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Meta-Review of Efficiency Potential Studies and Their Implications for the South

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ABSTRACT

This paper reviews 19 separate studies published over the past 12 years that examine the potential for deploying greater energy efficiency in the South. These studies contain more than 250 estimates of the energy efficiency potential for different fuels (electricity, natural gas, and all 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.

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Meta-Review of Efficiency Potential Studies and Their Implications for the South

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Executive Summary

The rapid growth of energy consumption in the South, coupled with a concern for dependable, affordable, and climate-friendly energy in the future, has led policymakers to ask how much energy waste can be eliminated by investing in energy-efficient technologies. This report is the first in a series of research studies being developed by a team of researchers at Duke University, the Georgia Institute of Technology and Oak Ridge National Laboratory, focused on identifying the potential for expanding energy efficiency and renewable energy options in the South.

The geographic scope covered by these studies is defined by the U.S. Census Bureau's definition of the South, which is 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 nearly 37 percent of the nation's population. Its population has grown by 20 percent in the last ten years, and it is expected to continue to expand rapidly.

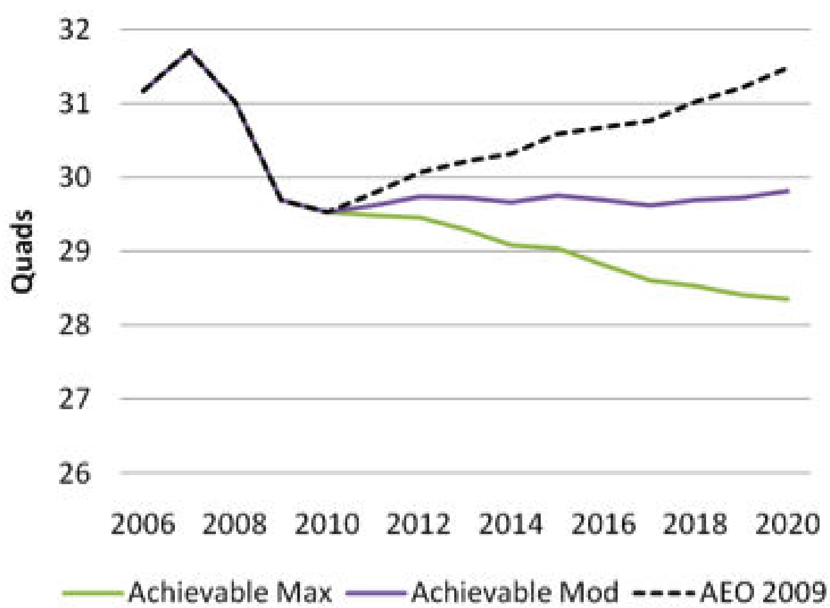
The South accounts for 44 percent of the nation's total energy consumption (considerably more than its population share). It also produces a large portion of the nation's fossil fuels, and the vast majority (77 percent) of the energy it consumes is derived from fossil fuels. If the region could achieve the substantial energy efficiency improvements that have occurred in many other parts of the country, this would significantly reduce carbon emissions across the region, improve air quality, and postpone the need for building new power plants. The South has been one of the last regions in the country to embrace energy efficiency programs and to develop an energy-efficiency culture of consumer behavior.

This report reviews 19 separate studies published over the past 12 years that examine the potential for deploying greater energy efficiency in the South. These studies contain more than 250 estimates of the energy efficiency potential for different fuels (electricity, natural gas, and

all 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 nine percent below projected levels, which would bring future consumption to slightly less than present levels, as shown in Figure A. This would entirely offset the need to expand electricity generation capacity in the South through the year 2020.

Figure A. Achievable Energy Efficiency Potential in the South Could Bring Energy Consumption in 2020 Down to Below Current Levels



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 two 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 one percent per year, which would more than eliminate the projected growth in energy demand in the region.

1. Introduction

Perhaps at no time since the 1970s has the South faced so many energy challenges. After decades of steadily expanding energy consumption, it is hard to imagine how continued rapid growth in energy demand can be accommodated. Concerns about global climate change, energy security, urban traffic congestion, and air quality compound the skepticism that the South can continue to build out its energy infrastructure and resources by simply replicating past practices. As a result, policymakers at all levels of government want to know how much of the region's forecasted growth in energy consumption can be met by improved energy efficiency. A corollary of this is a desire to identify what types of policies, programs, and technologies hold the greatest potential to curb the growth of energy consumption – at the least cost.

This report is part of a broader project, funded by the Energy Foundation and Turner Foundation, to assess the cost and availability of supply- and demand-side energy resources in the South.

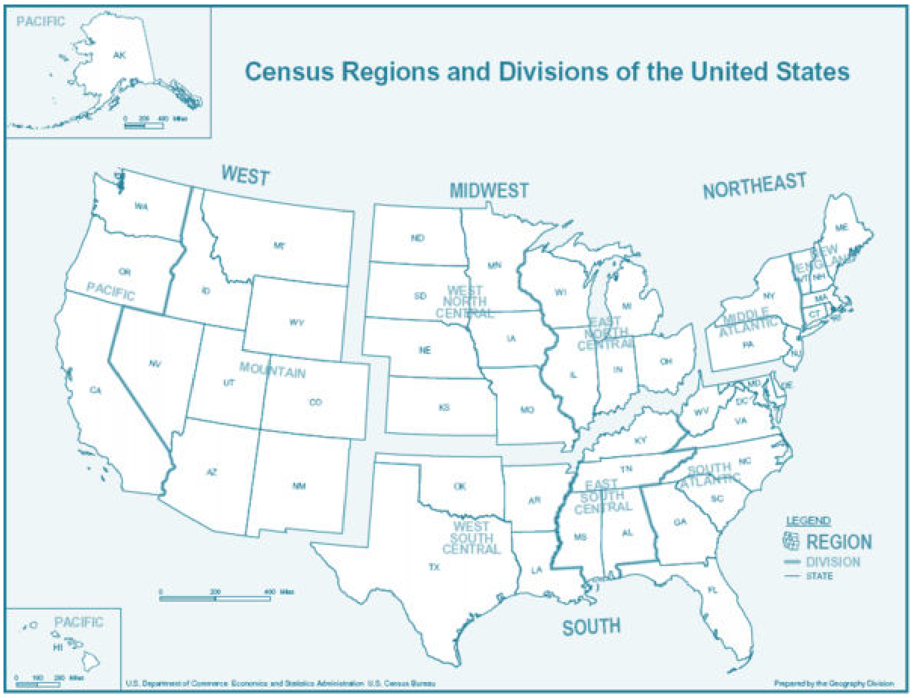
The report begins with a short description of the South census region, covering its unique endowment of energy resources and its current pattern of energy consumption and energy efficiency policies (Section 2). Section 3 summarizes the existing literature describing the potential for expanding energy efficiency in the South. Section 4 analyzes and compares the studies by normalizing their estimated savings on an annual basis. Section 5 synthesizes the results of these individual studies in order to estimate the total potential for improved energy efficiency in the South.

2. The South

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 region sweeps from Delaware to Texas and includes Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Virginia and West Virginia. The U.S. Census Bureau divides the Southern region into three divisions. The **South Atlantic** includes 8 states and the District of Columbia; all but West Virginia fall along the eastern seaboard. The **East South Central** includes 4 states with western borders that touch the Mississippi River. The **West South Central** region also includes 4 states, but they 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).[1] It is slightly larger than the 11-state region served by the Southeast Energy Efficiency Alliance.[2]

Figure 1. The Census Regions and Divisions of the United States[3]



With 36.7 percent of the country's population in 2008, the South is the most populous of the four census regions of the United States (U.S. Bureau of the Census, 2008). The South region leads the nation not only in population but also in in-migration and population growth.[4] As the nation's largest and fastest growing region, the South has experienced a 20 percent population growth over the past decade, and this rapid rate of population growth is expected to continue.

[1] 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.

