SEEA, 2009; Lemar, 2001). To determine the savings that industrial CHP systems could yield, one must establish the current status of these systems in the South region. It is estimated that there is currently 41 GW of installed CHP capacity at 598 sites within the South region (EEA, 2009). The gulf coast of Louisiana and Texas has one of the largest concentrations of CHP capacity in the nation. Heat recovery steam generators (Figure 5.9) are one of the components that comprise such systems, which can be quite capital intensive.

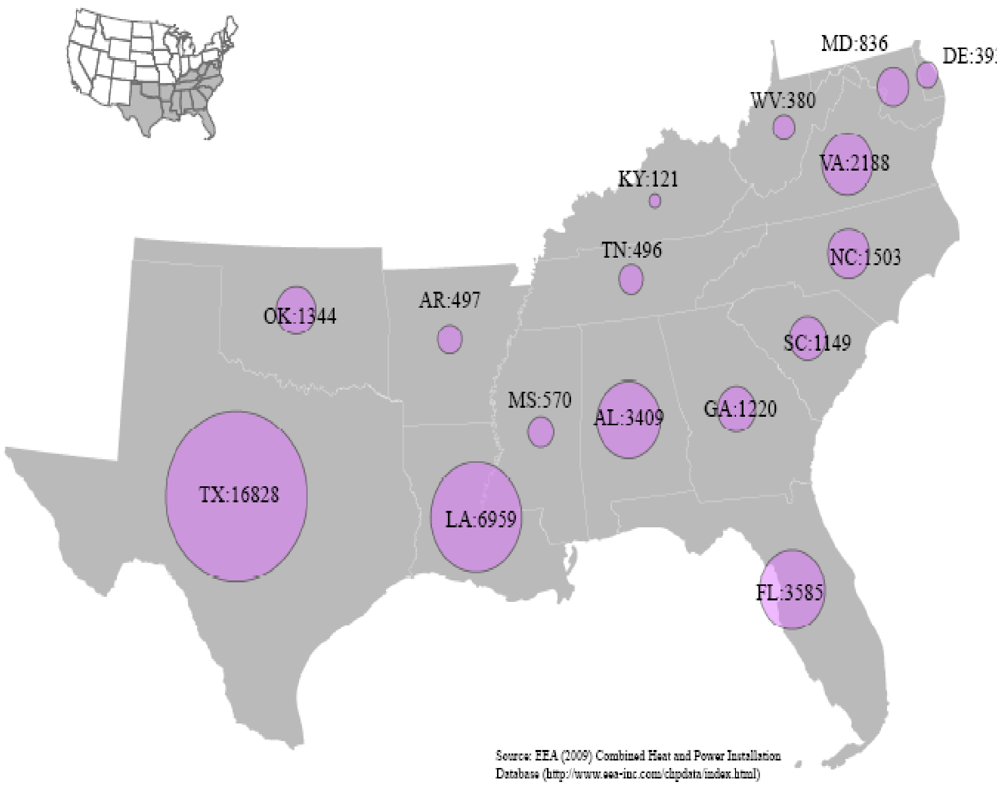

Figure 5.10 Installed CHP Capacity (MW) by state in the Southeast (EEA, 2009)
(Includes industrial and commercial CHP capacity)

Many states have policies that support CHP equipment installations and R&D activities for new technologies. The policies listed in Table 5.14 includes grants, loans, special rates, tax credits, and ease of interconnection with the national electrical grid. Arkansas and Delaware provide additional emission credits based on the outputs from CHP systems. Some states, as well as the federal Waxman-Markey proposal, consider CHP as a promising energy efficiency option to meet the Renewable Portfolio Standard (RPS). The Waxman-Markey bill proposed incentives for innovative waste heat recovery (for electricity or thermal use), of up to 25% of the projected value of energy savings for the first 5 years. Grant programs are used to accelerate R&D activities for enhancing overall efficiency, improving heat rates, and reducing installation costs. The U.S. Department of Energy (DOE) recently issued a Funding Opportunity Announcement for up to $40 million in R&D and demonstration of CHP systems. DOE expects this grant program could achieve efficiencies up to 80 percent better compared to the roughly 45 percent for conventional CHP production. Florida applies Renewable Energy Production Tax Credit to the amount of electricity generated from CHP ($0.01/kWh). In sum, these existing policies are designed to motivate plant owners to install new CHP systems and actively use their existing equipment.

Table 5.14 Summary of CHP-Supportive Policies in the South			
Type of Policy	**State**	**Applicability and Amount**	**Requirements and Limits**
Environmental Regulations	AR, DE	Output-Based Regulations, Combined heat and power (CHP) systems can receive emissions credits	
Renewable Portfolio Standard	DC, MD, VA, WV		
Grants for New Technologies		EPA small business innovation research program (phase I R&D funding by $70,000, phase II $225,000)	
Interconnection	DC, TX, MW, KS, FL, DE		DC, TX Interconnection Standards, up to 10 MW, KS (5MW), FL (2MW) and DE (1MW)
Long-term Loans for Customer-side Distributed Generation		$150 million available	
Renewable Energy Production Tax Credit	FL	$0.01/kWh of electricity produced and sold	
Renewable Energy Tax Credit	NC	35 % of the cost of renewable energy systems built purchased, or leased	
Loan	MS	Energy Investment Program, interest rate 3%, max 7 years $15,000 to $300,000	

5.3.6 SNUG-NEMS Modeling of Industrial CHP with Incentives

To motivate plant owners to install more CHP equipment, policy makers must address several technology barriers. Two key parameters that influence economic viability are operating costs (driven by efficiency and fuel price) and capital costs (driven by initial installation costs) (ORNL, 2008). We have developed a policy scenario to address the two factors. To assess the magnitude of cost-effectiveness and achievable energy-efficiency improvements from CHP proliferation, we have assumed adoption of a set of transformative energy policies: 1) extension of the duration of existing tax credit programs and 2) acceleration of R&D activities.

The first part of the policy bundle was modeled in SNUG-NEMS by extending the duration of the current Investment Tax Credits (ITC) included in the Energy Improvement and Extension Act of 2008. Congress passed this law on October 3, 2008 and established a new ITC for CHP systems. The credits began in 2008 and are currently scheduled to continue through 2016. In this study, we assumed that policymakers would extend the duration of the ITC through 2030. In addition, we implemented a 20% subsidy policy for accelerating additional installation of CHP equipment. On balance, 30% of the total investment cost for new CHP systems would be supported by government.

We also modeled grant programs that support R&D activities for improving the performance of CHP systems. We assumed that the programs could increase the overall efficiency by 0.7% annually and raise the average efficiency level up to 83% by 2030 without any additional increase in installation cost. Table 5.15 shows that the overall efficiency values for the EIA's reference case and those for our study. We approximated that the grant program would spend $20 million annually to cost share the R&D of research entities. CHP system performance and cost information from EIA were used to quantify energy savings and financial costs.

Table 5.15 Overall Efficiency by CHP System (Size)

		Reference*		Policy**	
System	**Size (kilowatts)**	**2020**	**2030**	**2020**	**2030**
1 Engine	1,000	0.73	0.74	0.77	0.82
2 Engine	3,000	0.74	0.75	0.77	0.83
3 Gas Turbine	3,000	0.70	0.71	0.75	0.80
4 Gas Turbine	5,000	0.72	0.72	0.76	0.82
5 Gas Turbine	10,000	0.71	0.72	0.76	0.82
6 Gas Turbine	25,000	0.72	0.73	0.77	0.82
7 Gas Turbine	40,000	0.73	0.73	0.78	0.83
8 Combined Cycle	100,000	0.72	0.73	0.76	0.81

* Industrial CHP Technology Performance Data used for EIA's AEO 2009 projections
** We increased the overall efficiency of each CHP system by 0.7% annually and raised the efficiency level up to 83% by 2030.

When the CHP policy is implemented, the electricity generation capacity would increase by 29.1% in the South, and the Region could produce 38.1 TWh of electricity and 122 TBtu of useful steam additionally. In sum, the South could produce 147.9 TWh of electricity and 1.1 Quads of useful steam from both existing (i.e. installed before the policy implementation) and newly installed CHP equipment in 2030 (Figure 5.11 and 5.12).

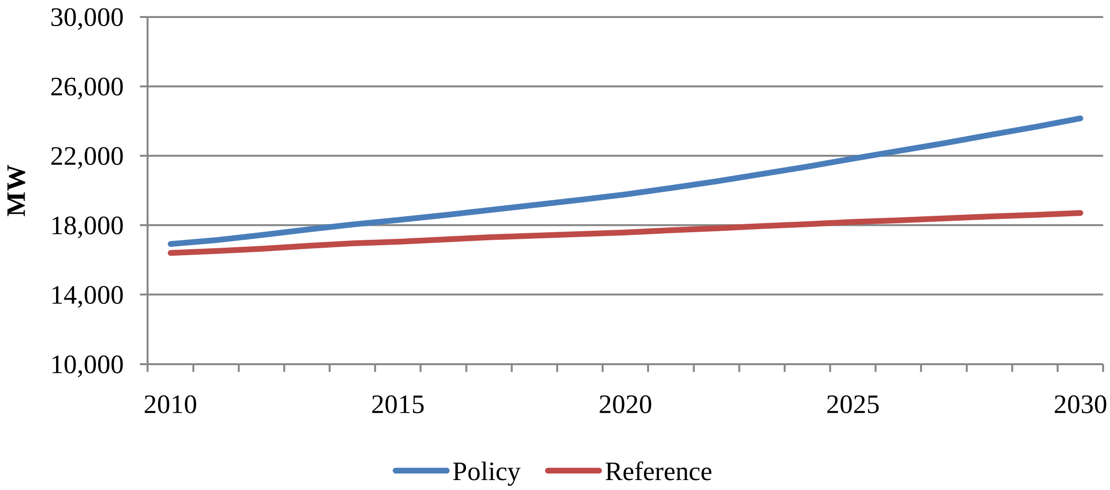

Figure 5.11 Electricity Generation Capacity in the Industrial Sector
(*Only industrial CHP capacity counted)

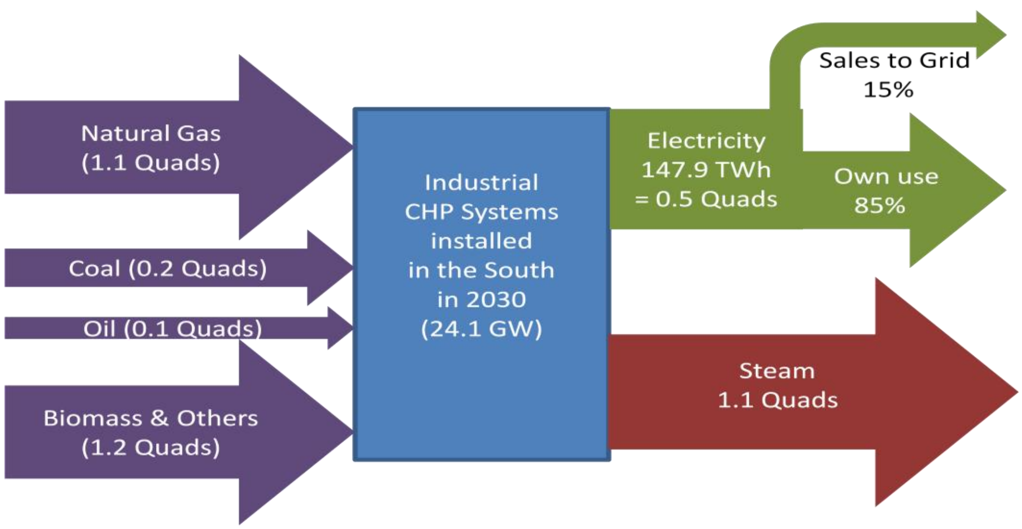

Figure 5.12 Energy Consumption and Production in Industrial CHP Systems in the South in 2030

The WSC shows the highest cumulative primary energy savings of 3,351 TBtu followed by the SA with 1,478 TBtu and the ESC with 591 TBtu (Table 5.16).

Table 5.16 Primary Energy Savings from CHP Policy (TBtu)				
Year	**WSC**	**ESC**	**SA**	**Total**
2020	68	12	30	110
2030	178	32	78	289
Cumulative to 2050	3,350	590	1,480	5,420

We could expect more than 2% of the energy efficiency gains in the WSC and the SA in 2030 (Figure 5.13).

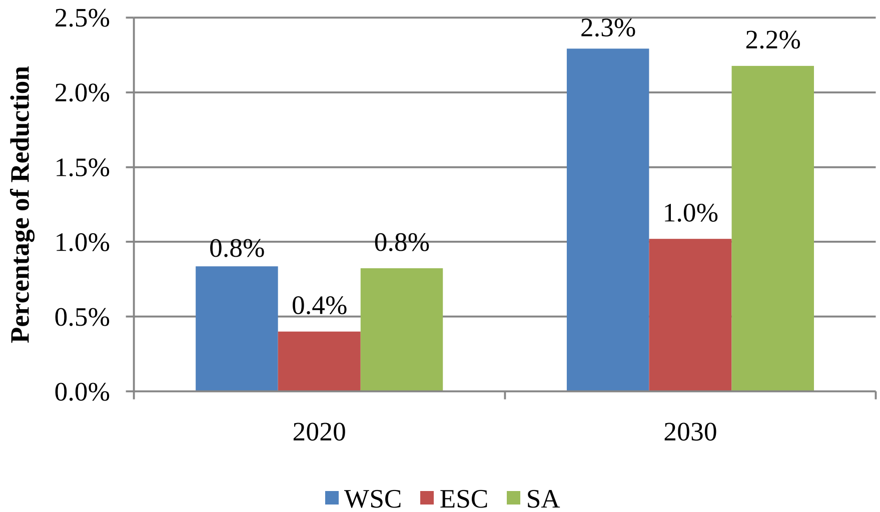

Figure 5.13 Primary Energy Savings from CHP policy

The impact of the policy would increase gradually throughout the study horizon. The total installed CHP equipment in the South could reduce the total industrial energy consumption by 3.5% in 2020 and 4.7% in 2030 (Table 5.17).

Table 5.17 Energy Production and Consumption in Total CHP systems					
Year	**Total Electricity Production (TWh)**	**Total Steam Production (TBtu)**	**Total Fuel Consumption (TBtu)**	**Net Primary Fuel Saved (TBtu)**	**% of Energy Saved**
2020	118	1,020	2,410	408	3.5%
2030	148	1,140	2,720	613	4.7%

Compared to a reference scenario, additionally installed CHP systems through this policy could save 288.5 TBtu of primary energy, which is equivalent to 2.19% of total projected industrial energy consumption in 2030. Oil and gas mining, food, and the plastics industries would sensitively respond to the policy and reduce 5% or more of their energy consumption in 2030; oil and gas mining (6.3%); food (12%), and plastics (5.9%) (Table 5.18).

Table 5.18 Energy Savings from Supported CHP by Industry in 2030: Estimated Changes and Savings[22]

Industry	Newly Installed CHP Capacity (MW)	Additional Fuel Consumption (TBtu)	Additional Electricity Production (GWh)	Additional Steam Production (TBtu)	Total Primary Energy Saved[23] (TBtu)	% of Energy Saved
Chemicals	2,875	166	20,260	60	152	2.9%
Paper	3	0.03	65	0	0.5	0.03%
Cement	17	1	116	0.4	0.9	0.6%
Steel	138	8	977	3	7	1.8%
Oil and gas mining	470	29	3,231	12	25	6.3%
Metal and other non-metal mining	6	0.4	44	0.2	0.3	0.3%
Food	680	42	4,641	17	36	12.0%
Plastics	144	9	989	4	8	5.9%
Oil Refinery[24]	397	24	2,774	9	21	2.5%
Others	722	45	4,976	18	38	0.9%
Total	5,453	323	38,070	122	289	2.2%

Energy Bill Savings. Figure 5.14 shows the annual investments by private and public entities and the energy savings from supporting CHP. This policy bundle is supported by a large public cost-share throughout the study's time horizon. Private investment costs and energy savings would gradually increase and reach $2.9 billion in investments and $2.2 billion in bill savings for 2030.

[22] All reported values in the Table 5.18 are differentiations between the REFERENCE and Policy cases.
[23] (Energy savings) = (Source fuel saved by electricity generated from CHP) + (Source fuel saved by steam captured by CHP) – (Fuel consumption for operating CHP). We set 3.34 as a source-to-site ratio in order to convert electricity to source energy consumption; 1.45 to convert steam to source energy.
[24] Because petroleum refining industry (NAICS 32411) is not included in the NEMS industrial module, we approximated the impact of the industry based on the current CHP capacity share of the oil refinery industry to the total industrial sector in the South: 7.86% of the installed CHP capacity is used for the industry.

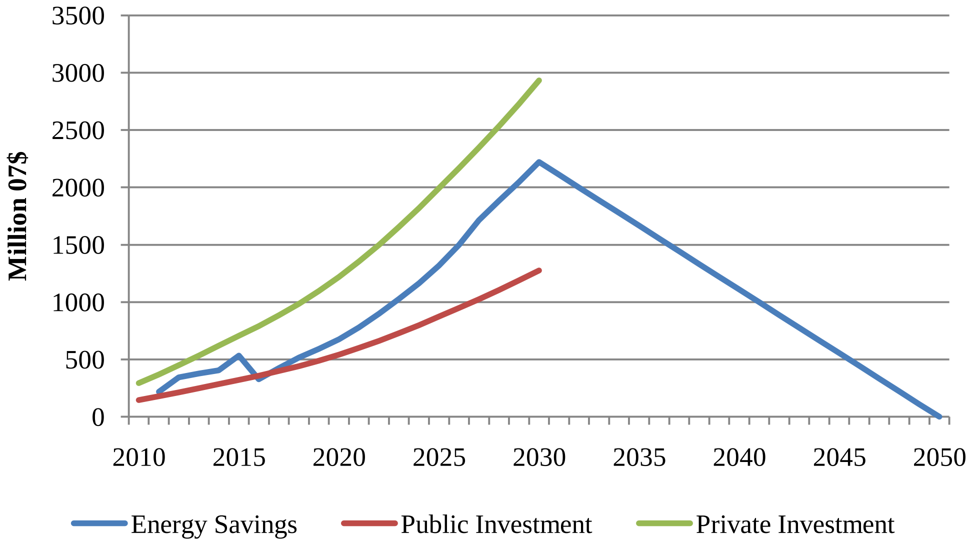

Figure 5.14 Energy Bill saving in Industrial CHP Policy

Economic Tests. Supporting CHP with incentives is cost-effective, with a benefit-to-cost ratio of about 1.01 for participants. It is not, however, cost effective, with a ratio of 0.67 based on total resource cost test. CHP systems are environmentally friendly equipment and they could contribute to reducing CO_2 emissions. The benefits expected from the CO_2 emissions reduction are not included in the benefit-cost ratio of this study. If we capture the environmental benefits and include them in the calculation, the benefit-cost ratio would be 1.04, assuming that a ton of CO_2 increases in value from $15 to $51 over the study period.

Table 5.19 Total Resource Test for CHP Policy

	(Million $2007)					B/C
	Public Costs		Private Costs	Total Discounted Costs	Total Discounted Savings	
	Annual Administration Cost	Annual Investment Cost	Annual (Investment & Other)	Cumulative Costs	Cumulative Savings	
2020	5	543	1,221	6,444	2,953	
2030	5	1,276	2,932	16,930	7,826	
NPV	56	5,214	11,660	16,930	11,380	0.67
					(17,570**)	(1.04**)

*Cumulative Costs beginning in 2010 and Savings beginning in 2011. NPV included savings post 2030
** In case that environmental benefits from CO_2 emissions avoided by CHP systems are counted

5.4 COMBINED INDUSTRIAL ENERGY EFFICIENCY POLICIES

5.4.1 Energy Efficiency Results

The three combined industrial energy efficiency policies could reduce the total industrial energy consumption by 15.8% under the no Carbon-Constrained Future (CCF) scenario and 16.5% under a CCF in the South in 2030 (Figure 5.15).

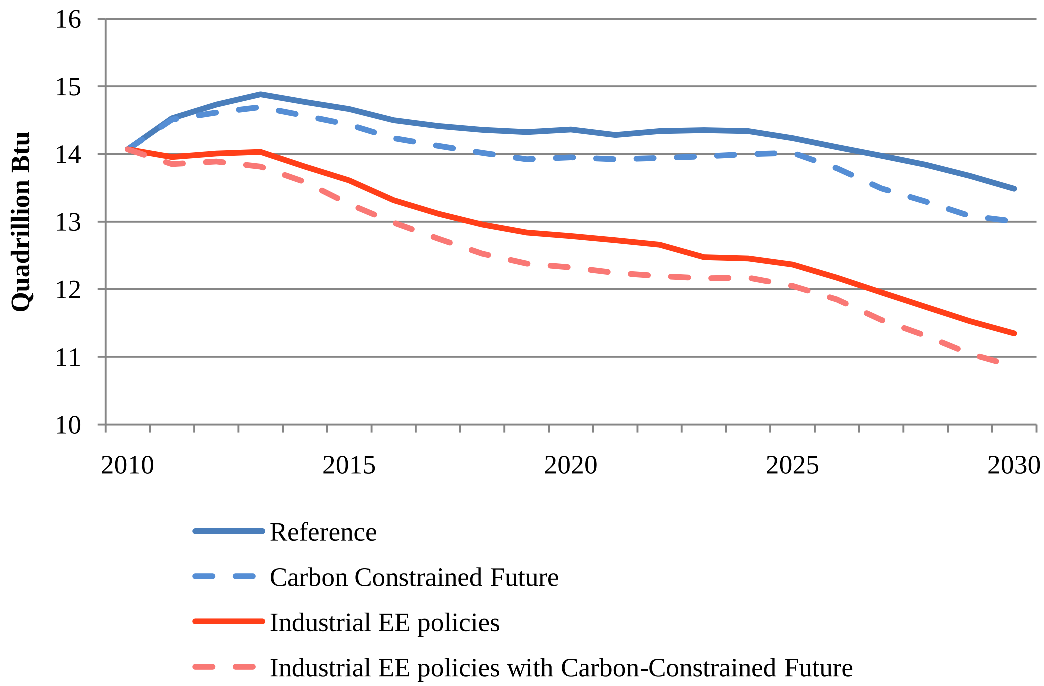

Figure 5.15 Industrial Energy Consumption Projections

The three policies are significant contributors to energy efficiency gains. The West South Central division presents the highest savings of 14% in 2020 and 21% in 2030, followed by the East South Central with 10% in 2020 and 15% in 2030. The South Atlantic shows the lowest energy savings levels, indicating only 7% in 2020 and 9% in 2030.

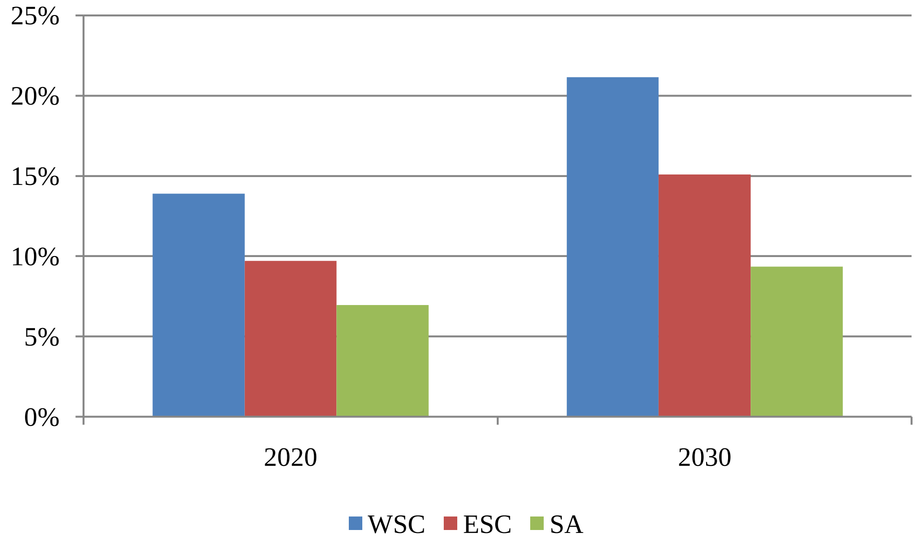

Figure 5.16 Percent Primary Energy Savings in Industry

5.4.2. Energy Price Results

The industrial energy efficiency policy bundle is expected to contribute to minimizing energy price increases in the future. Compared to a reference scenario, the policies lower electricity prices by 3% on average. The electricity prices would reach $23 per million Btu in the WSC, $19 in the SA, and $17 in the ESC respectively in 2030 (Figure 5.17).

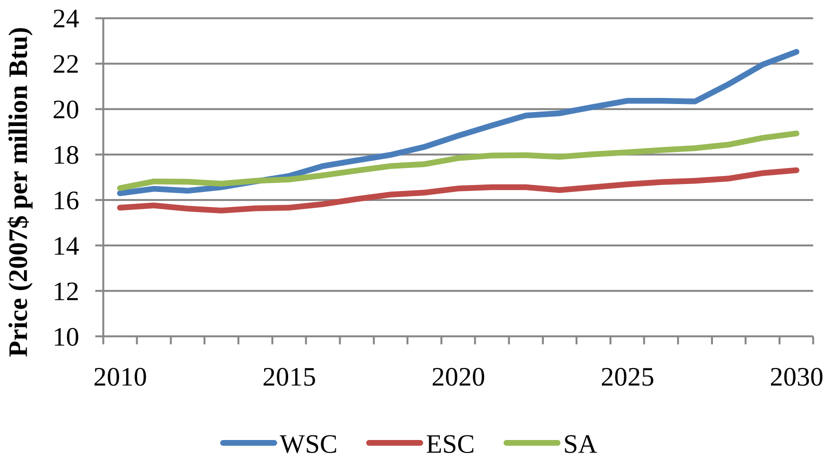

Figure 5.17 Electricity Price Projections

On the other hand, natural gas prices would be about 2% lower than a reference scenario, especially in the first decade after the policies are implemented. In 2030, the natural gas price is anticipated to be $10 per million Btu in the SA, $9 in the ESC, and $8 in the WSC (Figure 5.18).

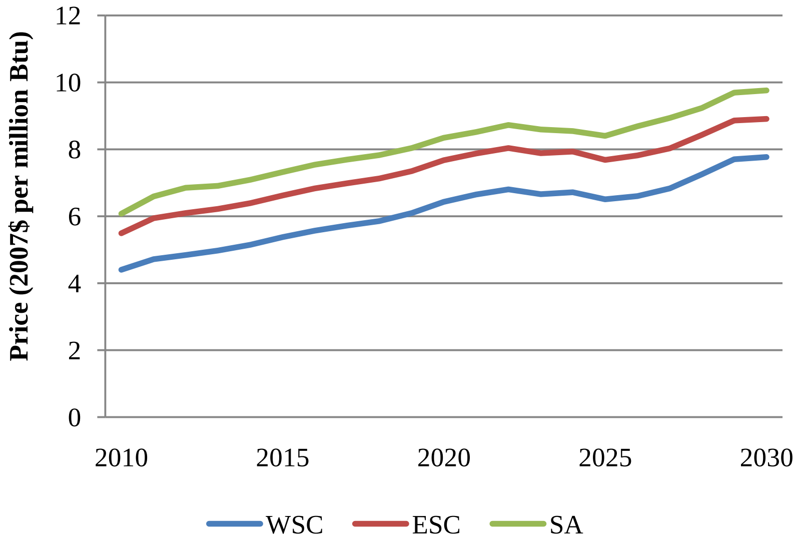

Figure 5.18 Natural Gas Price Projections

5.4.3 Energy Bill Savings

The three industrial energy efficiency policies would increase energy bill savings in all three census divisions (Figure 5.19). The savings are much greater in the West South Central states than those in other census divisions. The percentage of reduction of the WSC starts at 7% in 2010, reaches a peak in 2017, remains constant until 2027, and then shows a slight drop in 2030. The East South Central and South Atlantic show gradual increases in bill savings.

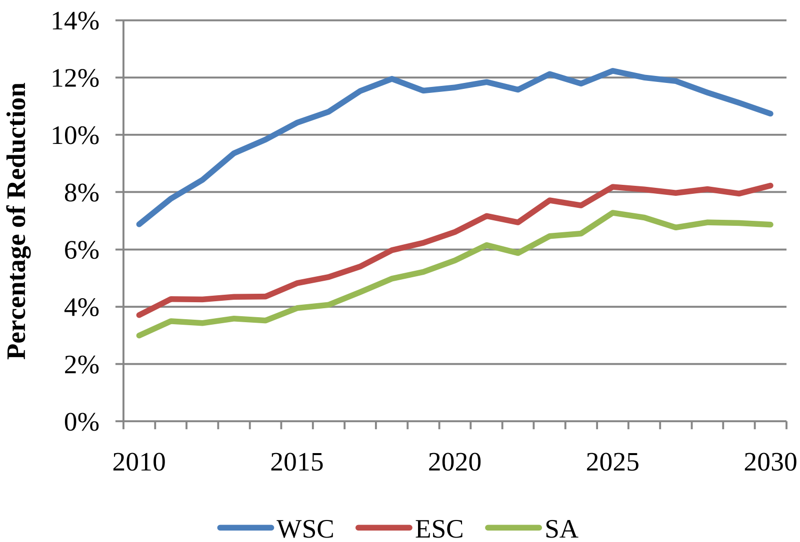

Figure 5.19 Percentage Change in Energy Bill Savings

5.5 SUMMARY OF RESULTS FOR INDUSTRIAL ENERGY EFFICIENCY

Our analysis of industrial energy efficiency policies suggests that the South could expect 11% of energy efficiency gains in 2020 and 16% in 2030 by implementing the three policy bundles. Since the South accounts for 50% of the total U.S. industrial energy use, these savings represent a significant reduction in national energy consumption. Accelerating process improvements could produce the greatest energy savings among the three policies, generating a 11% reduction in industrial energy consumption in 2030. Expanding assessments of plant utility upgrades and supporting CHP with incentives also reduce the energy required in this sector by 6% and 2% respectively.