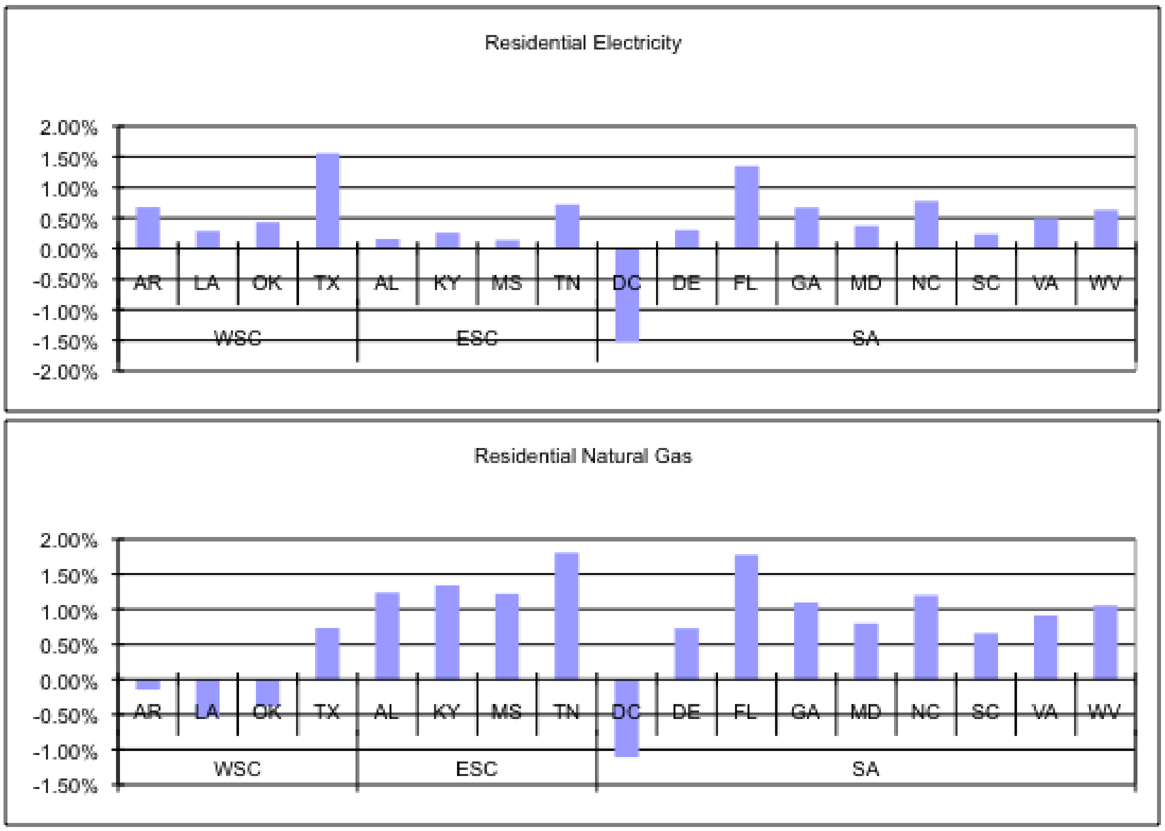
[2] The region as defined by SEEA includes the 11 states from Kentucky and Virginia south, and from Arkansas and Louisiana east – see www.seea.us.

[3] 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*

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

As a result, the projected annual growth rates of residential energy consumption in the region are higher than for the nation as a whole. For example, residential electricity consumption in the United States is expected to grow from 4.75 quads in 2007 to 5.67 quads in 2030 (EIA, 2009a), representing a 0.77 percent annual growth rate. In the South, residential electricity consumption is projected to grow from 2.27 to 2.92 quads over the same 23-year period, representing an annual growth rate of 1.09 percent. As Figure 2 illustrates, states in the South are likely to experience highly variable rates of residential energy growth, ranging from well

Figure 2. Projected Annual Growth Rates of Residential Electricity and Natural Gas in the South: 2007 – 2020



below the national average to more than twice the national average. The rapid increase in residential energy consumption forecast for Texas and Florida is particularly notable.

Across all sectors, electricity consumption in the South is expected to grow at an annual rate of 0.84 percent between 2007 and 2020, the period that dominates this meta review. Growth rates are highest for commercial buildings and lowest for industry.

Natural gas consumption over this same time frame is forecast to grow only slightly in the United States and in the South. Both nationally and in the South, natural gas use in industry is expected to decline markedly, while it is expected to continue to increase in residential and commercial buildings.

2.1 Energy Supply in the South

The South produces significant portions of the nation's fossil fuels. In 2006, the region supplied 48.4 percent 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):

--56.1% of conventional oil

--64.5% of natural gas marketed production

--37.8% of coal production

--42.6% of electricity production from nuclear power

--28.3% of renewable energy production.

With a fuel mix that is 77 percent 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. However, in three states, natural gas dominates, and in South Carolina, nuclear power is the principal source of electricity generation. 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 percent of U.S. carbon emissions.

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 8.72 cents per kilowatthour (EIA, 2009d), compared with a national average of 10.65 cents.[5] 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 (EIA, 2009d).

Despite its generous endowment of energy resources, the region is economically challenged. It accounts for only 33.0 percent 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.

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[5] http://www.eia.doe.gov/cneaf/electricity/epa/fig7p5.pdf

2.2 Energy Demand in the South

The South accounted for 43.6 percent of the nation's total energy consumption in 2006, considerably more than its share of the country's population – 34.8 percent (U.S. Census Bureau, 2008). Its higher-than-average per capita energy consumption is true for each of the major end-use sectors: residential buildings (39.8%), commercial buildings (37.9%), industry (50.9%), transportation (41.4%), and electric power (42.9%).

The South has been one of the last regions of the country to embrace energy efficiency programs and to develop an energy-efficiency culture of consumer behavior. For Energy Star appliances with sales data that are tracked by EPA, the South has the lowest rates of market penetration (McNary, 2009). Per capita spending on electric utility energy efficiency programs in the Southeast is just one-fifth the national average. This fact is reflected in the assessments of Elliott et al. (2003) and Elliott and Shipley (2005), which examined the effect of having each state implement policies like those developed in California and the Northeast. 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, grades were distributed as: A (12), B (12), C (8), and D (16).

The 2008 state efficiency scorecard does not include grades; rather, the authors' advise that states be evaluated in "bins" which are based on rankings (Eldridge et al, 2008). For consistency, this report assumes that the first bin would be the equivalent of an A and the last the equivalent of a D; grades would be distributed as A(10), B(12), C(9), D(17).[6] Of the 16 states in the South, 9 received a D – one less than in 2005. However, the score for Texas was downgraded to a "B" and no state in the South received an "A."

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

3. Summary of Studies

This review examines the results of more than 250 estimates from 19 energy efficiency potential studies with estimates of energy savings potential over the last 12 years – starting with the 1997 "Five labs study" and ending with the just published assessment for the Appalachian region. Six studies cover the nation as a whole, four cover regions, and sixteen

[6] The groupings, or "bins," are defined in Eldridge et al (2008) in Figure 8 on p.41.

estimates are state-specific. There have been many more studies across the nation in this same time, especially for California and the Northeast; however, studies specific to states or regions that do not include at least portions of the South census region are excluded.

Most of the states are covered implicitly, within a region, or explicitly by the potential studies included in this literature review. However, four states and the District of Columbia are not covered by the potential studies included in the analysis: Arkansas, Delaware, Louisiana, Oklahoma. These five states are included, of course, in all the national studies and in EPRI's (2009) estimate for the whole South census region.

3.1 Types of Efficiency Potential

When evaluating the potential for any electricity alternative to be deployed in future years, four types of estimates are generally used (Rufo and Coito, 2002; NYSERDA, 2003). These types of efficiency discussed in this analysis are briefly described below along with the concept of naturally occurring efficiency. Figure 3 shows a graphical representation of the general relationship between these types of efficiency potential.

Technical: Assumes that all technically feasible energy efficiency measures are adopted. These are also referred to as engineering estimates. Does not consider cost. In some cases, the technical potential assumes that the technology available changes over time via innovation.

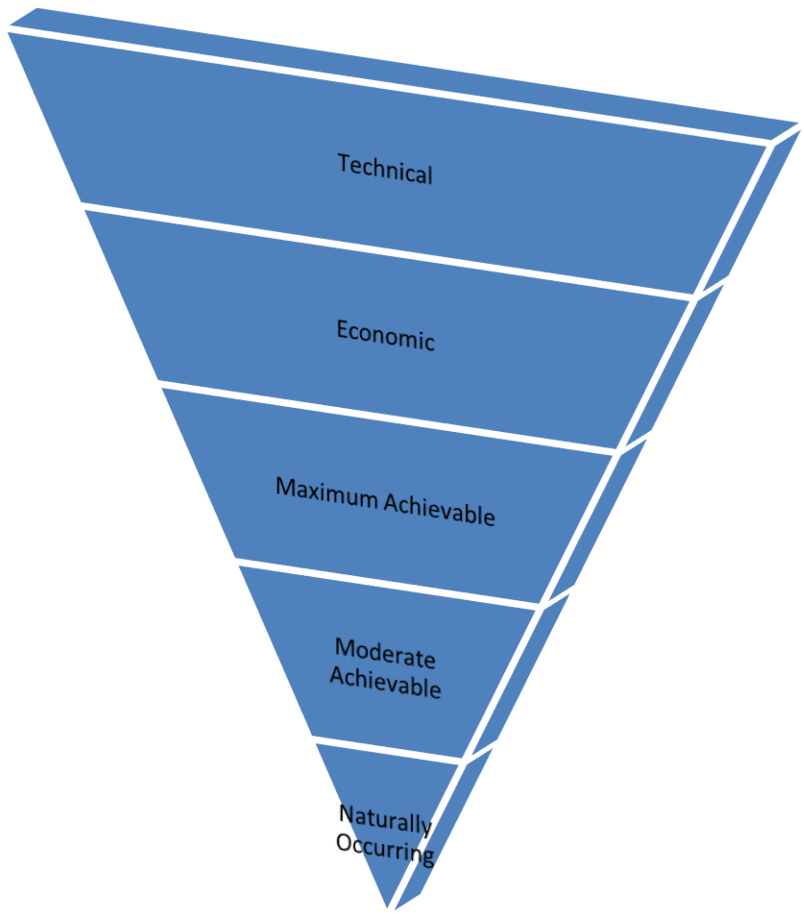
Economic: Generally a subset of technical potential that must pass a cost test. For example, the net present value for total costs must be positive; the rate of return must meet a particular threshold; or the cost of the measures must be less than the forecast cost of consumption that it is planning to offset.

Maximum Achievable: Generally a subset of economic potential that considers what portion of the cost-effective efficiency measures could reasonably be achieved by policy efforts; in some cases, the maximum achievable potential is analyzed before the economic potential, so it could include measures that are not cost-effective but might be adopted under aggressive policies. Usually, these estimates assume that policies offer substantial incentives to adopt, covering more than 50% and up to 100% of incremental costs.

Moderate Achievable: The moderate achievable potential is also referred to as the "reasonable" potential. This estimate generally considers a policy incentive of less than 30% of incremental costs.

Naturally Occurring: The level of efficiency expected to be achieved based on current policies and typical rates of technology improvement. The portion of future efficiency potential attributable to naturally occurring efficiency is generally excluded from assessments of energy efficiency potential. Instead, naturally occurring efficiency improvements are generally included in the baseline forecast of energy consumption – that is, they are treated as "endogenous." This is the approach taken in EIA's *Annual Energy Outlook*, which already includes current policy projections and typical rates of technology improvement in its baseline energy forecast. The AEO and most studies of energy efficiency potential do not include future efficiency projections from current utility-level programs in their naturally occurring figures, but utility studies and EPRI (2009) do.

Figure 3. Graphical relationship between types of efficiency potential



3.2 National Studies

Short summaries of six national studies are presented here in chronological order, five of which are included in our analysis.

- Interlaboratory Working Group. 1997. Scenarios of U.S. Carbon Reductions: Potential Impacts of Energy-Efficient and Low-Carbon Technologies by 2010 and Beyond. Oak Ridge, TN and Berkeley, CA: Oak Ridge National Laboratory and Lawrence Berkeley National Laboratory. ORNL-444 and LBNL-40533. September. http://enduse.lbl.gov/projects/5lab.html

Also known as simply the "five lab study," this report develops scenarios for reducing carbon emissions - focusing on four energy sectors: buildings, industry, transportation, and utilities. The study used four scenarios: a base case, an efficiency scenario, and two efficiency/low carbon scenarios. This study concludes "a vigorous national commitment to develop and deploy energy-efficient and low-carbon technologies could cost-effectively reduce U.S. carbon emissions by approximately 390 MtC per year," enough to meet Kyoto goals of reducing emissions to 1990 levels.

- Interlaboratory Working Group. 2000. Scenarios for a Clean Energy Future (Oak Ridge, TN; Oak Ridge National Laboratory and Berkeley, CA; Lawrence Berkeley National Laboratory), ORNL/CON-476 and LBNL-44029, November. http://www.ornl.gov/sci/eere/cef/

"The principal goal of this study is to produce well-documented scenarios that assess how public policies and programs can foster efficient and clean energy technologies to meet the nation's energy-related challenges." The Interlaboratory Working Group modeled three scenarios (business as usual, moderate, and advanced) using a specially modified version of NEMS (CEF-NEMS) to estimate potential savings. The study concludes that significant savings are available with benefits exceeding costs although there will be noticeable shifts in the economy if they are achieved.

- Elliott, N. and A. Shipley. 2005. Impacts of Energy Efficiency and Renewable Energy on Natural Gas Markets: Updated and Expanded Analysis. American Council for an Energy Efficient Economy, Report E052. http://www.aceee.org/pubs/e052.htm

This study updates a similar effort from 2003 to quantify the potential for energy efficiency and renewable energy sources to reduce the strain on natural gas markets to avoid skyrocketing and volatile natural gas prices. Based on existing policy and state and regional differences, the study estimates the total potential for achievable energy efficiency for electricity and natural gas - for the nation as a whole and individual states. Estimates of potential are given in 1, 5, 10, and 15 year increments - ending in 2020. The study was meant to drive the attention and commitment of policy makers to energy efficiency and renewable energy policies. Note: the 2003 analysis is not included because of the similarities.

- McKinsey Global Institute. 2007. Wasted Energy: How the U.S. Can Reach its Energy Productivity Potential. http://www.mckinsey.com/mgi/reports/pdfs/wasted_energy/MGI_wasted_energy.pdf

This report shows that cost-effective technologies (with an internal rate of return of at least 10 percent) can offset anticipated growth in U.S. energy demand for all sectors - finding the largest savings in the residential sector. The report offers a sobering view of the future without transformative policies; the United States is anticipated to remain the most energy intensive nation - with Europe and China making significantly greater advances in energy efficiency than the U.S. business as usual case. This study is included in this summary of existing studies because it offers a potential assessment; however, it is excluded from the analysis because the number of years to reach the potential is not given.

- Brown, Rich, Sam Borgeson, Jon Koomey, and Peter Biermayer. 2008. U.S. Building-Sector Energy Efficiency Potential. Lawrence Berkeley National Laboratory. http://www.osti.gov/bridge/servlets/purl/941430-cn2bC7/

Drawing on the techno-economic potential estimate of the Clean Energy Future study and an estimate of natural gas savings in downstate New York (as well as some self-calculated end-use estimates), this study uses the Annual Energy Outlook 2007 as a baseline to show potential savings for residential and commercial buildings. This report assumes that the efficiency potential estimated by the CEF study from 2000 to 2020 is the same "potential" available from 2010 to 2030; the assumption is taken to mean that new efficiency potential replaces that which is already achieved - due to advances in technology and markets.

- EPRI. 2009. Assessment of Achievable Potential from Energy Efficiency and Demand Response Programs in the U.S.: (2010–2030). EPRI, Palo Alto, CA.1016987. http://my.epri.com/portal/server.pt?Abstract_id=000000000001016987

This study provides estimates of efficiency potential at the national and census region levels; it was "undertaken to provide an independent, analytically-rigorous estimate of the electricity savings potential of energy efficiency and demand response programs to inform utilities, policymakers, regulators, and other stakeholder groups." This study uses the Annual Energy Outlook 2008 with an adjustment for utility energy efficiency programs in place as the baseline forecast. EPRI (2009) includes utility expectations for current programs in the baseline.

Table 1 shows the estimates of energy efficiency potential for electricity, natural gas, and “all fuels” as presented in the national level reports reviewed. Each study presents a potential estimate based on its own scope; some studies estimate savings for only one sector, some for only one fuel – most studies only look at one or two “types” of potential, such as technical or economic. As a result, Table 1 has numerous empty cells. Only one of the studies, EPRI (2009), has estimates of each of the four types of savings potential, and these are limited to electricity, ranging from 29 percent for technical potential in 2030 to 8 percent for moderate achievable potential in 2030 – a 3.5-fold range. Similarly, only two studies, IWG (1997, 2000) consider all three fuel types.[7]

Table 1. Summary of Percent Efficiency Reduction of Forecast End Year Consumption in National Studies

Study Ref	IWG (1997)	IWG (2000)	Elliott & Shipley (2005)	McKinsey Global Institute (2007)	Brown et al. (2008)	EPRI (2009)
End Year	2010	2020	2020	2020	2030	2030
Length (years)	13	20	15	13	20	22
			Technical			
Residential	--	--	--	--	--	--
Commercial	--	--	--	--	--	--
Industrial	--	--	--	--	--	--
Total	--	--	--	--	--	– (29/–)
			Economic			
Residential	--	– (37/12)	--	38 (–/–)	– (30/28)	--
Commercial	--	– (26/26)	--	17 (–/–)	– (34/35)	--
Industrial	--	--	--	a	--	--
Total	--	--	--	20 (–/–)	--	– (14/–)
			Maximum Achievable			
Residential	12 (17/3)[1]	21 (27/8)	--	--	--	--
Commercial	13 (15/5)[1]	19 (22/8)	--	--	--	--
Industrial	13 (15/14)	17 (22/11)	--	--	--	--
Total	13 (16/9)[2]	19 (24/9)[2]	--	--	--	– (11/–)
			Moderate Achievable			
Residential	5 (7/1)[1]	9 (13/2)	--	--	--	– (8/–)
Commercial	6 (6/9)[1]	9 (11/7)	--	--	--	– (9/–)
Industrial	7 (8/7)	7 (7/5)	--	--	--	– (8/–)
Total	6 (7/6)[2]	8 (10/5)[2]	– (11/10)	--	--	– (8/–)

Savings shown as percent of end year consumption for: ‘all fuels (electricity/natural gas)’. Combined, these studies account for 19 estimates for all fuels, 28 estimates for electricity, and 21 estimates for natural gas that included (or allowed calculation of) a percentage of end-year forecast savings.