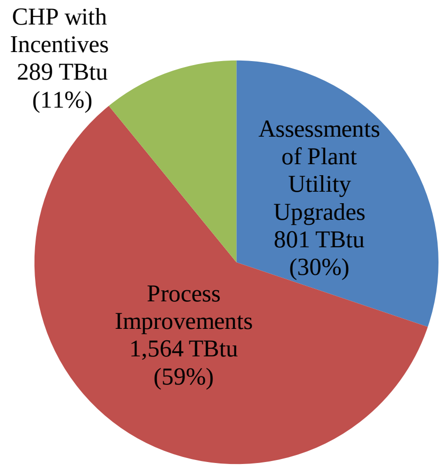

Figure 5.20 Industrial Energy Savings by Policy Package in 2030

The South could save 2.1 quads of industrial energy in 2030. The West South Central could expect the greatest energy efficiency gains among the three census divisions in South, followed by the South Atlantic and the East South Central (Table 5.20). These estimated savings are similar to other efficiency studies. They demonstrate that significant gains can be achieved by implementing industrial energy efficiency policies in the South.

Table 5.20 Summary of Industrial Primary Energy Savings by Policy and Census Division in 2020 and 2030 (TBtu)*

Policy	Year	WSC	ESC	SA	Total
Plant Utility Upgrades	2020	370	150	170	690
	2030	430	170	200	800
Process Improvements	2020	1,230	90	60	1,380
	2030	1,350	150	70	1,570
CHP	2020	70	10	30	110
	2030	180	30	80	290
Combined Policy Bundle	2020	1,040	250	290	1,580
	2030	1,380	370	400	2,150

* These results include the energy savings from Oil Refining Industry which was modeled in SNUG-NEMS.

The first two policies for Plant Utility Upgrades and Process Improvements are cost effective with a ratio of 4.5 and 3.6 respectively. On the other hand, supporting CHP with incentives is cost ineffective when we consider only primary energy savings as benefits. However, the benefit-cost ratio would be 1.04 if we capture benefits from avoided CO2 emissions by newly installed CHP systems.

Table 5.21 Summary of Economic Tests by Policy (Million $2007)

Policy	NPV Cost	NPV Benefit	B/C Ratio	Cumulative Savings to 2050 (TBtu)	Savings in 2030 (TBtu)
Plant Utility Upgrades	10,800	48,400	4.5	16,900	800
Process Improvements	36,000	129,000	3.6	41,000	1,570
CHP	16,900	11,400 (17,600*)	0.67 (1.04*)	5,420	290
Combined Policy Bundle	53,200	179,000	3.4	50,600	2,150

* Environmental benefits from CO_2 emissions avoided by CHP systems are included in this alternative set of calculations.

5.5.1 Comparison with Other Studies

A large number of previous studies have analyzed the potential for energy efficiency improvements in the South over the past decade. Based on a meta review of more than 250 estimates from 19 of these, Chandler and Brown (2009) concluded that 9% of the industrial energy consumption (1.3 Quads) could be saved with a set of aggressive, but feasible policies in 2020. Compared to the estimated energy efficiency of the previous studies, we could expect 2% more energy savings with the policies suggested by this study. The improved efficiency can be explained by a set of policies for accelerating industrial process improvements of 5 energy intensive industries such as petroleum refining, iron and steel, cement, chemicals manufacturing, and pulp and paper.

McKinsey and Company (2009) recently released a national analysis of the “NPV-positive potential for energy efficiency” providing results by region and sector. According to the results for the industrial sector in the South, the estimate of energy efficiency potential is 17% in 2020, which means 2.5 Quad of energy consumption could be avoided in a cost efficient way. Similar to our study, the McKinsey report took into account energy support systems, industrial processes, and CHP. However, the McKinsey study focused on “economic potential” and not “achievable potential;” thus, it assumes fill penetration of all measures that are cost-effective. Our study, on the other hand, recognizes that policies cannot deliver 100% of economic potential.

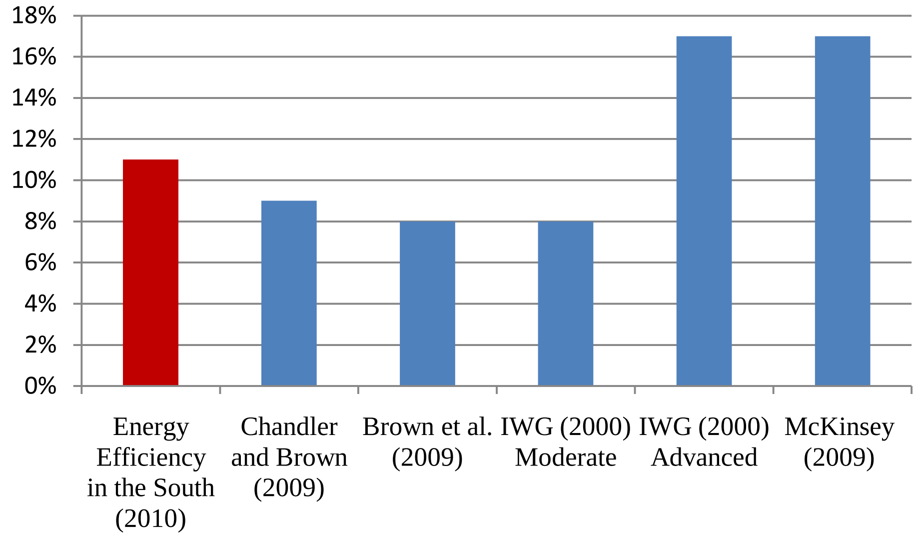

Figure 5.21 Comparison of Estimates of Industrial Energy Efficiency Potential in 2020 from Other Key Studies

The results of several key studies are summarized in Figure 5.21. Our study's estimate for industrial efficiency potential is 3% greater than the estimate for Appalachia (Brown, et al., 2009), which employed a similar analytical approach but did not include process improvements for energy intensive industries. Compared to the estimates of the IWG (2000) study, our result is located in between those of the moderate and advanced scenarios of the IWG. Unlike our study, the IWG (2000) study includes a set of aggressive environmental policies and industrial standards in the policy coverage. On balance, the industrial energy efficiency potential estimated in this study is comparable to other studies.

5.5.2 Limitations and the Need for Further Research

In this study, we analyze industrial energy efficiency potential in the South using a comprehensive energy-market model. However, there is still room for improvement by addressing a range of additional issues such as following.

- More of the analysis needs to be conducted inside the SNUG-NEMS so that we can evaluate how various policy factors interplay in the simulation system. The principal variables and factors that can be adjusted in the Industrial Demand Module (IDM) are the unit energy consumption by industry, technology possibility curves, and capital cost functions. Because the NEMS treats supply and demand in the petroleum refinery industry separately in the Petroleum Market Module (PMM), the energy savings from petroleum manufacturing were calculated in spreadsheets external to the SNUG-NEMS. In addition, investment costs for implementing Process Improvements and accelerating Assessments of Plant Utility Upgrades are indirectly estimated with external data sources. By internalizing the above-mentioned components, we could have a more realistic estimate of industrial energy efficiency potential.

- Further analysis of knowledge and technology transfer from large firms to small and medium-sized firms could strengthen our results. In terms of scope, our industrial policy analysis excludes small firms with less than 49 employees. Due to a difficulty of handling diverse firms in size in a single policy framework, we implement efficiency-assessment programs to relatively large firms and analyze the direct policy impacts. However, we anticipate that spin-off benefits would occur to small-sized firms.

- A more comprehensive set of emerging technologies should be included in the industrial technology bundles in the SNUG-NEMS. The technology profiles included in the IDM input files are incomplete and in some cases do not reflect the most recent advancements. For instance, the IDM uses unit energy consumption by industry and technology possibility curves collected in 2002. Considering the rapid technological development in the energy field, more recent technology profiles should be used.

- If this study captured environmental benefits of the efficiency policies, the benefit to cost (B-C) ratios would be higher. This study regards only primary energy savings as benefits, and does not include additional benefits that we could expect such as avoiding greenhouse gas emissions. For example, CHP systems are environmentally friendly equipment and they could contribute to reducing CO_2 emissions. However, the benefits expected from the CO_2 emissions reduction are not included in the B-C ratio of this study. This results in 0.7 of the B-C ratio of the CHP policy. Were environmental benefits include it in the calculation, the B-C ratio would be greater.

- More policy options to motivate plant owners to recycle exhaust energy could be analyzed. The industrial policy bundle in this study contains three policy options for boosting the use of CHP. However, not only waste heat but also other types of exhaust energy such as compressed air and flared gas could be reused in the industrial sector. NEMS does not allow explicit modeling of such technology opportunities.

- Further sensitivity analyses would strengthen our results. For instance, sensitivity on fuel prices and discount rates could provide a range of efficiency estimates under various scenarios, which might better bracket the range of future energy-efficiency potential possibilities.

In sum, these limitations lead us to conclude that our estimate of industrial energy efficiency potential is conservative because it does not include small firms, the full range of technologies, and environmental policies.

6. INTEGRATED ANALYSIS

6.1 INTRODUCTION

Bringing all of the Energy-Efficiency Policies together is one of the most important parts of this modeling analysis. The integrated analysis involved combining the residential, commercial, and industrial Energy-Efficiency Policies into one "Energy-Efficiency Policies" scenario. Unlike a more simplified approach where each policy is evaluated unto itself, frequently overlooking second-order effects, using the SNUG-NEMS model captures a host of complicated interactive effects. By examining how multiple policies operate together as system, unanticipated, non-additive, and indirect outcomes can be illuminated. In particular, four types of interactions will be discussed in this chapter.

First is the interaction of Energy-Efficiency Policies on one another and their effect on the final demand for energy. If policies tackle similar market barriers and target the same market segments, the combined energy savings will be less than the sum of the individual policy effects. Alternatively, if policies are designed to target distinct barriers and markets, their total energy savings could in fact be greater than the sum of their individual policy effects. For example, the development of a trained workforce to certify building code compliance, the benefits of this improved workforce could spillover into other market areas.

Second is the interaction of demand-side policies on supply-side trends. For example, how do Energy-Efficiency Policies influence decisions about the timing, size, fuels and types of new plant investments. Similarly, to what extent do Energy-Efficiency Policies impact decisions to retire, convert, or upgrade existing power plants. An integrated modeling approach allows us to evaluate important and even more complicated questions that might otherwise be overlooked. For example, is there a counterintuitive effect that at some point, more energy efficiency has diminishing returns in that newer, more efficient supply is delayed?

Third is the feedback of Energy- Efficiency Policies on energy prices, and the second-order effect of prices on the subsequent demand for energy. If prices escalate as the result of power plant construction prompted by a rising demand for energy, consumers will invest in technologies, products, and practices to cut their energy bill consumption. In contrast, declining energy prices can precipitate an increase in energy use. In addition, an integrated modeling approach will capture the effect of energy efficiency in one sector lowering electricity prices noticeably for non-participants in that sector or in other demand sectors.

Finally, we examine the interaction of Energy-Efficiency Policies with the implementation of some sort of carbon constraint. It is not intuitively obvious if the two policy effects will be additive, synergistic, or duplicative.

This chapter will attempt to shed light on many of these questions and make clear where the largest uncertainty lies related to achieving energy efficiency's "program potential."

6.2 ENERGY-EFFICIENCY POLICY SCENARIO RESULTS

6.2.1 Energy Savings and Efficiency

In the Reference Scenario future, energy consumption in the South is expected to grow by 16% over the next 20 years. However, Energy-Efficiency Policies could keep energy use essentially flat or better. As modeled, the Energy-Efficiency Policies keep long term energy consumption hovering close to its current level (Figure 6.1). This represents a reduction of 5,600 trillion Btu in 2030, or cumulatively 75,300 trillion Btu by 2030 (cumulative value is the area between the lines). The reduction by 2020 reaches the level predicted by Chandler and Brown (as discussed in Chapter 1).

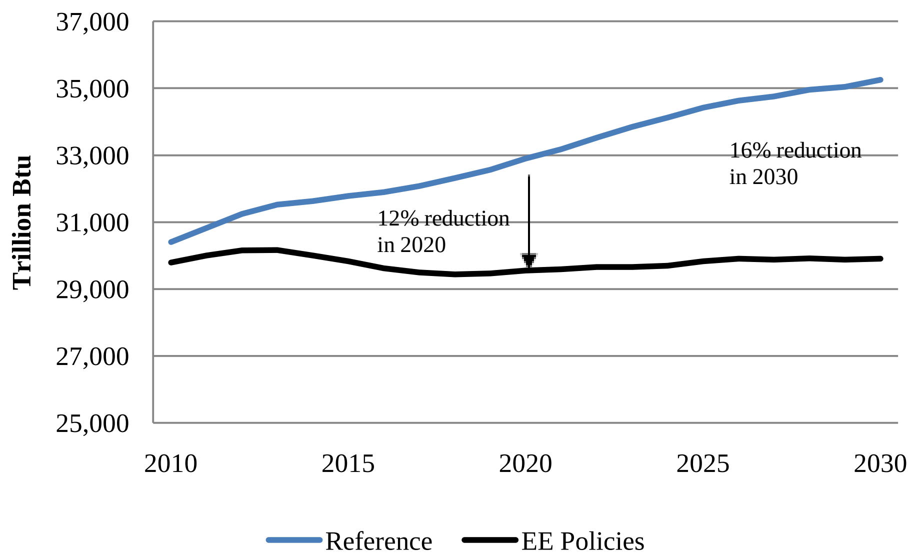

Figure 6.1 Primary Energy Consumption (RCI Sectors) in the South

Table 6.1 compares the energy efficiency potentials when evaluated three different ways. The first row shows the sum of the savings for the nine policies each evaluated independently. The second row has the sum of savings when the nine policies are combined into three groups by sector and the fourth row shows the savings from integrating all nine policies into one Energy-Efficiency Policy scenario. The potential is lower as policies are combined because of possible redundancies between policies. Also, due to the lower energy prices, there may be a small “take-back” effect. Integrated modeling is a great tool to capture the extent of these interactions. Rows three and five show how much energy-efficiency savings are reduced by these interactions.