– Estimate not presented in report
a Estimate provided but percent not calculated
[1] Includes all fossil fuels
[2] Calculated by authors

[7] In this review of efficiency potential studies, fuels are: “all fuels” which is defined differently by study, electricity, and natural gas.

According to the Electric Power Research Institute, the South Census region has the greatest technical potential for electric energy efficiency of the four regions nationwide (EPRI, 2009). Comparing the study's national and regional estimates suggests that the economic potential for electric efficiency in the South is actually smaller that of the nation, perhaps reflecting the lower electricity rates in the South; however, the physical potential, based on these percents, is largest for the South for all types of potential because of the South's larger baseline consumption.

3.3 Region-level Studies in the South Census Region

Four studies investigated savings at a regional level. The EPRI (2009) study also estimated savings at a national level, so only three summaries are presented here – in chronological order.

- Beck, Fredric, Damian Kostiuk, Tim Woolf, and Virinder Singh. 2002. Powering the South: A Clean Affordable Energy Plan for the Southern United States. Renewable Energy Policy Project. http://www.repp.org/articles/static/1/binaries/pts_repp_book.pdf

Powering the South estimates the potential for efficiency and renewable resources in the southeast by 2020, showing that aggressive efficiency policies can offset more than half of expected load growth over this period. The study concludes that the suite of policies presented can substantially decrease emissions of harmful pollutants and improve other measures of environmental quality. Potential estimates are given for the combined six state region (dubbed the "South" for this study) as well as rough estimates on a state-by-state basis.

- MEEA. 2006. MEEA Midwest Residential Market Assessment and DSM Potential Study. Sponsored by Xcel Energy. http://www.mwalliance.org/image/docs/resources/MEEA-Resource-5.pdf

The MEEA (2006) market assessment and potential study characterizes the potential for energy efficiency and demand side management in the residential sector. The study included surveys to collect primary data. The study presents estimates of potential for electricity and natural gas in the residential sector for the MEEA region and for its eight component states, including Kentucky. The study finds that natural gas savings potentials are larger and more consistent across states than the electricity savings potentials.

- Brown, Marilyn. John "Skip" Laitner, Sharon "Jess" Chandler, Elizabeth D. Kelly, Shruti Vaidyanathan, Vanessa McKinney, Cecelia "Elise" Logan, and Therese Langer. 2009. Energy Efficiency in Appalachia: How Much More is Available, at What Cost, and by When? Prepared by the Southeast Energy Efficiency Alliance (SEEA) for the Appalachian Regional Commission (ARC). http://www.arc.gov/index.do?nodeId=3335

SEEA (2009) assesses the potential for cost-effective energy efficiency gains across the 410-county Appalachian Region's residential, commercial, industrial, and transportation sectors. The study assesses "long-term energy-efficiency gains that could be achieved by implementing an ambitious package of energy-efficiency policies throughout Appalachia". Savings for Appalachia (from a population weighted extract of the Annual Energy Outlook 2008) are estimated to be about 24% over all four sectors by 2030; the study's explicit inclusion of the transportation sector is a striking difference from most energy efficiency potential studies. The study described possible double counting of savings from two programs in the commercial sector; estimates that eliminate one of these programs are used here. A May 2009 update to this report shows estimates of savings by fuel and sector; this analysis uses numbers from the updated report.

Table 2. Summary of Percent Efficiency Reduction of Forecast End Year Consumption in Regional Studies

	Appalachia	IL, IN, IA, KY, MI, MN, MO, OH, WI	South Census	TN, NC, SC, GA, FL, AL
Study Ref	SEEA (2009)	MEEA (2006)	EPRI (2009)	Beck et al. (2002)
End Year	2030	(blank)	2030	2020
Length (years)	20	20	22	20
		Technical		
Residential	--	-- (24/47)	--	--
Commercial	--	--	--	--
Industrial	--	--	--	--
Total	--	--	-- (31/--)	--
		Economic		
Residential	--	--	--	--
Commercial	--	--	--	--
Industrial	--	--	--	--
Total	--	--	-- (13/--)	--
		Maximum Achievable		
Residential	15 (11/23)	--	--	--
Commercial	28 (30/32)	--	--	--
Industrial	22 (42/15)	--	--	--
Total	24 (47/14)	--	-- (11/--)	--
		Moderate Achievable		
Residential	--	-- (10/25)	--	-- (14/--)
Commercial	--	--	--	-- (14/--)
Industrial	--	--	--	-- (15/--)
Total	--	--	-- (8/--)	-- (14/--)

Savings shown as percent of end year consumption for: 'all fuels (electricity/natural gas)'. Combined, these studies account for 4 estimates for all fuels, 14 estimates for electricity, and 6 estimates for natural gas that included (or allowed calculation of) a percentage of end-year forecast savings.
-- Estimate not presented in report

3.4 State-level Studies in the South Census Region

Below are summaries, in chronological order, of the ten state-level studies not included as part of a larger regional study. Both Beck et al. (2002) and MEEA (2002) estimate state level savings but are summarized above.

- Hadley, S. 2003. The Potential for Energy Efficiency and Renewable Energy in North Carolina. Oak Ridge National Laboratory. http://www.ornl.gov/~webworks/cppr/y2006/rpt/116643.pdf

Hadley (2003) provides an initial estimate of the potential for energy efficiency and renewable energy in North Carolina using an extraction from the South Atlantic Census Division results from NEMS. The finding is that there is substantial available cost-effective savings without fiscal policies, like subsidies or tax incentives. Estimates of improved consumer adoption based on changes in perception/marketing are modeled by changing the discount rate input to the NEMS model - based on the Moderate scenario of the Clean Energy Future study (IWG, 2000).

- Jensen, V., & Lounsbury, E. (2005). *Assessment of Energy Efficiency Potential in Georgia*. ICF Consulting for Georgia Environmental Facilities Authority. http://www.gefa.org/Modules/ShowDocument.aspx?documentid=46.

This study estimated the technical, economic, and achievable (with policies ranging from minimally to very aggressive) energy efficiency potential across the state of Georgia. Further, the study examined the costs and environmental benefits of achieving the potential. A companion report lists a number of policies that could be adopted to capture the potential estimated here.

- GDS Associates. (2006). *A Study of the Feasibility of Energy Efficiency as an Eligible Resource as Part of a Renewable Portfolio Standard for the State of North Carolina*: North Carolina Utilities Commission.

This study was designed to estimate the level of energy efficiency that is both cost-effective and achievable for determining whether or not energy efficiency should be included as a source for a Renewable Portfolio Standard in North Carolina. The study found that the achievable cost-effective efficiency potential was 14% of forecast sales in 2017, much higher than the 2.5% of sales that will be expected from energy efficiency as anticipated under a 10% renewable generation requirement in 2017 (efficiency is supposed to be a max of 25% of the renewable source). While this study projects program and participant costs (with a levelized cost of 2.9 cents per kwh saved) to achieve the RPS savings of 2.5%, it does not present program costs for the efficiency potential presented.

- Tiller, J. (2007). Evaluation of Energy Efficiency Opportunities for North Carolina Buildings and Industrial Facilities. Prepared for the North Carolina State Energy Office. (via personal communication with author)

This study provides a basis for estimating how much energy can be saved in North Carolina's residential, commercial, and industrial sectors through aggressive implementation of energy efficiency measures. The analysis considers three market penetration scenarios - low, medium, and high - depending on the return on investment (from a customer or investor standpoint). Those measures with higher rates of return will achieve a higher market penetration. Under the low market penetration scenario, energy savings are 2.3% and electricity savings are 2.4% in 2020; under the high penetration scenario, energy savings are 12.3% and electricity savings are 16.3% in 2020.

- Elliott, R. N., Eldridge, M., Shipley, A. M., Laitner, S., Nadel, S., Fairey, P., et al. (2007). Potential for Energy Efficiency and Renewable Energy to Meet Florida's Growing Energy Demands (No. E072): American Council for an Energy Efficient Economy.

This report "estimates the capacity for energy efficiency and renewable energy resources in Florida and suggests a suite of policy options that the state should consider to realize their achievable potential" (p.2). The study finds that Florida could cost-effectively offset 45% of its forecast conventional electricity needs by 2023 using a combination of renewable (two-thirds of reduction) and efficiency (one-third of reduction) measures. For efficiency, this report provides an estimate by sector for economic potential based on the cost of electricity in Florida; then, Elliott (2007) estimate the total "realistically achievable savings" if a suite of best practices policies were implemented.

- Eldridge, Maggie, Neal Elliott, William Prindle, Katie Ackerly, John "Skip" Laitner, Vanessa McKinney, Steve Nadel, Max Neubauer, Alison Silverstein, Bruce Hedman, Anne Hampson, and Ken Darrow. 2008. Energy Efficiency: The First Fuel for a Clean Energy Future: Resources for Meeting Maryland's Electricity Needs. American Council for an Energy Efficient Economy and EEA division of ICF International. http://www.aceee.org/pubs/e082.htm

This report sought to demonstrate that cost-effective energy efficiency can meet the Maryland's statewide goals for electricity demand reductions. In addition, it shows that efficiency investments, driven by substantial policy, can create jobs and boost the economy. Edridge et al. (2008) estimates economic potential for each sector and the total achievable potential based on a 50% incentive.

- Elliott, Neal, Maggie Eldridge, Anna M. Shipley, John “Skip” Laitner, Steven Nadel, Alison Silverstein, Bruce Hedman, and Mike Sloan. 2007. Potential for Energy Efficiency, Demand Response, and Onsite Renewable Energy to Meet Texas’s Growing Electricity Needs. American Council for an Energy Efficient Economy, Report E073. http://www.aceee.org/pubs/e073.htm

This report assesses the potential for Texas to meet its future energy service needs through energy efficiency, demand response, and renewable energy. The study finds that aggressive efficiency, demand response, and renewable energy policies can cost-effectively (at a levelized cost of 4.5 cents per kwh) help Texas cover all of the projected growth in peak demand by 2013. These policies could also reduce consumption from forecast by 8% in 2013 and 22% in 2023.

- American Council for an Energy-Efficient Economy, Summit Blue Consulting, ICF International, and Synapse Energy Economics. 2008. Energizing Virginia: Efficiency First. ACEEE Report No. E085. http://www.aceee.org/pubs/e085.htm

This study estimates the potential for energy efficiency to reduce forecast electricity needs in Virginia out to 2025.   The report was developed because the state of Virginia appeared to be moving towards a favorable policy environment for types of policies included, and the state was not already a leader in the area. Low, medium, and high (degrees of aggressiveness) policy potentials are examined. Under the medium policy scenario, the study finds that efficiency can replace 8% of the forecast by 2015 and 19% by 2025.

- Kentucky Pollution Prevention Center and American Council for an Energy Efficient Economy. 2007. An Overview of Kentucky's Energy Consumption and Energy Efficiency Potential. Prepared for the Governor's Office of Energy Policy. http://louisville.edu/kppc/publications

This report forecasts future consumption and analyzes energy consumption in Kentucky’s residential, commercial and industrial sectors and estimates the impact that energy efficiency could play in reducing future energy demand. Two policy forecasts are shown - minimally and moderately aggressive - drawing on the Annual Energy Outlook's high technology and best available technology cases; under the moderately aggressive scenario, all of the forecast load growth is offset by energy efficiency.

- Itron, Inc. 2008. Assessment of the Feasible and Achievable Levels of Electricity Savings from Investor Owned Utilities in Texas: 2009-2018, Final. Prepared for the Public Utility Commission of Texas, December. http://www.puc.state.tx.us/electric/reports/index.cfm

This study sought to estimate the technical, economic, and achievable energy efficiency potential for the state of Texas and for the larger investor owned Texas utilities and using achievable potential, assess the reasonableness of the newly set energy saving goals for 2010 and 2015. The study finds that utilities will have difficulty meeting the goals for 2010, but can meet them later with cost-effective programs. The study also shows that changes in regulations that allow more flexible approaches to demand side management programs can increase savings.

3.5 Summary of Policy Recommendations

Not surprisingly, most of the potential studies that included policy recommendations (or proposed and analyzed particular policies) considered the same general policy types. Every study included some recommendation for more stringent or more broadly applied appliance and equipment standards. Equally popular were building energy codes; in most cases, the call is for tighter codes with much more enforcement. Several studies considered or recommended a portfolio standard for increasing electric efficiency – either as a stand-alone efficiency standard or as part of a Renewable Portfolio Standard.

A few policies appeared in a handful of studies. A policy of expanded public information about efficiency and options was found with varying associations to other policies, such as those offering financing or financial incentives. Increased research, development, and demonstration was discussed as improving building, appliance, and equipment technology while also offering the potential to increase production efficiency. Expansion or development of Combined Heat and Power programs was offered as a way to increase efficiency for certain buildings or facilities. Expanding weatherization programs for low-income families is expected to improve the efficiency of some of the least efficient existing houses.

Many other policies appeared in fewer studies. While this list of policies will not be discussed here, a few policies are provided as examples: Expanded utility efficiency programs, residential retrofit (non-low-income), and implementing a carbon trading system.

Table 3. Summary of Percent Efficiency Reduction of Forecast End Year Consumption in State Studies

	FL	GA	KY	KY	MD	NC	NC	NC	TX	TX	VA
Study Ref	Elliott et al. (2007)	Jensen, V. & Lounsbury (2005)	MEEA (2006)	KPPC & ACEEE (2007)	Eldridge, M. et al. (2008)	GDS Associates (2006)	Tiller, J. (2007)	Hadley, S. (2003)	Itron, Inc. (2008)	Elliott, N. et al. (2007)	ACEEE et al. (2008)
End Year	2023	2010	(blank)	2017	2025	2017	2020	2020	2018	2023	2025
Length (years)	15	5	20	10	17	10	12	20	10	15	18
Technical											
Residential	--	--	-- (30/48)	--	--	-- (40/--)	--	--	-- (39/--)	--	--
Commercial	--	--	--	--	--	-- (32/--)	--	--	-- (19/--)	--	--
Industrial	--	--	--	--	--	-- (24/--)	--	--	-- (12/--)	--	--
Total	--	--	--	--	--	-- (33/--)	--	--	--	--	--
Economic											
Residential	-- (34/--)	--	--	--	-- (31/--)	--	--	--	-- (23/--)	-- (32/--)	-- (26/--)
Commercial	-- (28/--)	--	--	--	-- (35/--)	--	--	--	-- (17/--)	-- (39/--)	-- (28/--)
Industrial	-- (24/--)	--	--	--	-- (8/--)	--	--	--	-- (11/--)	-- (26/--)	-- (25/--)
Total	--	--	--	--	--	--	--	--	--	--	-- (31/--)
Maximum Achievable											
Residential	--	-- (9/5)	--	--	--	-- (20/--)	--	18 (20/--)	--	--	-- (25/--)
Commercial	--	-- (10/10)	--	--	--	-- (22/--)	--	11 (16/--)	--	--	-- (29/--)
Industrial	--	-- (7/5)	--	--	--	-- (18/--)	--	--	--	--	-- (27/--)
Total	--	-- (9/6)	--	--	--	-- (20/--)	12 (16/--)	--	-- (7/--)	--	-- (27/--)
Moderate Achievable											
Residential	--	-- (5/4)	-- (14/26)	8 (--/--)	--	-- (17/--)	--	5 (7/--)	--	--	-- (18/--)
Commercial	--	-- (8/8)	--	7 (--/--)	--	-- (12/--)	--	4 (6/--)	--	--	-- (21/--)
Industrial	--	-- (5/4)	--	-- (16/10)	--	-- (12/--)	--	--	--	--	-- (19/--)
Total	-- (26/--)	-- (6/4)	--	--	-- (29/--)	-- (14/--)	9 (11/--)	--	-- (5/--)	-- (11/--)	-- (20/--)

In addition, Beck et al. (2002) estimated moderate achievable electric efficiency potential for individual states: AL,GA, NC, SC, and TN at 23% and FL at 22% over 20 years

Savings shown as percent of end year consumption for: 'all fuels (electricity/natural gas)'. Combined, these studies account for 15 estimates for all fuels, 83 estimates for electricity, and 15 estimates for natural gas that included (or allowed calculation of) a percentage of end-year forecast savings.

--Estimate not present in report

4. Analysis of Studies

For the purposes of analysis, estimates are excluded if they cannot be compared with other studies on a per year basis; as such, comparisons require a defined study timeframe. For this reason, McKinsey (2007) is excluded from the analysis; the other summarized studies are all included.