Table 6.1 Energy Efficiency and Interactions (TBtu)		
	2020	**2030**
Summing up Individual Policies	4,100	6,120
Sum of Three Sectors Combined (RCI)	3,610	5,690
% Change Attributed to Policy Interactions	-12%	-7%
Energy-Efficiency Policies (Integrated)	3,340	5,340
% Additional Change Attributed to Sector Interactions	-7%	-6%

The integrated energy savings are shown by region relative to the Reference Scenario in Figure 6.2. The West South Central region has the largest energy efficiency potential. The potential for large industrial energy savings gives the WSC the highest energy-savings potential for the RCI sectors as a whole, with more than half of its efficiency potential coming from the industrial sector. Across all three regions, the estimated cost-effective energy efficiency improvements continue to rise from 2020 to 2030. The efficiency gains seem to be stronger earlier in the modeling forecast, perhaps because the available technology advances in the second decade is more limited within SNUG-NEMS.

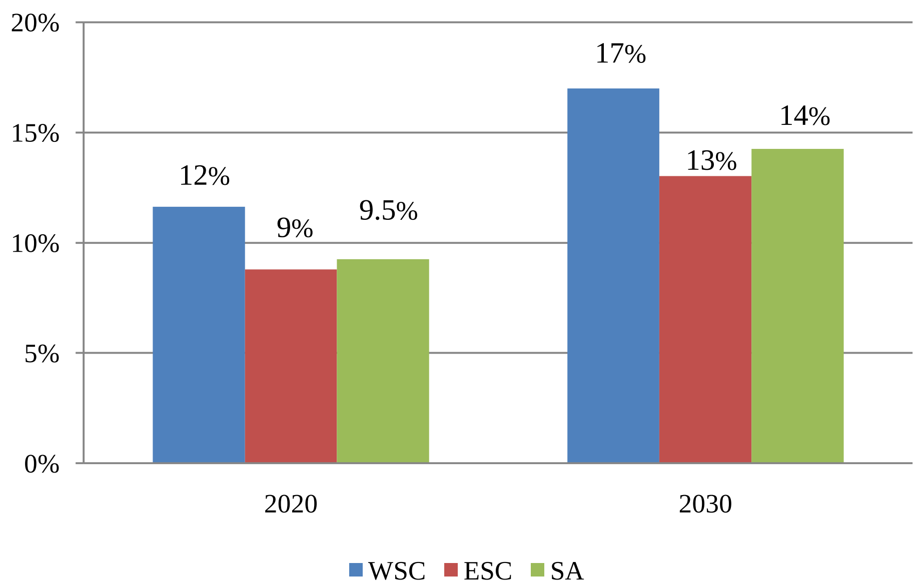

Figure 6.2 Energy Efficiency by Region in 2020 and 2030

In this study, the commercial sector has the largest energy efficiency potential in percentage terms while the industrial sector possesses the largest efficiency potential in real energy terms as Table 6.2 relates. In 2020, the South could cost-effectively reduce its commercial energy use by almost 12%, and by 2030, it could expand this to an 18% reduction. Compared to McKinsey's recent assessment of opportunities (Granade, et al., 2009), the industrial potential is similar (Figure 5.21 above), while the building sectors show a little more than half of what McKinsey identified (Figure 4.19 above). The main reasons for this difference in energy efficiency potentials are due to the number of policies analyzed, and the definition of what is considered as potential.

Table 6. 2 Energy Efficiency Potential by Sector (TBtu)				
	2020		2030	
Residential	910	9%	1,570	13%
Commercial	1,120	12%	1,980	18%
Industrial	1,580	11%	2,140	16%
Total	3,610		5,690	

6.2.2 Electricity Capacity

SNUG-NEMS forecasts electricity generation and capacity, as well as power plant retirements and construction. These results are characterized by North American Electricity Reliability Council (NERC) region and by fuel and type of power plant. Because of the lack of a one-to-one correspondence between these NERC regions and the South Census Region, we have elected to characterize capacity in the South by summarizing the results for the three NERC regions that are located entirely, or almost entirely, within the 16-state Census region (Figure 2.3 in Chapter 2 shows how NERC and Census regions correspond). This is an incomplete approach as this leaves out at least three states.

One natural and anticipated outcome of increased energy efficiency is the construction of fewer new power plants, while a few older plants also end up retiring. Figure 6.3 shows how the growth in new electricity generating capacity changes as a result of Energy-Efficiency Policies.

By 2030, the Reference Scenario forecasts that the growing demand for electricity in the Southern NERC regions will result in an increase of 49 GW of electricity capacity above the capacity in operation in 2010. Growing demand is expected to be met primarily by new natural gas plants and new combined natural gas/diesel plants, along with some additional nuclear power, coal plants, and renewables.

However, if Energy-Efficiency Policies were in place, the need to expand combined cycle capacity between 2010 and 2030 is eliminated; and as a result, electricity capacity in the South decreases over the 20-year period by 19 GW. Energy-Efficiency Policies eliminate the need for all but 7 GW of new capacity, in order to replace retiring capacity. The avoided new capacity is mostly nuclear and natural gas.

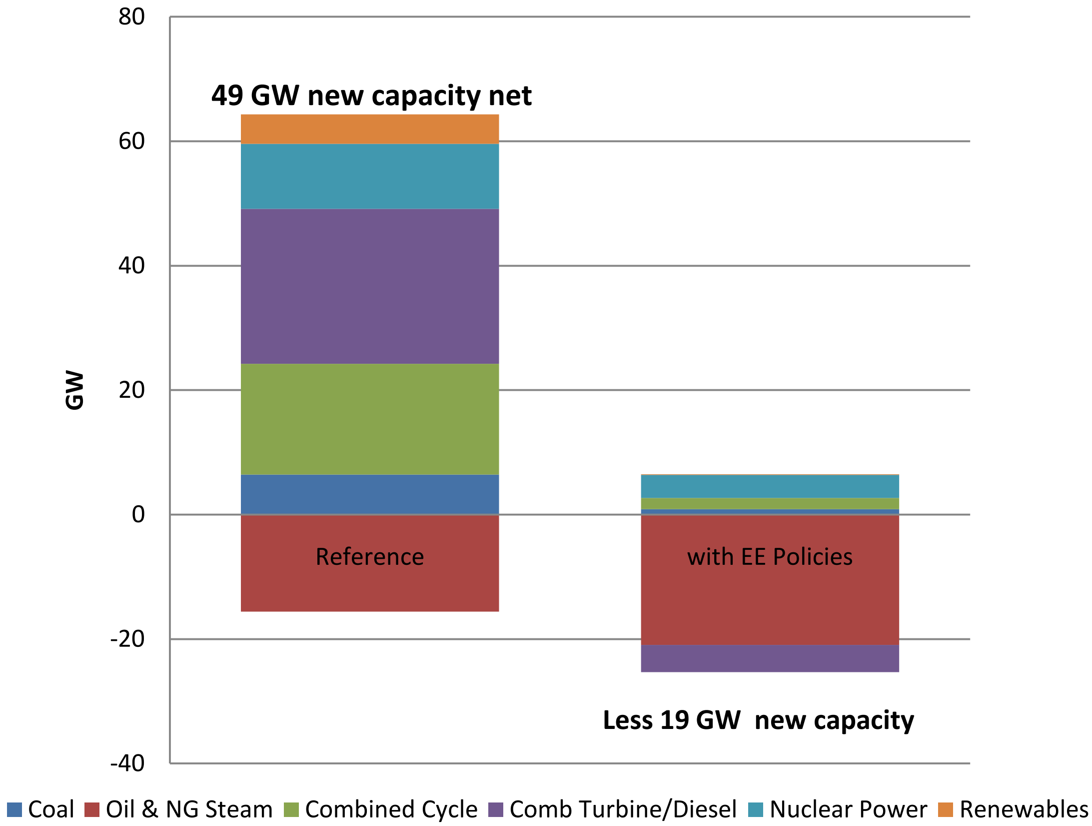

Figure 6.3 Southern NERC Incremental Generating Capacity in 2030 Beyond 2010

Most notable of all, the Energy-Efficiency Policies not only lead to fewer new power plants being built, but after retirements, in 2030 less capacity should exist than in 2010. Table 6.3 shows how the policies would affect the number and type of plants not built and retired. The related effect on freshwater consumption is discussed in section 6.4.

Table 6.3 Energy-Efficiency Policies Effect on Electricity Plants in The South

Generation Type	Avoided (GW)	Retired (GW)	Plants not Built*	Additional Plants Retired*
Coal	6	-	9	-
Combustion Turbine	25	4	124	22
Combined Cycle	16	-	64	-
Nuclear	7	-	7	-
Renewable	5	-	94	-
Oil and Natural Gas Steam	-	5	-	18

* Note: Plant numbers are approximate based on simplified average plant sizes. Using NEMS sizes as guidance. New coal plants 600 MW, Combustion Turbines 200 MW, Combined Cycle 250 MW, Nuclear 1 GW, Renewable 50 MW (as wind predominates), and existing Steam 300 MW .

As energy efficiency leads to fewer new clean plants and does not result in the retirement of any coal plants, the average generation in the future would be less polluting without the policies. However, energy efficiency measures more than make up for this average effect by reducing overall consumption to an extent that exceeds the incremental rise from average generation.

6.2.3 Rate Impact

The most obvious measure of the economic effects of the Energy-Efficiency Policies is how customers' rates might be impacted. Energy-Efficiency Policies leads to a moderation of the energy price escalation that is otherwise forecast to occur in the future. Table 6.4 illustrates how the Energy-Efficiency Policies are expected to affect electricity rates in the three sectors.

Table 6.4 Change Projected to Southern Electricity Rate due to Energy-Efficiency Policies

	2015	2020	2025	2030
Residential	-3%	-8%	-11%	-17%
Commercial	-1%	-6%	-8%	-13%
Industrial	-3%	-8%	-11%	-16%

6.2.4 Energy Bill Savings

On a regional basis, the economic effect of the Energy-Efficiency Policies is shown below in Figure 6.4. Consumers should expect a dollar savings higher than the regional energy savings. After all bill savings are the result of both lower energy consumption and lower fuel prices across the board relative to the Reference Scenario. Table 6.5 shows that the total energy bill savings in the South in 2020 is nearly $41 billion (14%), while in 2030 savings amounts to $71 billion (21%). The East South Central division saves the least in percentage and absolute terms in both years.

Table 6.5 Energy Bill Savings from Energy Efficiency Polices (Billion 07$)

	2020		2030	
WSC	$19.3	15%	$29.1	20%
ESC	$ 5.1	12%	$ 9.5	19%
SA	$16.5	13%	$32.4	22%
Total	$40.9	14%	$71.0	21%

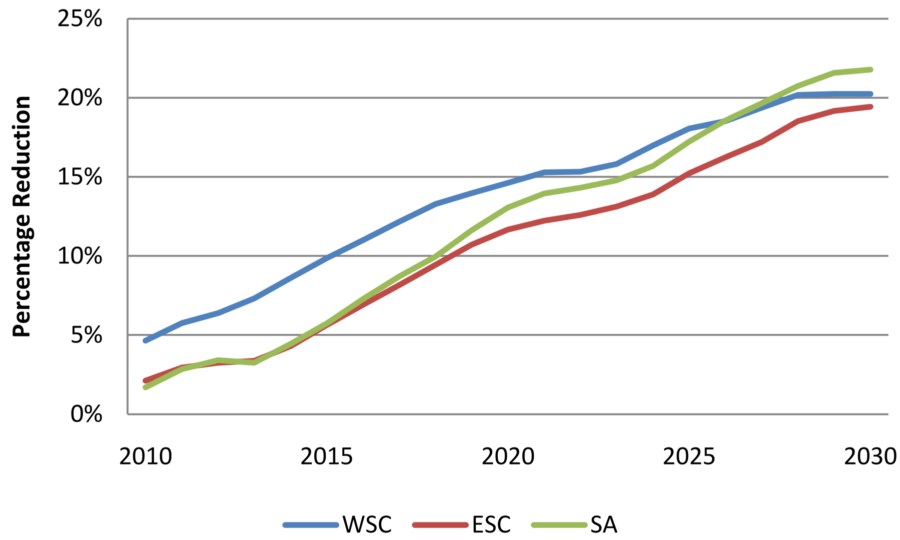

Figure 6.4 Annual Energy Bill Reduction by Region

6.2.5 Economic Tests and Supply Curves

This section sums up results for all policies across multiple sectors but is not from integrated modeling. The following results show economic measures for multiple policies that were evaluated independently. These numbers come from chapters 3-5. They give an overall view of how policies interact within sectors and their cost-effectiveness[25]. Table 6.6 provides information about the cost-effectiveness of each policy and how policies from the same sector interact. For each policy and each sector, the **benefit/cost (B/C) ratio** was determined using the total resource cost test.

As Table 6.6 shows, the portfolio of nine energy-efficiency policies is cost-effective. The two policies addressing commercial buildings have the highest combined ratio of benefits to costs. Over the 20-year period, an investment of $31.5 billion[26] would generate energy bill savings of $126 billion. Energy bill savings would begin immediately in 2010, would grow through 2030, and would then taper off until 2050 when the useful life of the improved technologies is expected to end. The result is a B/C ratio of 4.0 for the commercial sector. That is, for every dollar invested by the government and the private sector, four dollars of benefit is received. The industrial and residential sector policies are similarly cost effective with B/C ratios of 3.4 and 1.3.

The savings from the greater efficiency stimulated by these nine policies would total approximately $448 billion in present value to the U.S. economy. It would require an investment over the 20-year planning horizon of approximately $200 billion in present value terms. These costs include both public program implementation costs as well as private-sector investments in improved technologies and practices.

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[25] The interaction between sectors was addressed in Section 6.2.1, Energy Savings and Efficiency. There were a number of reasons that integrated results are not used for this section. First, the economic test makes most sense on a policy-by-policy basis. Second, these analyses are very time consuming and were not expected to provide significant new insights.

[26] In 2007 dollars, using a 7% discount rate.

Table 6.6 Total Resource Cost Tests by Sector (Million 07$)			
Residential Sector Policies			
	NPV Cost	NPV Benefit	B/C Ratio
Building Codes with Third-Party Verification	$10,000	$41,400	4.1
Appliance Incentives and Standards	$25,500	$7,060	0.3
Expanded Weatherization Assistance Program	$5,840	$6,420	1.1
Residential Retrofit and Equipment Standards	$86,600	$119,000	1.4
Combined Policies	**$115,000**	**$143,000**	**1.3**
Commercial Sector Policies			
	NPV Cost	NPV Benefit	B/C Ratio
Tighter Commercial Appliance Standards	$26,300	$109,000	4.6
Commercial Retrofit Incentives	$8,540	$20,900	2.4
Combined Policies	**$31,500**	**$126,000**	**4.0**
Industrial Sector Policies			
	NPV Cost	NPV Benefit	B/C Ratio
Industrial Plant Utility Upgrades	$10,800	$48,400	4.5
Industrial Process Improvement Policy	$36,000	$128,811	3.6
Combined Heat and Power Incentives	$16,900	$11,400 $17,600*	0.67 1.04*
Combined Policies	**$53,200**	**$179,000**	**3.4**

* Includes the environmental benefits from CO_2 emissions avoided by CHP systems.

The findings of McKinsey's "Unlocking Energy Efficiency in the U.S. Economy" are quite consistent with these estimates for the South, despite the fact that their analytic approach is quite different (Granade, et al., 2009). They conclude that by 2020, the United States could cost-effectively reduce its annual energy consumption by 23 percent from a business-as-usual projection, saving 9.1 quads of end-use energy. Further, these savings would be worth approximately $1.2 trillion in present value to the U.S. economy, and would require an initial upfront investment of about $520 billion. Public costs associated with implementing the policies needed to achieve these savings are not included in this estimate.

Among the nine individual policies, only two have benefit/cost ratios of less than one – indicating that they are not cost-effective. These include appliance incentives and standards (with a B/C ratio of 0.3) and combined heat and power incentives (with a B/C ratio of 0.7). When clothes washers and refrigerators are removed from the suite of appliance standards with incentives, the B/C ratio rises to 0.7. When carbon dioxide emission reductions are valued (at a range of $15 per metric ton in 2010 rising to $51 in 2030), both of these policies approach or exceed the breakeven B/C ratio of 1.

According to the total resource cost test, the most cost-effective policy is tighter commercial appliance standards (with a B/C ratio of 4.6), followed by B/C ratios of 4.5 for industrial plant utility upgrades and 4.1 for residential building codes with third party verification. These high B/C ratios combined with the fact that we examined an incomplete set of policies and technologies, suggests that greater levels of investment could generate additional, cost-effective energy savings.

Energy-efficiency supply curves have typically focused on individual technologies. Since the emphasis of this report is on program achievable energy efficiency potential, we have developed policy supply curves. The magnitude of energy demand resources that can be achieved by launching aggressive energy efficiency programs is shown along the horizontal axis, and they are ordered from the lowest to the highest levelized cost.

The energy supply curve for the South in 2020 (Figure 6.5) illustrates how over 4,300 TBtu of cost-effective opportunities for energy efficiency could be realized through policy implementation in 2020. McKinsey's 2009 study estimated a slightly smaller energy-efficiency opportunity in 2020 – 3,650 TBtu (Ostrowski, 2009).

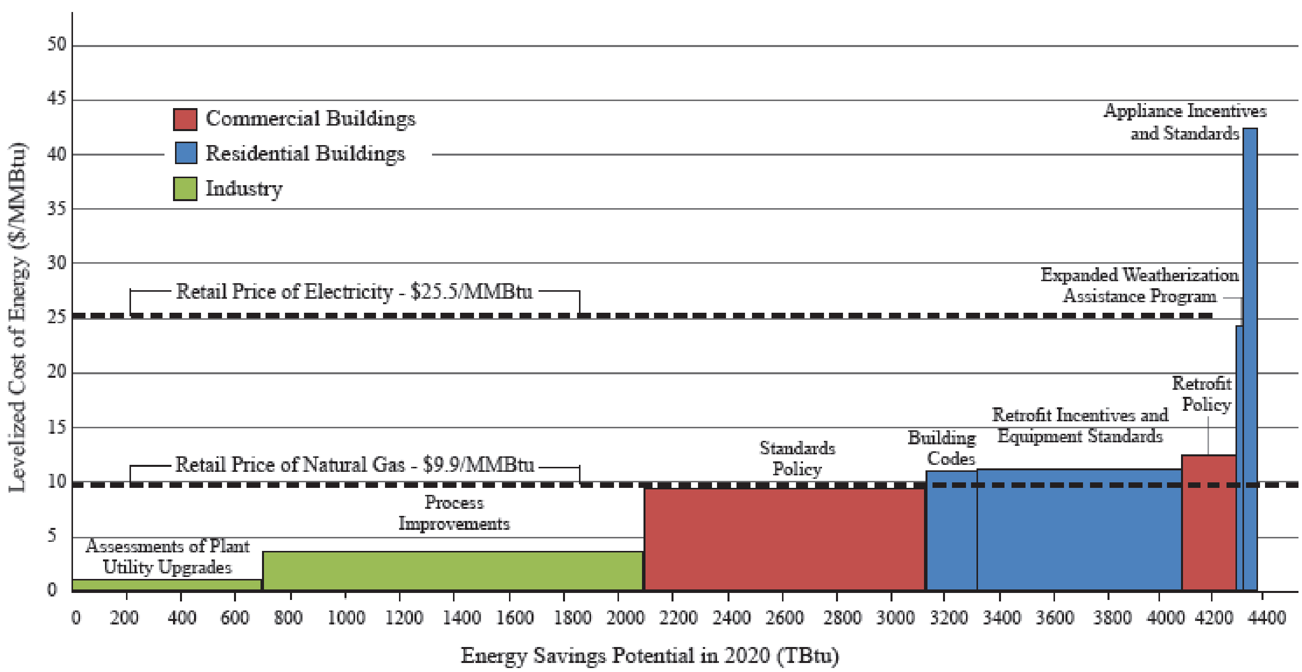

Figure 6.5 Supply Curve Energy-Efficiency Policies in the South in 2020 (RCI Sectors)

The least-cost savings can be achieved in the industrial sector, where over 50% of the potential would be realized. On the other hand, Residential Retrofit Incentives with Equipment Standards achieve very little energy efficiency for a much higher price.

The electricity efficiency supply curve for the South (Figure 6.6) illustrates how more than 2,100 TBtu of electricity savings could be realized from implementing eight energy-efficiency policies. (The combined heat and power policy could not be assigned a levelized cost value.) The supply curve also highlights the large, low-cost potential of industrial efficiency opportunities, which together could save more than 500 TBtu of electricity for a levelized cost that is significantly lower than the price of electricity for industrial consumers (6.2 cents/kWh). The next most cost-effective efficiency option is the commercial standards policy, followed by building codes, bringing the cumulative savings for these four policies to nearly 900 TBtu. When the retrofit incentives and equipment standards are added, a large additional savings can be achieved. The three remaining policies do not save as much electricity, including appliance incentives and standards, which produce electricity savings at a levelized cost that exceeds the residential price of electricity (10.5 cents/kWh).

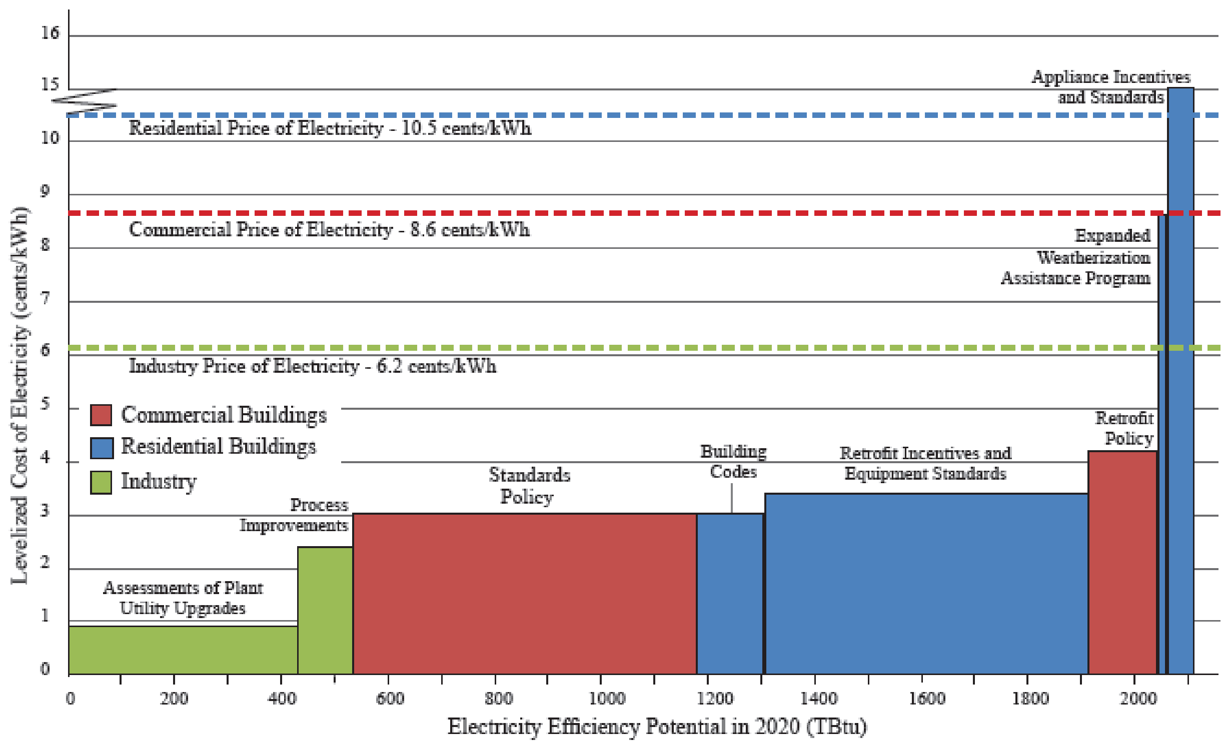

Figure 6.6 Supply Curve for Electricity Efficiency Resources in the South in 2020 (RCI Sectors)

The natural gas supply curve (Figure 6.7) distributes approximately 1,450 TBtu of savings across the eight efficiency policies. While commercial standards and residential building codes offer the least-cost natural gas savings, the magnitude of impact of these two policies is limited. Industrial plant utility upgrades and process improvements are also low-cost, and they offer larger-scale opportunities for cost-effective natural gas savings in the South.

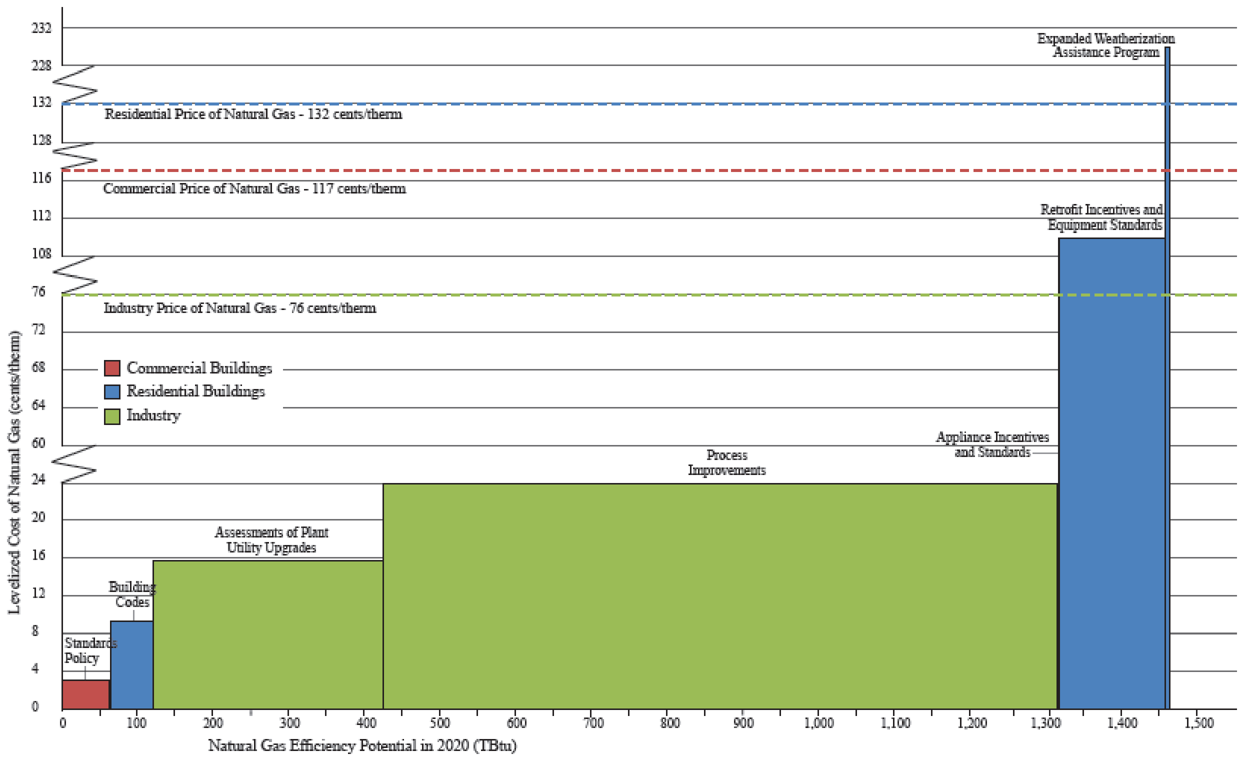

Figure 6.7 Supply Curve for Natural Gas Efficiency in the South in 2020 (RCI Sectors)

6.2.6 Macroeconomic and Job Impacts

To evaluate how the nine energy-efficiency policies might impact levels of employment and economic activity in the South, we use an Input-Output Calculator developed by the American Council for an Energy-Efficient Economy (ACEEE) for evaluating macroeconomic and job impacts of investments in energy efficiency (Laitner and Knight, 2009). The most important component of the calculator are the South Census Region's impact coefficients for 2008 provided by IMPLAN (IMpact Analysis for PLANing). IMPLAN is an econometric modeling system developed by applied economists at the University of Minnesota and the U.S. Forest Service. Currently in use by more than 500 organizations, IMPLAN models the trade flow relationships between businesses and between businesses and final consumers.[27]

Methodology. The critical statistics for estimating employment impacts are the jobs coefficients, which represent the number of jobs generated by an investment of $1 million in a particular industry. These coefficients indicate that an investment of $1 million in the construction and energy-efficient product manufacturing sectors (which includes both new building and retrofitting) generated 16.45 jobs in 2008. For the electricity and natural gas sectors, $1 million generated only 5.63 and 8.43 jobs, respectively. All other sectors of the economy had an average impact coefficient of 13.86 jobs per million dollars in 2008 (Figure 6.8). The higher labor intensity indicated by the large jobs coefficient for construction and energy-efficient manufacturing is one of the indicators that investing in energy efficiency is an engine for job creation.