4.1 Methodology

Study results are normalized by using a common metric across studies: energy efficiency potential per year, to account for different study lengths. To be clear, each study's energy efficiency potential as a percent of end-year consumption is divided by that study's time horizon. The duration of scenario planning is important because of the variable lifetimes of energy-related capital stock and the time required for future technological developments to displace existing equipment (International Energy Agency, 2008, pp. 73-75; Philibert, 2007)). Infrastructure and product longevity contributes to the "lock-in" of incumbent technologies (Unruh, 2002; Brown and Chandler, 2008), and can cause studies with shorter time horizons to estimate a more limited magnitude of stock turnover and hence a more limited efficiency improvement than could be achieved in longer time-frames. Generally, energy efficiency end-use measures are more short-lived than the long-lived energy infrastructure systems of highways, buildings, power plants, and transmission lines. When incumbent technologies (e.g., power plants) are more long-lived than alternative technologies (such as efficient appliances and industrial motor and drive systems), transformation from one to the other will take a long time.

A multitude of other criteria could be evaluated in future work to explain variations across studies, such as the baseline energy forecast, weather, economic conditions, year the study was conducted, and study methodology and sponsorship. In the absence of a more extensive effort, estimating annual percent savings provides a rough approximation of the range of annual savings.

In the discussion of results (Section 4.3), the individual, the study averages, and the extreme (positive and negative) estimates of energy efficiency potential will be considered to place the average in perspective.

4.2 Results

Percent per year estimates quickly show the estimates of potential across multiple studies of different length. These results, shown in Table 4, are as anticipated. Technical potential is generally around two percent per year, economic potential is generally more than one percent per year, maximum achievable potentials are about one percent per year, and moderate achievable potential average about one-half of one percent per year. Potentials for electricity savings appear to be greater than that for natural gas or "all fuels."

Table 4. Summary of Percent Efficiency Potential per Year by Study Geography Type[8]

	State	Region	Nation	All
		Technical		
Residential	-- (3.13/2.39)	-- (1.18/2.33)	-- (--/--)	-- (2.64/2.36)
Commercial	-- (2.55/--)	-- (--/--)	-- (--/--)	-- (2.55/--)
Industrial	-- (1.79/--)	-- (--/--)	-- (--/--)	-- (1.79/--)
Total	-- (3.27/--)	-- (1.42/--)	-- (1.32/--)	-- (2.0/--)
		Economic		
Residential	-- (2.0/--)	-- (--/--)	-- (1.68/1.0)	-- (1.91/1.0)
Commercial	-- (1.95/--)	-- (--/--)	-- (1.5/1.53)	-- (1.82/1.53)
Industrial	-- (1.27/--)	-- (--/--)	-- (--/--)	-- (1.27/--)
Total	-- (1.72/--)	-- (0.61/--)	-- (0.62/--)	-- (0.98/--)
		Maximum Achievable		
Residential	0.91 (1.57/0.98)	0.76 (0.56/1.13)	0.97 (1.34/0.32)	0.9 (1.36/0.69)
Commercial	0.55 (1.64/1.9)	1.42 (1.51/1.09)	0.98 (1.13/0.4)	0.98 (1.47/0.95)
Industrial	-- (1.52/0.92)	1.09 (2.12/0.73)	0.8 (1.11/0.82)	0.9 (1.56/0.82)
Total	1.02 (1.47/1.1)	1.22 (0.93/0.71)	0.92 (0.98/0.57)	1.02 (1.21/0.74)
		Moderate Achievable		
Residential	0.44 (0.86/1.04)	-- (0.6/1.26)	0.42 (0.53/0.08)	0.43 (0.72/0.7)
Commercial	0.34 (0.88/1.54)	-- (0.68/--)	0.45 (0.47/0.51)	0.39 (0.73/0.85)
Industrial	-- (1.24/0.88)	-- (0.73/--)	0.39 (0.36/0.4)	0.39 (0.91/0.64)
Total	0.72 (1.12/0.88)	-- (0.52/--)	0.45 (0.53/0.45)	0.54 (0.95/0.56)

In a few cases, the estimates for maximum achievable potential are actually higher than the estimates for economic potential, reflecting the impact of public subsidies in the former. Similar "inversions" can occur when the policies used to accelerate the deployment of clean energy technologies cause energy prices to rise. This is because more efficiency investments are cost-effective as the price of fuels increases, as is likely to be the case well into the future. By comparison, Elliott and Shipley (2005) considered potential savings for all states if they applied policies like those of California and the Northeast based on their census region end-uses and current state policy structure, finding an average achievable electric efficiency potential across southern states of 6.9% after 10 years. Using the results above, the achievable electric efficiency potential for the South ranges from 7.2 to 13.6% after 10 years.

The average annual energy efficiency potentials across all of the included studies, shown in the rightmost column in Table 4, are the estimates used for application later to the South. Figure 4 clearly shows the relationship of these estimates.

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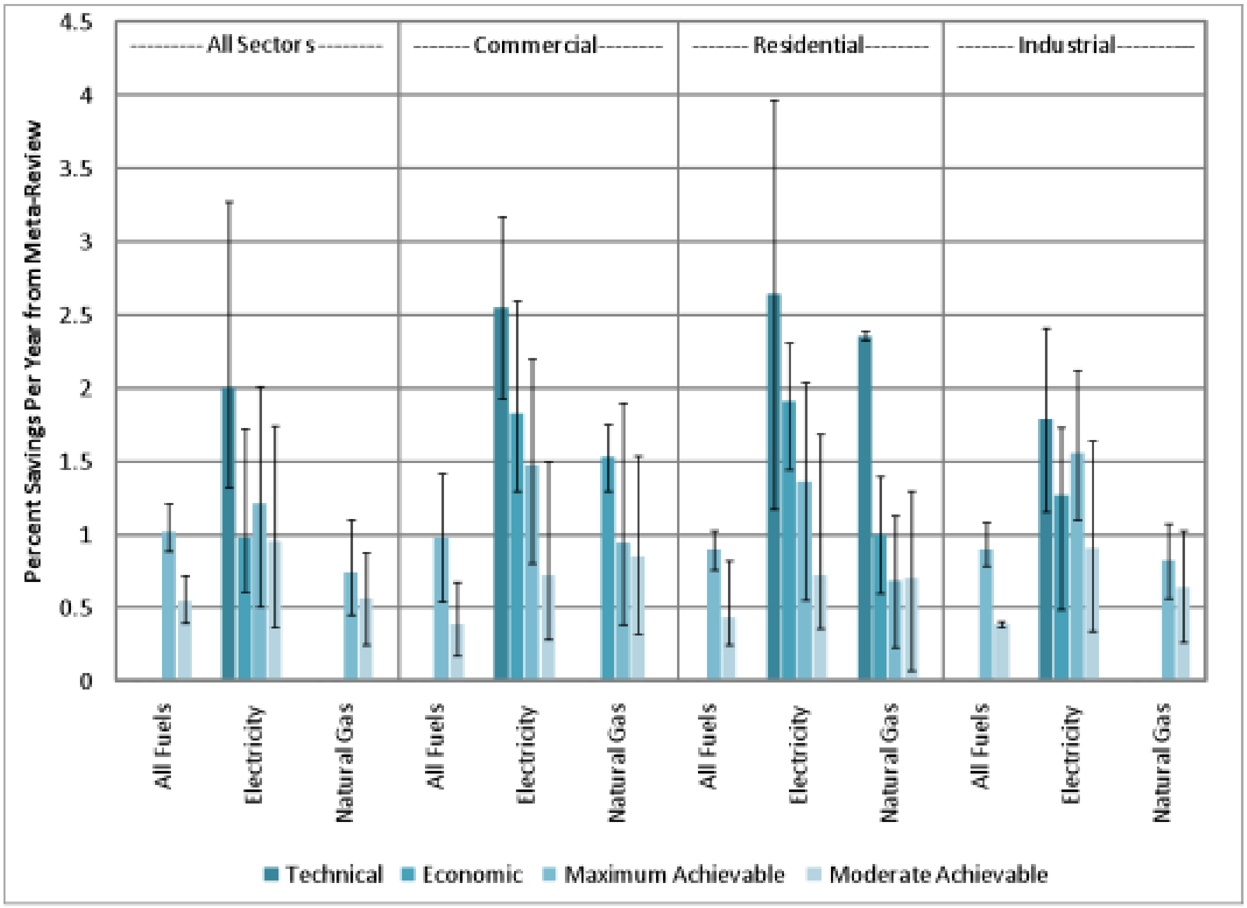
[88] Estimates in this table are shown to two decimal points to show the differences between average estimates; however, these estimates are not considered accurate to this level of detail. Please round to one significant digit when citing.

Figure 4. Average Annual Energy Efficiency from Included Studies



4.3 Discussion

Averages developed in section 4.2 will be used to estimate efficiency potential in the South as described in Section 5. The robustness of the averages is explored below.