[27] http://www.massachusetts.edu/econimpact/methodology.html

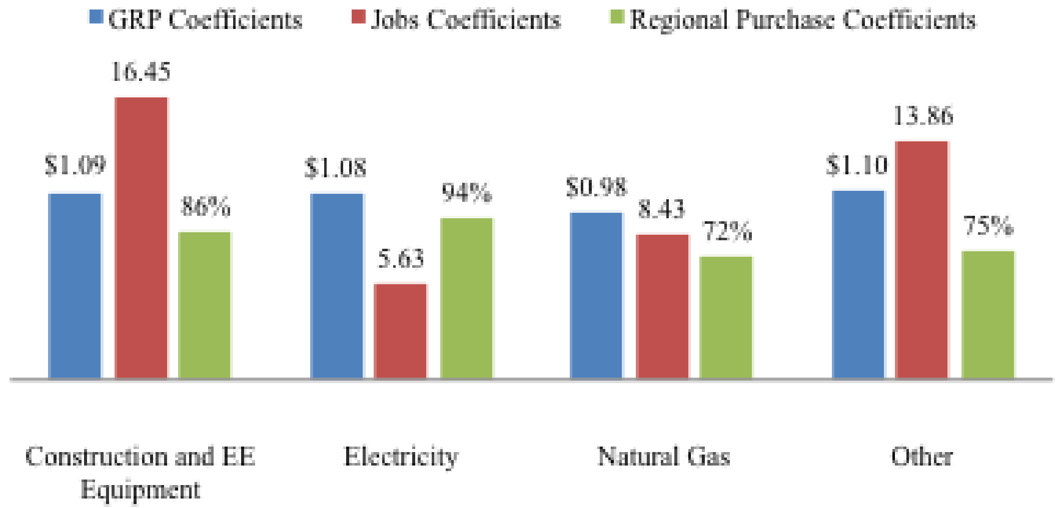

Figure 6.8 GSP, Jobs, and Regional Purchase Coefficients of Economic Sectors in the South

Jobs calculations going forward in time use the same coefficients, but also accounts for an annual 1.9% increase in labor productivity, based on Bureau of Labor Statistics (2009a) estimates.

Also important for estimating regional employment impacts are the Regional Purchase Coefficients (RPCs). An RPC is the proportion of the total demand for commodities by all users in the region that is supplied by producers located within the region. Of the four sectors examined here, the RPC in the South is highest for electricity (0.96) followed by construction and energy-efficiency product manufacturing (0.86), other sectors (0.75), and natural gas (0.72). Thus, 86% of the demand for construction and energy-efficiency product manufacturing in the South is supplied by producers located in the South, while 14% of the demand is satisfied by import.[28] Investment in goods with significant "local" content (i.e., larger RPC's) leads to greater local job creation. Local job growth is particularly large when a high RPC Coefficient is combined with a high Job Coefficient, as in the case of construction and energy-efficiency manufacturing.

The critical statistics for estimating impacts on economic activity are the GRP Coefficients, which represent the value added to the economy per dollar of investment. In 2008 the IMPLAN GRP coefficients for the South Census Region were 1.09 for construction and energy-efficient product manufacturing, 1.08 for electricity, 0.98 for natural gas and 1.10 for all other sectors. (See Table F.3.1 in Appendix F for the aggregation scheme of the sectors in the ACEEE calculator).

[28] These coefficients tend to be smaller and more variable as the size of the region shrinks – e.g., in the analysis of State impacts.

Results. The ACEEE calculator indicates that 127,000 jobs could immediately be added to the Southern economy, with 380,000 jobs added by 2020 and as many as 520,000 by 2030 (See Table 6.7).

The calculator estimates that **direct investment** associated with the nine energy-efficiency policies in 2020 could create 220,000 jobs, while that number could rise to 243,000 a decade later. One limitation with the direct investment method is that it is not clear what employment these dollars have forgone to invest in efficiency. The remainder of the job increases will be growth in employment created from homeowners and businesses shifting spending away from utility expenditures into more productive sectors.

The calculator also estimates that the nine energy-efficiency policies could improve the GRP by $1.2 billion in 2020 rising to $2.1 billion in 2030 based on changing spending patterns away from electricity and natural gas expenditures (See Appendix F for a State-by-State Summary of estimated GSP impacts in Table F.3.5).

Table 6.7 ACEEE Calculator, Inputs from SNUG-NEMS Leading to Job and GRP Effects

		2020	2030
Inputs (in Millions of 2007 Dollars)	Total Productive Investment	$16,800	$22,400
	Change in Electricity Demand	-$48,500	-$83,100
	Change in Natural Gas Demand	-$7,710	-$9,940
Effects	Overall Increased Employment	380,000	520,000
	Increased Employment from Direct Investments	246,000	243,000
	Additional Gross Regional Product (in Millions of 2007 Dollars)	$1,230	$2,120

ACEEE's calculator indicates a higher rate of job growth than other recent methodologies estimating the employment impacts of energy efficiency in the United States. A Center for American Progress (CAP) study (Pollin *et. al.*, 2008) estimated that $100 billion in clean energy investment could create 2 million additional jobs. For programs of the American Recovery Reinvestment Act – including Weatherization, the State Energy Program and other efficiency efforts – the President's Council of Economic Advisors (2009) estimated that $92,000 of spending would generate 1 job. Table 6.8 compares these ratios to the input-output methods

Table 6.8 Increased Employment Resulting from the Energy-Efficiency Polices Using Three Different Methods

	2020	2030
ACEEE Input-Output Calculator	380,000	520,100
Center for American Progress (CAP) Ratio (2 million jobs per $100 billion)	347,000	461,000
Council of Economic Advisors (CEA) ($92,000 for 1 job)	119,000	251,000

Note: In our calculations for the Center for American Progress Ratio and the Council of Economic Advisors, we include both total productive investment as well as non-incentive administrative costs, which were $17.35 billion in 2020 and $23.05 billion in 2030.

The most notable reason why the ACEEE Input-Output Calculator estimates higher job growth is that the saved expenditures on utility bills for electricity and natural gas customers foster long-term growth in other productive sectors of the economy. Both the CAP Ratio and the Council of Economic Advisors (CEA) formula, rely exclusively on the direct investments, focusing on short-term impacts of the economic stimulus provided by the American Recovery and Reinvestment Act (ARRA). Meanwhile this report considers two decades of implementation. The CEA job estimate is not a perfect comparison, as it is derived from all forms of spending, not just cost-saving energy efficiency improvements.

Figure 6.9 shows that the ACEEE job total from direct investments falls within the range of the other two formulas. For the first five years of the study, the ACEEE Input-Output calculator returns a lower increase in employment than the ACEEE projected job total exclusively based on direct investment. This is because the projected job creation from utility bill savings lags behind the decline in revenue for electricity and natural gas businesses.

A more complete analysis of the non-energy or productivity benefits of energy efficiency investments would likely increase the overall GRP impacts. There is a growing literature that documents several categories of "non-energy" financial benefits including reduced operating and maintenance costs, improved process controls, increased amenities or other conveniences, water savings and waste minimization, and direct and indirect economic benefits from downsizing or elimination of other equipment (Laitner 2009; Worrell et al. 2003).

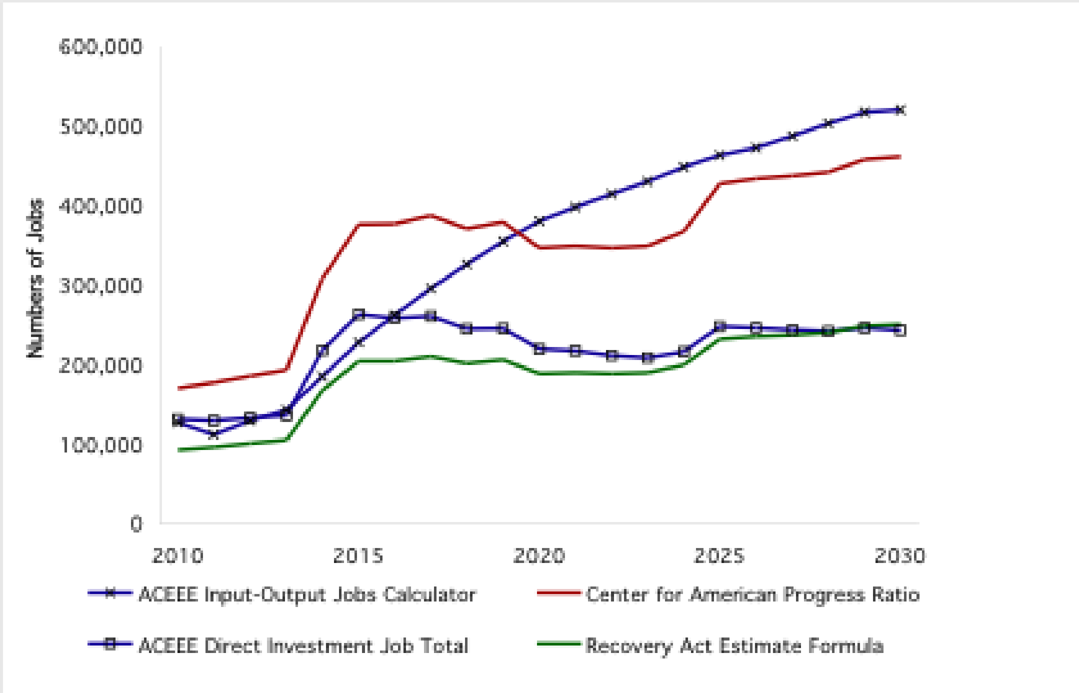

Figure 6.9 Increased Employment Impacts from Energy-Efficiency Policies for the Region
*Includes jobs from direct investment and changes in electricity

Shifting revenues from the non-labor intensive energy production industries to more labor intensive industries can create long-term job growth prospects, particularly during periods of high unemployment when labor is underutilized. The seasonally adjusted unemployment rate in the South Census Region was 9.6% in December 2009 (Bureau of Labor Statistics, 2009b). While this is lower than the national rate of 10.0%, the District of Columbia, Florida, North Carolina, and South Carolina all had over 11% unemployment.

While energy-efficiency policies may not be an instantaneous or complete solution to the current financial difficulties of the South, our analysis suggests that the public and private investments stimulated by the nine energy-efficiency policies will have a positive impact on employment and macroeconomic growth over the next two decades.

6.3 SENSITIVITY ANALYSIS

We use sensitivity analysis to help capture uncertainty associated with SNUG-NEMS forecasting. Sensitivity analysis helps practitioners and policymakers understand the implications of key assumptions, such as the future price of carbon or future technology breakthroughs.

The major topic chosen for sensitivity analysis of the Energy-Efficiency Policies was a case where a price is placed on carbon emissions, starting at $15/tonne CO_2 rising to $51/tonne in 2030. This sensitivity is called the Carbon Constrained Future (CCF). This sensitivity was chosen because regional and national regulation of greenhouse gases has been prominent and seems likely to affect the marketplace for energy-efficient technologies and the response to energy policies. To evaluate the combined effect of Energy-Efficiency Policies with a carbon constraint, we modeled CCF alone and combined with the Energy-Efficiency Policies. As mentioned in Chapter 2 there will be four scenarios compared in this section: Reference, Reference with Energy-Efficiency Policies, CCF, and CCF with Energy-Efficiency Policies.

6.3.1 Elements of the CCF Sensitivity

The CCF parameters include a very basic modeling of limiting greenhouse emissions, because this is not meant to be an analysis of any particular aspects of potential greenhouse gas legislation, many others have done that. EPA (2009) conducted a holistic estimate of greenhouse gas emissions and possible means of reduction in the U.S. McKinsey & Company (2008), from an economics perspective, estimated the U.S. greenhouse gas emission potential and some of the associated costs. In addition, the Center for Climate Strategies (2009) examined the greenhouse gas reduction strategies and potentials in the South. Further, a major report released by ACEEE in 2008 documents the large economic development contribution of productive investments in green technologies, which will likely be seen in a carbon-constrained future (Laitner, 2008).

Therefore, unlike anything being discussed in Congress, our CCF scenario is purposely simplistic which has its limitations, but also serves the purpose of keeping the scenario straightforward and simple. The main components and caveats include:

- Modeling a modest emissions reduction by picking a carbon price that is within EPA's (2009) range of allowance prices ($15 to $51).[29]
- No international offsets, banking, or borrowing.
- Allowance revenues are not put into R & D or Energy Efficiency programs.
- A portion of revenues are distributed to Load Distribution Companies (LDCs) in order to offset price increases that consumers would otherwise face[30]. This has the side-effect of reducing the market signal to consumers.

Figure 6.10 shows greenhouse gas emissions of CCF scenario relative to the Reference Scenario, both in the absence of Energy-Efficiency Policies, leading to 26% less emissions in 2030 from three demand sectors. Compared to Figure 6.11 which presents the energy consumption in CCF and Reference Scenarios, the energy savings from CCF are less pronounced (4%) than the emissions effect. The reason for this is that carbon constraints will first lead to cleaner fuels being used before reducing total consumption[31].

[29] Appendix F Figure F.2.1 illustrates the change of allowance price over years.
[30] Appendix B Table B.1 shows the annual allowance given to LDCs.
[31] In the EIA's analysis of ACESA, they project that in most cases between 6 and 85 percent of existing coal power plants will be retired by 2030, and that the capacity will be replaced by nuclear, renewable, and coal plants equipped with CCS. It is projected that annual electricity demand growth will decline from 0.9% to 0.64% between 2007 and 2030 (EIA, 2009i).

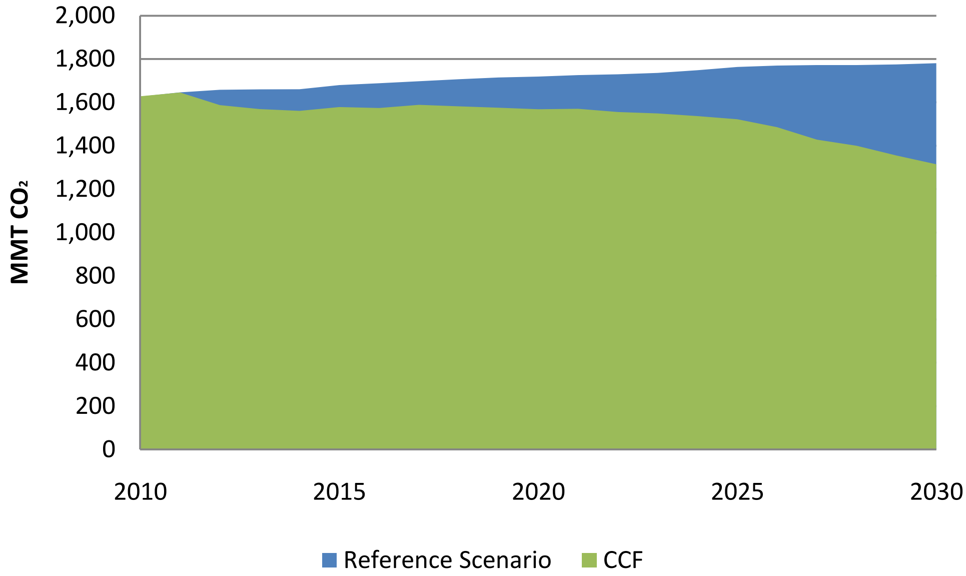

Figure 6.10 Southern CO_2 Emissions Divergence for Sensitivity Analysis

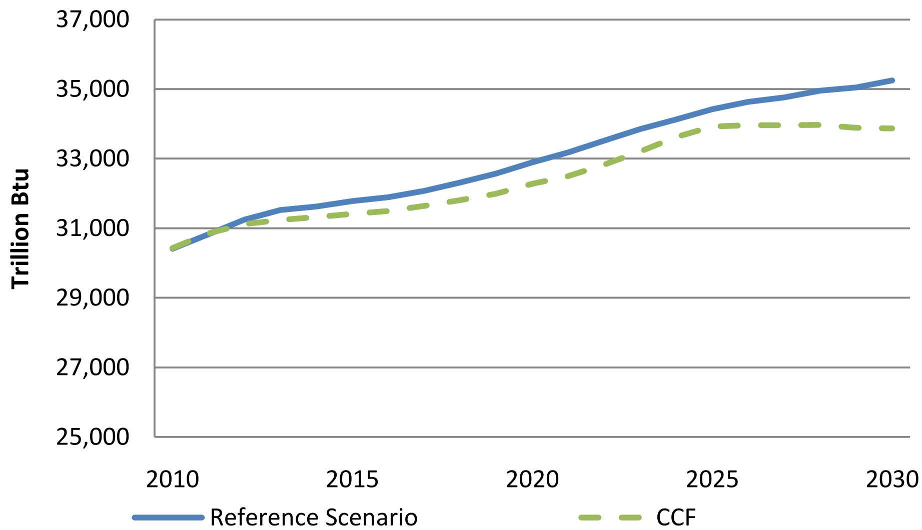

Figure 6.11 Southern Energy Divergence for Sensitivity Analysis

Figure 6.12, which shows the forecast for new capacity in 2030 for the Reference Scenario compared to the CCF. Most noticeable is that the CCF scenario has increased the nuclear generating capacity by nearly 44 GW while lowering the combined cycle and combustion turbine/diesel by over 17 GW each. However, capacity is largely unchanged (marginally higher) because the CCF effect on total demand is secondary to its effect on fuel type associated with generation. In both scenarios, more than 15 GW of oil and gas steam generation are retired.

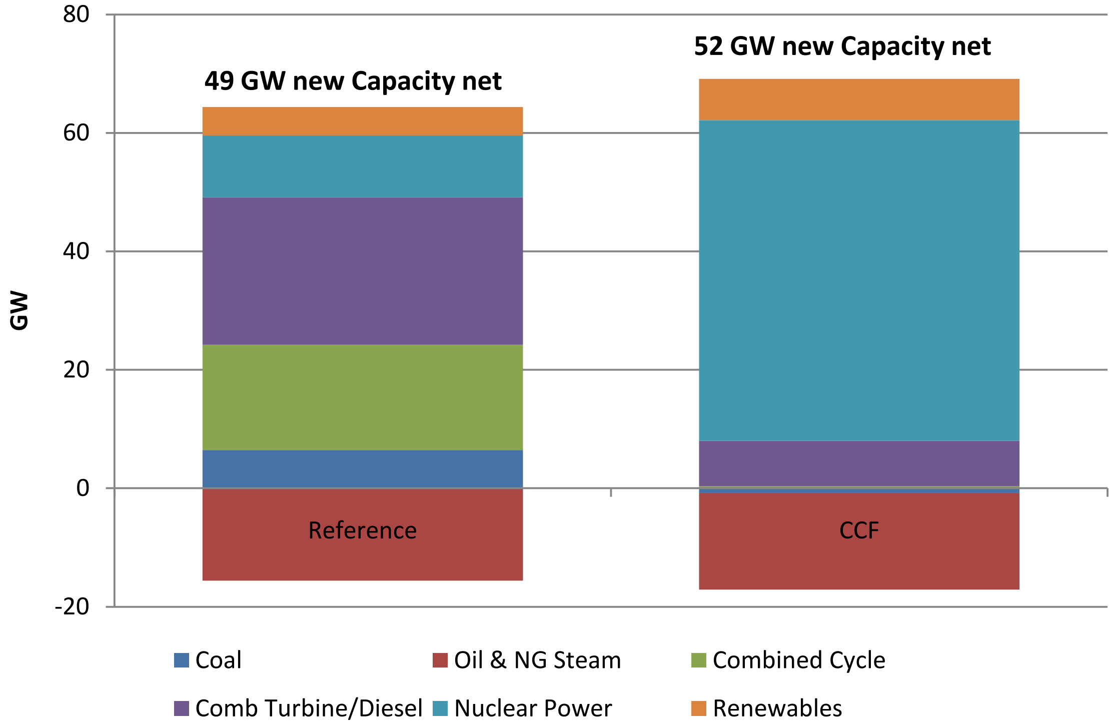

Figure 6.12 Generating Capacity Installed in 2030 Beyond 2010 Comparing the Reference Scenario and CCF

The next section addresses the question of whether implementing the Energy-Efficiency Policies under a carbon constrained future leads to similar or different conclusions regarding efficiency potential and economics than previously discussed in section 6.2.

6.3.2 Energy-Efficiency Policies and CCF

The main conclusion of the sensitivity analysis is that Energy-Efficiency Policies reduce energy consumption even in a carbon constrained future, when the higher price of fossil fuels has already lowered the overall consumption. When combined, the Energy-Efficiency Policies lower energy consumption still further.

This section will attempt to point out how and why CCF and Energy-Efficiency Policies interact. The energy interactions seem to be limited because at the chosen levels the CCF primarily leads to lower emissions and higher energy rates, and these rate increases are below the threshold that leads to significant consumer efficiency choices.

Energy Savings. Figure 6.13 shows that the predominate driver of reduced consumption is Energy-Efficiency Policies, while this CCF adds only a few percent of further reductions. There seems to be little synergy or redundant savings at these levels. Measuring the energy savings from the nine policies added to either the CCF or Reference Scenario reveals a very similar pattern (Figure 6.13), both reach about a 15% reduction of energy consumption in 2030 and a cumulative energy savings above 65,000 trillion Btu over 20 years.

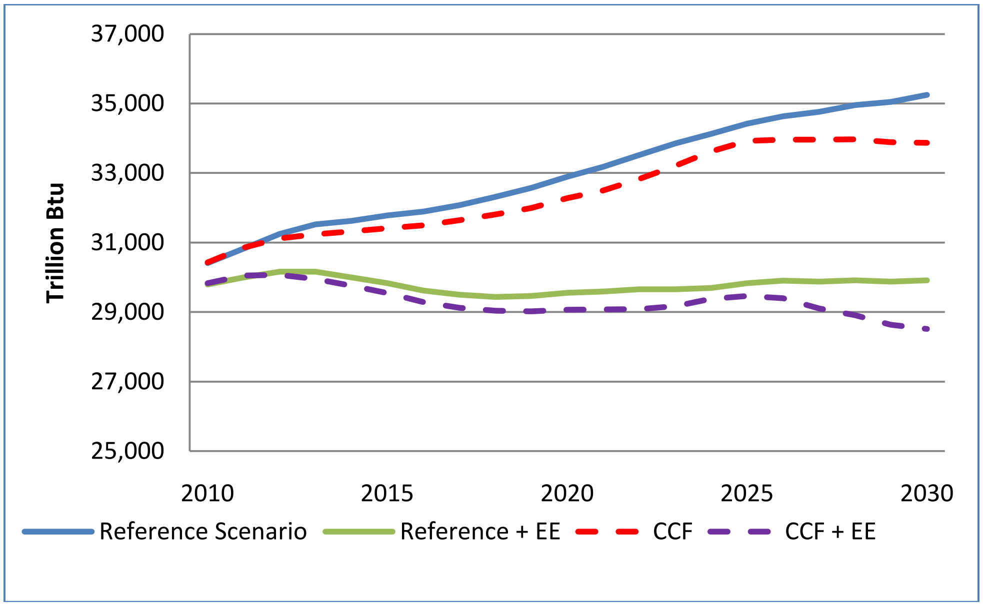

Figure 6.13 Primary Energy Consumption (RCI Sectors) in the South

At this level of energy efficiency, adding this carbon constraint does not lead to much interactive energy savings. However, digging deeper reveals interactions away from the primary focus of energy efficiency potential. While it may be no surprise that the energy rate reductions and energy bill savings effect from adding the Energy-Efficiency Policies to a CCF scenario are similar to the effect from adding the Energy-Efficiency Policies to the reference case;[32] actually the savings are a little smaller than the savings shown above in sections 6.2.3 and 6.2.4, and the modeling economics point to the reason for these energy results.

Carbon Dioxide Emissions. Emissions have value in the CCF scenario. Figure 6.13 shows the emissions for the reference future (top line), the CCF future (top of red area), and Energy-Efficiency Policies combined with CCF future (the line between the red and pink areas). Therefore, the red area represents the additional emissions avoided by adding Energy-Efficiency Policies. The value of energy efficiency in the CCF scenario can be reflected not only by rate reduction, and bill savings, but also by emission revenues avoided. The red area in Figure 6.14 reflects an NPV of $28 Billion for the South. This cumulative savings in allowance costs are calculated using the EPA (2009) price trajectory of $15 to $51 per tonne of carbon dioxide.

[32] Details in Appendix F section F.2

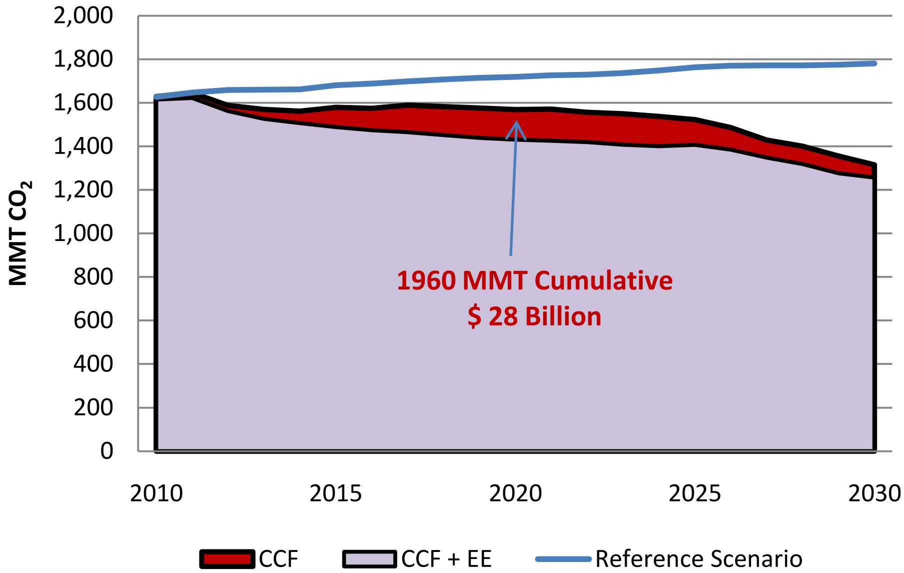

Figure 6.14 Emissions and Allowance Revenue with CCF

While energy savings are not interactive between the CCF and the policies, emissions reductions are. Figure 6.15 shows that combining the emissions levels for the four scenarios under discussion. In the short term, through 2020, the CCF and Energy-Efficiency Policies in and of themselves, lead to similar emissions reductions and the combination of the two seems to reach an additive level that might be expected without any interactions. After 2023 or so, CCF emissions continue to decline, but when CCF and Energy-Efficiency Policies are combined the emissions effect starts to diminish. At first, energy efficiency leads to less fossil generation, but after a while, energy efficiency more and more leads to less clean generation (less nuclear and renewable). This is reflected below as the dotted lines begin to converge after 2024.

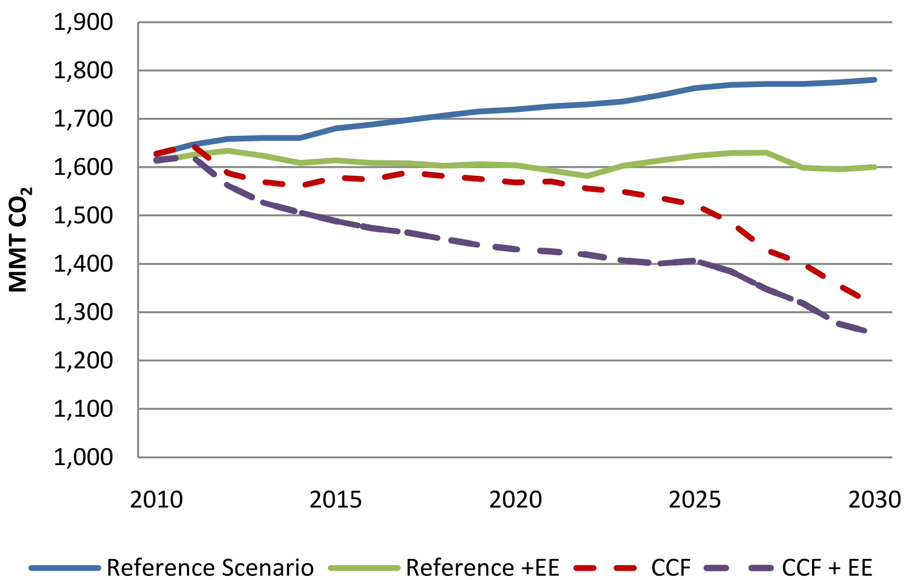

Figure 6.15 Carbon Dioxide Emissions with Energy-Efficiency Policies

Generating Capacity

Emissions limits, as discussed above, transform power plant fuels but do not lead to much energy savings in and of it itself. Net capacity growth, beyond 2010, for the four scenarios is shown in Figure 6.15. As noted regarding consumption, capacity is also about the same regardless of a CCF, but the fuel mix is quite different when under the CCF scenarios.

In a CCF future, nuclear replaces the new combined cycle and coal plants and some of the combustion turbines built in a Reference future. In the absence of Energy-Efficiency Policies, over 50 GW of nuclear power would be built by 2030. Implementing Energy-Efficiency Policies in this CCF scenario, reduces by half the new nuclear power built. Some renewable plants are also built to replace retiring generators, but the net capacity change is a reduction of 12 GW in the Southern NERC regions. Energy-Efficiency Policies mean 64 - 68 GW less capacity in the Southern NERCs by 2030.