4.3.1 Number of Estimates

The number of studies providing a particular point estimate is important to consider for evaluating the reliability of the average. Across sectors, the most frequently estimated potentials are for residential and commercial buildings. Across fuels, the most reliable averages are for electricity, where most averages are based on at least five potential studies. Across the types of potential studies, the least reliable estimates are for technical and economic potential for natural gas, where few estimates are included. Table 5 shows the count of studies for each particular estimate.

Table 5. Count of Studies for Efficiency Potential Estimates by Fuel and Sector

	All Fuels	Electricity	Natural Gas
		Technical	
Residential	--	4	2
Commercial	--	2	--
Industrial	--	2	--
Total	--	3	--
		Economic	
Residential	--	7	2
Commercial	--	7	2
Industrial	--	5	--
Total	--	3	--
		Maximum Achievable	
Residential	4	7	4
Commercial	4	7	4
Industrial	3	5	4
Total	4	10	4
		Moderate Achievable	
Residential	4	10	5
Commercial	4	8	3
Industrial	2	7	4
Total	3	20	4

4.3.2 Minimum and Maximum Values

In addition to considering the average annual efficiency potentials per year, extreme values can be informative as well.

Tables 6 to 8 identify the studies that produce the highest and lowest savings estimates for all fuels. It also reports the standard deviations from the average result for estimates derived from four or more studies. A difference of two or more standard deviations would indicate that an extreme value was unusually distinct from the average for all studies. For all fuels, most of the highest and lowest estimates differ from the average by about one standard deviation (Table 6).

Table 6. Extrema of Study Estimates for All Fuels, by Sector

	Average Annual Efficiency Potential	Highest Percent per Year	Highest	Standard Deviation above Average	Lowest Percent Per Year	Lowest	Standard Deviation below Average
			Maximum Achievable				
Residential	0.90	IWG (2000)	1.03	1.1	SEEA (2009)	0.76	1.3
Commercial	0.98	SEEA (2009)	1.42	1.2	Hadley, S. (2003)	0.55	1.2
Total	1.02	SEEA (2009)	1.22	1.4	IWG (1997)	0.89	0.9
			Moderate Achievable				
Residential	0.43	KPPC & ACEEE (2007)	0.82	1.6	Hadley, S. (2003)	0.25	0.8
Commercial	0.39	KPPC & ACEEE (2007)	0.68	1.3	Hadley, S. (2003)	0.18	0.9

For all fuels, SEEA (2009) presents the lowest estimate for maximum achievable potential for residential and the highest for the commercial and total sectors. Hadley (2003) has the lowest estimate for commercial sector maximum and moderate achievable and the lowest estimate for residential moderate achievable potential. KPPC and ACEEE (2007) presents the highest estimates for moderate achievable potential in the residential and commercial sectors.

Unlike the estimates above, the differences of the extrema from the average are more variable for the electricity estimates in Table 7. The largest differences from the average are found in the minimum achievable type of estimate – where three studies have estimates that are about two standard deviations above the average.

GDS Associates (2006) is the potential study that most often accounts for the "highest" estimate of electric efficiency potential – all but industrial for maximum achievable, and the technical and moderate achievable potential estimates for the residential sector. The EPRI (2009) estimates are the lowest in three cases – maximum and moderate achievable estimates for the combined sectors, and for the moderate achievable potential in the industrial sector. Similarly, Hadley (2003) provided the lowest estimate for maximum achievable potential in the residential sector and for maximum and moderate achievable in the commercial sector.

Table 7. Extrema of Study Estimates for Electricity, by Sector

	Average Annual Efficiency Potential	Highest Percent per Year	Highest	Standard Deviation above Average	Lowest Percent Per Year	Lowest	Standard Deviation below Average
			Technical				
Residential	2.97	GDS Associates (2006)	3.97	0.9	MEEA (2006)	1.18	1.7
			Economic				
Residential	2.04	Itron, Inc. (2008)	2.31	0.6	ACEEE et al. (2008)	1.44	1.4
Commercial	1.85	Elliott, N. et al. (2007)	2.59	1.7	IWG (2000)	1.3	1.3
Industrial	1.53	Elliott, N. et al. (2007)	1.73	0.3	Eldridge, M. et al. (2008)	0.49	1.6
			Maximum Achievable				
Residential	1.26	GDS Associates (2006)	2.04	1.1	SEEA (2009)	0.56	1.0
Commercial	1.33	GDS Associates (2006)	2.2	1.2	Hadley, S. (2003)	0.81	0.7
Industrial	1.22	SEEA (2009)	2.12	1.8	IWG (2000)	1.11	0.2
Total	1.18	GDS Associates (2006)	2.01	1.4	EPRI (2009)	0.5	1.1
			Moderate Achievable				
Residential	0.68	GDS Associates (2006)	1.69	2.3	Hadley, S. (2003)	0.36	0.7
Commercial	0.71	Jensen, V. & Lounsbury (2005)	1.5	1.5	Hadley, S. (2003)	0.28	0.8
Industrial	0.74	KPPC & ACEEE (2007)	1.64	2.0	EPRI (2009)	0.35	0.9
Total	0.88	Elliott et al. (2007)	1.75	1.9	EPRI (2009)	0.37	1.2

The extrema for natural gas estimates, shown in Table 8, are mostly about one standard deviation above or below the mean. For natural gas, Jensen and Lounsbury (2005) most frequently has the highest estimates while the two Interlaboratory Working Group (1997, 2000) studies typically produce the lowest estimates.

Table 8. Extrema of Study Estimates for Natural Gas, by Sector

	Average Annual Efficiency Potential	Highest Percent per Year	Highest	Standard Deviation above Average	Lowest Percent Per Year	Lowest	Standard Deviation below Average
			Technical				
Residential	2.36	MEEA (2006)	2.39	0.7	MEEA (2006)	2.33	0.7
			Economic				
Residential	1.00	Brown et al. (2008)	1.4	0.7	IWG (2000)	0.6	0.7
Commercial	1.53	Brown et al. (2008)	1.75	0.7	IWG (2000)	1.3	0.7
			Maximum Achievable				
Residential	0.69	SEEA (2009)	1.13	1.0	IWG (1997)	0.23	1.0
Commercial	0.95	Jensen, V. & Lounsbury (2005)	1.9	1.3	IWG (1997)	0.38	0.8
Industrial	0.82	IWG (1997)	1.08	1.1	IWG (2000)	0.56	1.2
Total	0.74	Jensen, V. & Lounsbury (2005)	1.1	1.3	IWG (2000)	0.45	1.1
			Moderate Achievable				
Residential	0.70	MEEA (2006)	1.3	1.0	IWG (1997)	0.08	1.0
Industrial	0.64	KPPC & ACEEE (2007)	1.03	1.2	IWG (2000)	0.27	1.2
Total	0.56	Jensen, V. & Lounsbury (2005)	0.88	1.2	IWG (2000)	0.25	1.2

4.3.3 Potential Estimate Types and their Relationships

The extent that technical potential is also economic (i.e., cost-effective) is of great interest. When there is minimal overlap, technically feasible technologies exist that could deliver significant energy savings, but they are not cost-effective. This might suggest that investing in applied engineering research and manufacturing cost reductions could produce cost-effective technology options for the future.

The extent that economic potential is achievable is also of great interest. When there is minimal overlap, barriers of various sorts are preventing the adoption of cost-effective energy efficiency, suggesting that policy interventions might be able to deliver a substantial amount of energy savings. The difference between maximum and moderate achievable is of interest as well because this reflects the cost of policy interventions – what can be achieved with moderate policy interventions as compared to aggressive interventions.

There are only a sufficient number of studies covering energy efficiency potential in the South to allow for comparison across all four types of potential estimates by sector for electricity. However, for natural gas, comparison can be made within the residential sector

Table 9. Relationships between Types of Potential Estimates, by Fuel and by Sector

	Residential	Commercial	Industrial	Total
		All Fuels		
ModA/MaxA	48%	39%	43%	53%
		Electric		
Econ/Tech	72%	71%	71%	49%
MaxA/Econ	71%	81%	123%	124%
ModA/Econ	38%	40%	72%	97%
ModA/MaxA	53%	49%	59%	78%
		Natural Gas		
Econ/Tech	42%	--	--	--
MaxA/Econ	69%	62%	--	--
ModA/Econ	70%	56%	--	--
ModA/MaxA	102%	90%	78%	76%

For electricity, about seventy percent of the estimated technical potential in the South is found to be economic while less than half of the technical potential is estimated to be economic for natural gas. This suggests that technologies to improve efficiency of natural gas consumption are more expensive than technologies to improve efficiency of electricity consumption, relative to the prices of those fuels. It might also be an indication that natural gas consuming technologies are already quite efficient and are facing diminishing returns. However, it is not possible to identify causality at this level of abstraction.