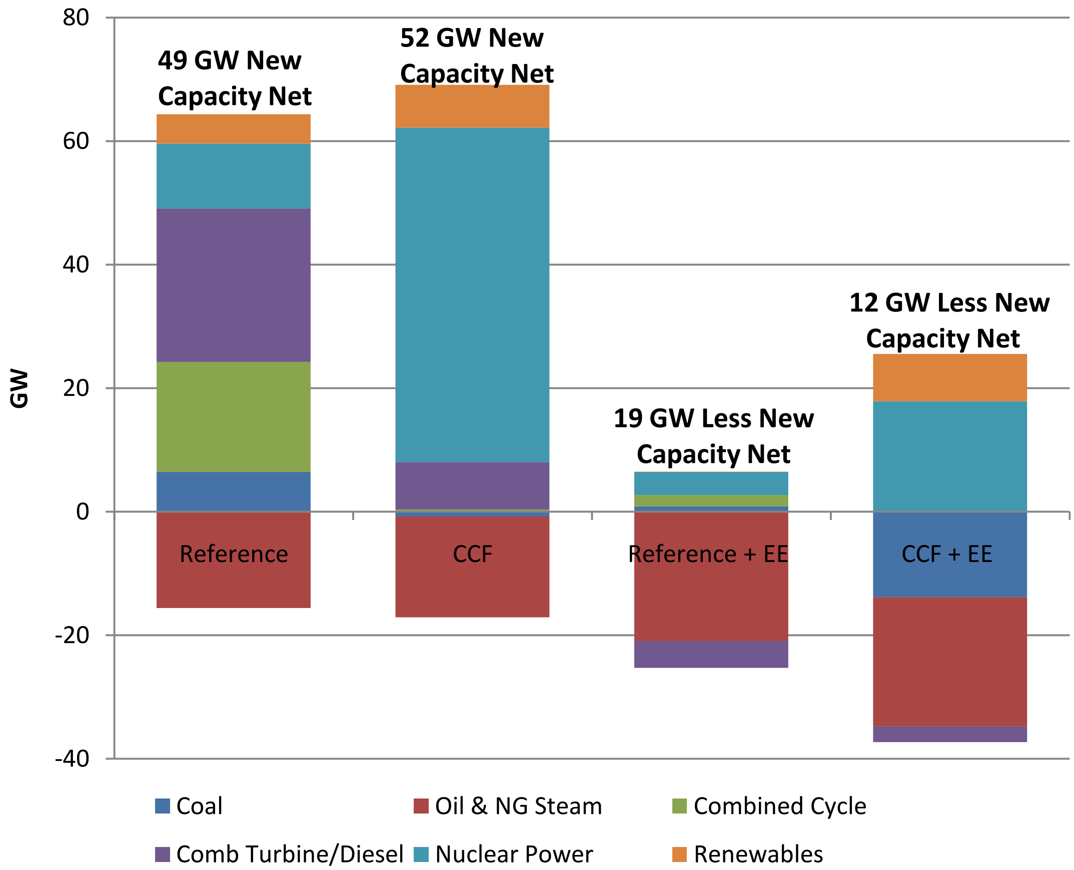

Figure 6.15 Southern NERC Incremental Generating Capacity in 2030 beyond 2010,

The change in number of plants built and retired for CCF with and without Energy-Efficiency Policies is shown in Appendix Table F.2.2.

6.4 WATER CONSERVATION THROUGH ENERGY EFFICIENCY

6.4.1 Water in Reference Future

Water conservation is another potential benefit of energy-efficiency measures; while we make no effort to capture the economic value of water conservation, it is of growing interest in the South and indeed worldwide. Water availability can constrain the siting of new power plants, it can limit the continued operation of plants with inefficient cooling technologies, it changes from year to year, and it is subject to its own regulations and competing uses. This section discusses a rough method for calculating freshwater conservation potential. This analysis only accounts for consumption (water lost to evaporation in the energy production process), and not non-consumptive withdrawal that returns water into the aquatic system.

The Southern forecast for freshwater consumed as cooling water in conventional and nuclear thermoelectric power plants is shown in Table 6.10.[33] Florida's freshwater consumption is particularly low because 95 percent of cooling water withdrawn in Florida is from saline sources. For Texas and the rest of the southeast, 74 percent and 70 percent of cooling water respectively is from freshwater rivers, lakes, or streams. The projections (as explained in Appendix B) show that the three NERC regions will consume 334 billion gallons in 2020 and 381 billion gallons in 2030 to produce electricity.

Table 6.10 Freshwater Consumption of Cooling Water in Conventional and Nuclear Power Plants, Reference (Billions of Gallons)

NERC Region	2020	2030
TRE	62	66
FRCC	12	15
SERC	260	300
Total	334	381

[33] Water use is based on generation, which is, similar to the capacity results in section 6.2.2, based on the Southern NERC regions, not the Southern Census Division. Figure 2.3 shows the overlap between the two regional definitions. TRE is most of Texas, FRCC is Florida, and SERC includes most of the rest of the Southern Census Division, not including Oklahoma, Kentucky, West Virginia, as well as parts of other states.

6.4.2 Water Conservation from the Energy-Efficiency Policies

From the implementation of our water calculator (more details in section 2.7 and Appendix F), we found that energy efficiency could avoid the consumption of significant quantities of freshwater across the South (Table 6.11). The nine energy-efficiency policies alone, could avoid generation that in turn would save the South 8.6 billion gallons of water in 2020 and 20.1 billion gallons in 2030.

Table 6.11 Freshwater Saved with Energy-Efficiency Policies

Comparison	In 2020	In 2030
Billions of Gallons Saved	8.6	20.1
	2009 to 2020	**2020 to 2030**
Projected Change in Consumption (Reference Case)	4.6%	12.2%
Cumulative Avoided Increase from Policies	3%	7%
Cumulative Avoided Marginal Increase from Policies	56%	43%

On a percentage basis, the Energy-Efficiency Policies could reduce more than half of the projected growth in cooling water needs for conventional and nuclear power from 2009 to 2020 and 43% of the projected growth for 2020 to 2030. Table 6.12 shows the new consumption forecasts with energy-efficiency policies for 2020 and 2030.

Table 6.12 Freshwater Consumption of Cooling Water in Conventional and Nuclear Power Plants, Reference with Energy-Efficiency Policies (Billions of Gallons)

NERC Region	2020	2030
TRE	62	65
FRCC	12	14
SERC	252	282
Total	**326**	**361**

6.4.3 Water Conservation in the Carbon Constrained Future

Table 6.13 shows the cooling water consumption forecast for the CCF scenario in the South. More nuclear power in 2030 in the CCF scenario accounts for an increase in cooling water consumption beyond the reference forecast.

Table 6.13 Freshwater Consumption of Cooling Water in Conventional and Nuclear Power Plants, CCF (Billions of Gallons)

NERC Region	2020	2030
TRE	59	65
FRCC	13	17
SERC	245	322
TOTAL	**317**	**404**

Implementing Energy-Efficiency Policies under the carbon priced scenario would reduce the water consumption by 18.8 billion gallons in 2020 and 90 billion gallons for the year 2030. Under a carbon-constrained future, there would be no projected growth in cooling water consumption between 2009 and 2020, with the Energy-Efficiency Policies. From 2020 to 2030, Energy-Efficiency Policies prevent 79% of the marginal annual increase. These savings in 2030 represent about four times the current total water needs of the City of Atlanta. Table 6.15 shows the new consumption forecasts with Energy-Efficiency Policies for 2020 and 2030 in the Carbon Constrained Future.

Table 6.14 Projected Reduction of Marginal Increase from Energy-Efficiency Policies, Relative to CCF

Scenario	In 2020	In 2030
Billions of Gallons Saved	18.8	90.0
	2009 to 2020	**2020 to 2030**
Projected Change in Consumption (CCF)	-1%	22%
Cumulative Avoided Increase from Policies	6%	22%
Cumulative Avoided Marginal Increase from Policies	No Increase	79%

Table 6.15 Freshwater Consumption of Cooling Water in Conventional and Nuclear Power Plants, CCF with Energy-Efficiency Policies (Billions of Gallons)		
NERC Region	**2020**	**2030**
TRE	54	48
FRCC	12	16
SERC	233	250
TOTAL	**298**	**314**

Table 6.16 provides a summary of the forecasts for the different scenarios. It shows clearly that freshwater consumption of cooling water in conventional and nuclear power plants in the South is lowest under a carbon-constrained scenario with energy-efficiency policies. Although fresh water savings as a percentage of reference case consumption are not as high as the percent energy savings, water conservation is a significant benefit of energy efficiency.

Table 6.16 Freshwater Consumption of Cooling Water in Conventional and Nuclear Power Plants, Summary of Scenarios for the TRE, FRCC and SERC NERC Regions (Billions of Gallons)		
NERC Region	**2020**	**2030**
Reference Case	334	381
Reference Case with EE Policies	326	361
CCF	317	404
CCF with EE Policies	298	314

Further research and analysis is likely to show other water conservation co-benefits from energy efficiency.

- The weatherization and retrofit programs discussed in this report may include water conservation components (such as instillation of low-flow toilets) on top of the energy saving measures.
- Power-plant water withdrawals would be reduced as the result of energy-efficiency policies, but this is difficult to characterize due to the high variability between power plants in this area. Water withdrawals, even where used cooling water is returned to the environment, can have a deleterious impact on freshwater ecosystems.
- Energy efficiency may also lead to reductions in mining and extraction, thereby preventing degradation of waterways from coal-ash and other harmful materials.

As noted in a recent Government Accountability Office report (2009), available data on power-plant water consumption is relatively incomplete. Policy-makers and researchers have only recently begun focusing on the energy-water nexus regarding the significant benefit of water conservation from energy efficiency, but it could be a useful tool for integrated resource planning.

6.5 CONCLUSIONS

The Energy-Efficiency Policies modeled in this study suggest the potential for significant energy savings in the South – either in a reference future or in a future where carbon emissions are priced. In 2030, more than 5,600 trillion Btu could be saved, with or without a future carbon constraint, and the cumulative energy savings from 2010 to 2030 could be more than 65,000 trillion Btu. These results are in line with estimates from other major studies.

Our analysis has documented that Energy-Efficiency Policies generally dampen energy price increases. Rate reductions coupled with energy savings leads to significant energy bill savings. In 2030, the South could realize $68 billion energy bill saving in the CCF scenario and more than $70 billion in the reference case, which each represent more than 20% of total expenses.

In addition, it is estimated that 49 GW of new power plant capacity would not need to be built in the South, if aggressive Energy-Efficiency Policies were implemented instead. At the same time, Energy-Efficiency Policies could conserve 90 billion gallons of water that would otherwise be consumed in processes related to energy generation, in the year 2030.

Though our Energy-Efficiency Policies result in significant energy savings, it is conservative in many respects, as is illustrated in Figure 6.17. On a percentage basis, the energy savings estimated in this report are lower than those of many other studies of the South. In some cases this is because we're comparing our estimates of achievable economic potential with NPV-positive estimates that do not account for shortfalls in implementation (McKinsey). In other cases, the higher potential is produced in part by the assumption of major technology improvements from large-scale R&D investments (IWG).

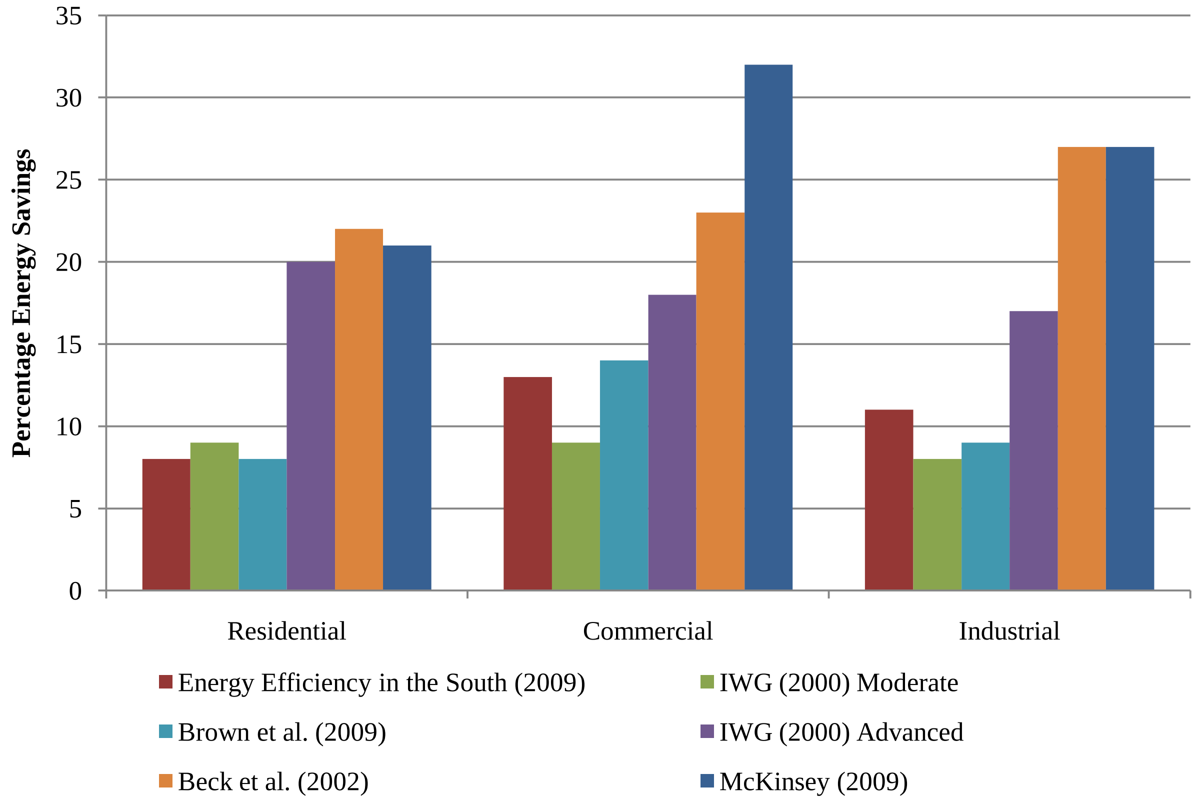

Figure 6.17: Comparisions with Other Studies for 2020 Savings

Our analysis is also limited by a range of simplifying assumptions and omissions. A number of these are described below.

- Limited assumptions are made about the technology improvements that could emerge from expanded R&D investments. Greater resources could be committed to energy efficiency R&D in the future if, for instance, a price were to be put on carbon, which is also not fully explored in this study. While we do examine a simplified carbon constrained future scenario, it does not include many policy dimensions currently under debate such as the use of domestic and international carbon offsets and the creation of a national trading program for carbon credits and energy efficiency certificates.
- Many aspects of consumer behavior are treated inadequately. For example, we do not consider the transformational influence of an increased public commitment to clean energy as a means of addressing global climate change. Indeed, we do not consider the impacts of a 2 degree Centigrade rise in global temperatures by mid-century, on requirements for air conditioning and the availability of water-demanding forms of electricity generation including hydropower, coal, and nuclear plants.
- Several sectors and technologies are insufficiently addressed (including new construction of commercial buildings, residential lighting technologies, and several forms of recycled

energy in industry). More comprehensive coverage of these would increase our estimates of energy efficiency potential.

- Transportation energy efficiency is omitted from our analysis, and yet it could have a large impact on the operation of the three sectors we do address. For example, the electrification of transportation in the U.S. could escalate power prices, creating greater demand for energy-saving devices. Several other synergies between policies are also not fully elaborated such as workforce development issues including possible economies of scale in training the future green workforce.

In the future, sensitivity analysis taking these factors into account should further explore the additional potential for energy efficiency under a range of assumptions about future carbon policies and climate conditions.

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