The maximum achievable potential is estimated to be about 70 percent of the economic potential for residential electricity and 81 percent of the economic potential for electricity consumption in commercial buildings. Maximum achievable potential is approximately 60 to 70 percent of the economic potential for natural gas in residential and commercial buildings, suggesting that tackling non-technical barriers in these sectors could generate substantial energy savings. (For a recent description of such barriers and possible policy options to address them, see Brown, Chandler, Lapsa and Ally, 2009). For the industrial and total estimates for electricity, the maximum achievable potential is higher than the economic potential; this reflects the study methodologies: some assessments of maximum achievable potential assume policies are implemented that promote technologies that are not yet cost-competitive and hence are not included in estimates of economic potential. In addition, industrial customers tend to have different, and generally lower, rates for electricity and natural gas because they are large customers; technologies which are cost-effective at a higher rate, such as paid in the commercial sector, may not be so at a lower rate.

The moderate achievable potential is about half the maximum achievable potential for the all fuels and electricity estimates for each of the three main consumer sectors. For electricity and natural gas across all sectors – i.e., the last column in Table 9 – the proportion of the maximum achievable potential that can be delivered by moderate policy interventions is much higher. Nadel, Shipley, and Elliott (2004) found that, for studies conducted before 2004, the median economic potential for electricity was about two-thirds of the technical potential while the median economic potential for natural gas was about half the technical potential. This result is close to what is found with the current analysis.

5. Estimate of Potential in the South Census Region and States

The normalized results, presented in section 4.2, in combination with forecast consumption, allow for an approximation of efficiency potential for the region in terms of possible reductions in energy consumption. This regional estimate is presented in graphical form based on the *Annual Energy Outlook 2009* forecast (as updated in April 2009) and the per year estimates shown above in Table 4 and Figure 4.

Figure 5. Electric Efficiency Potential Estimate for the South, 2006-2020

Figure 5a. Residential Electricity

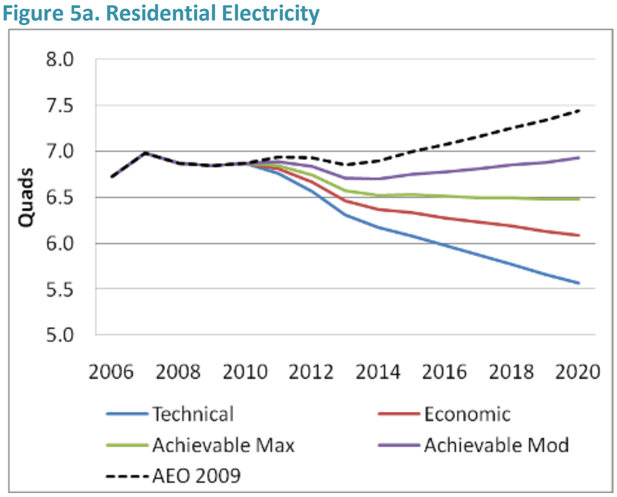


Figure 5b. Commercial Electricity

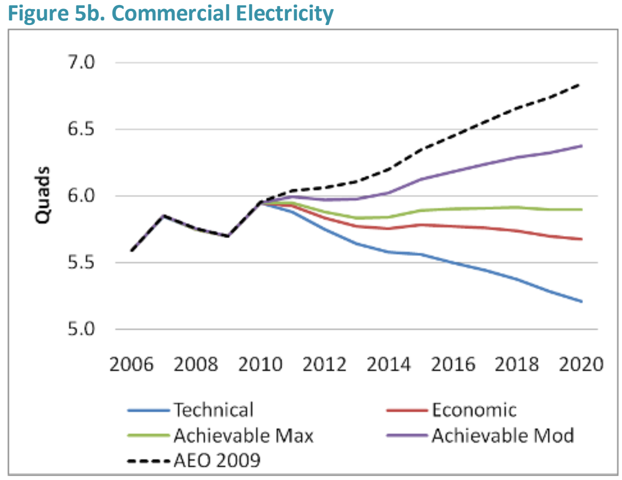


Figure 5c. Industrial Electricity

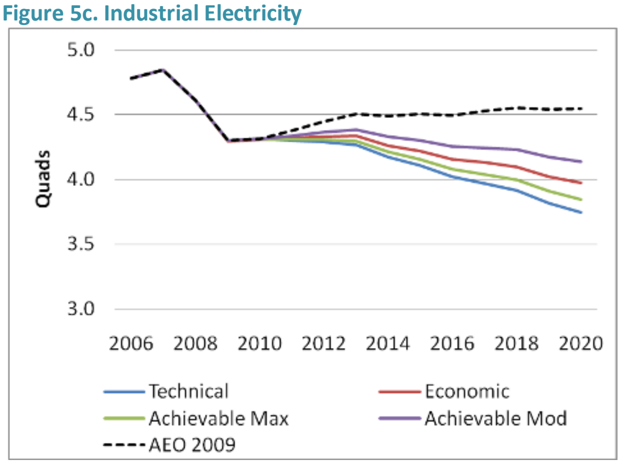
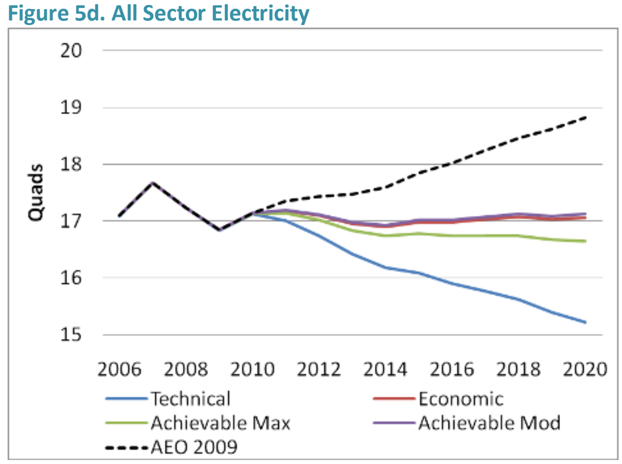


Figure 5d. All Sector Electricity



5.1 Electricity

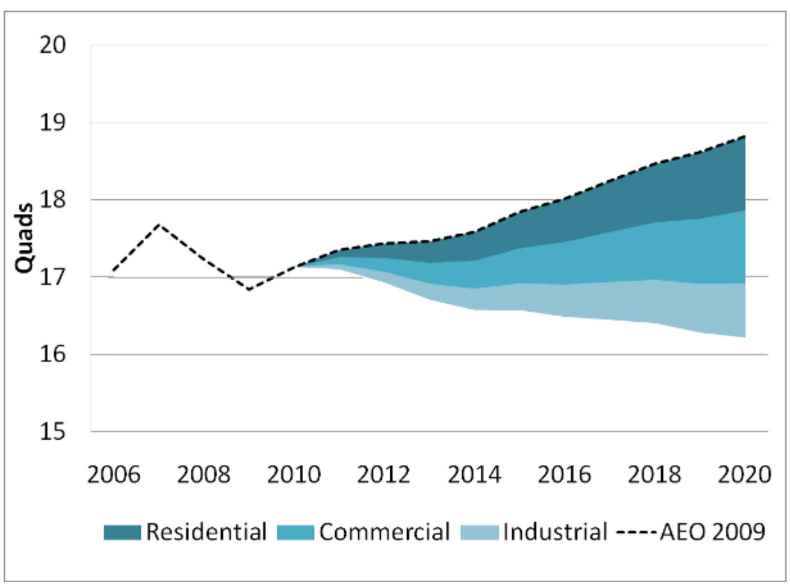
Figure 5 indicates that the technical and economic efficiency potentials would deliver the largest reductions in electricity consumption in the residential and industrial sectors. In both of these sectors, the maximum achievable potentials for energy efficiency also deliver significant reductions, bringing consumption in 2020 well below current levels.

The efficiency potential in the commercial sector appears to be more constrained, based on the studies reviewed here. While the maximum achievable potential could deliver 1 quad of energy savings in 2020, the sector would still experience a small increase in electricity requirements relative to its consumption in recent years.

Figure 6 illustrates the separate estimates of maximum achievable potential for electricity efficiency improvements in the three end-use sectors. In 2020, the maximum achievable residential and commercial sector savings are expected to amount to about three-fourths of a quad each, and the industrial sector savings are expected to be about half a quad over a ten-year period.

Figure 6 also shows that the sum of the estimates derived separately for each sector is greater than the estimate of maximum achievable for "all sectors." This difference occurs because the two approaches are based on different sets of studies. Nevertheless, in both cases, exploitation of the maximum achievable potential could result in less electricity being consumed in the South in 2020 than was consumed in 2006-2007.

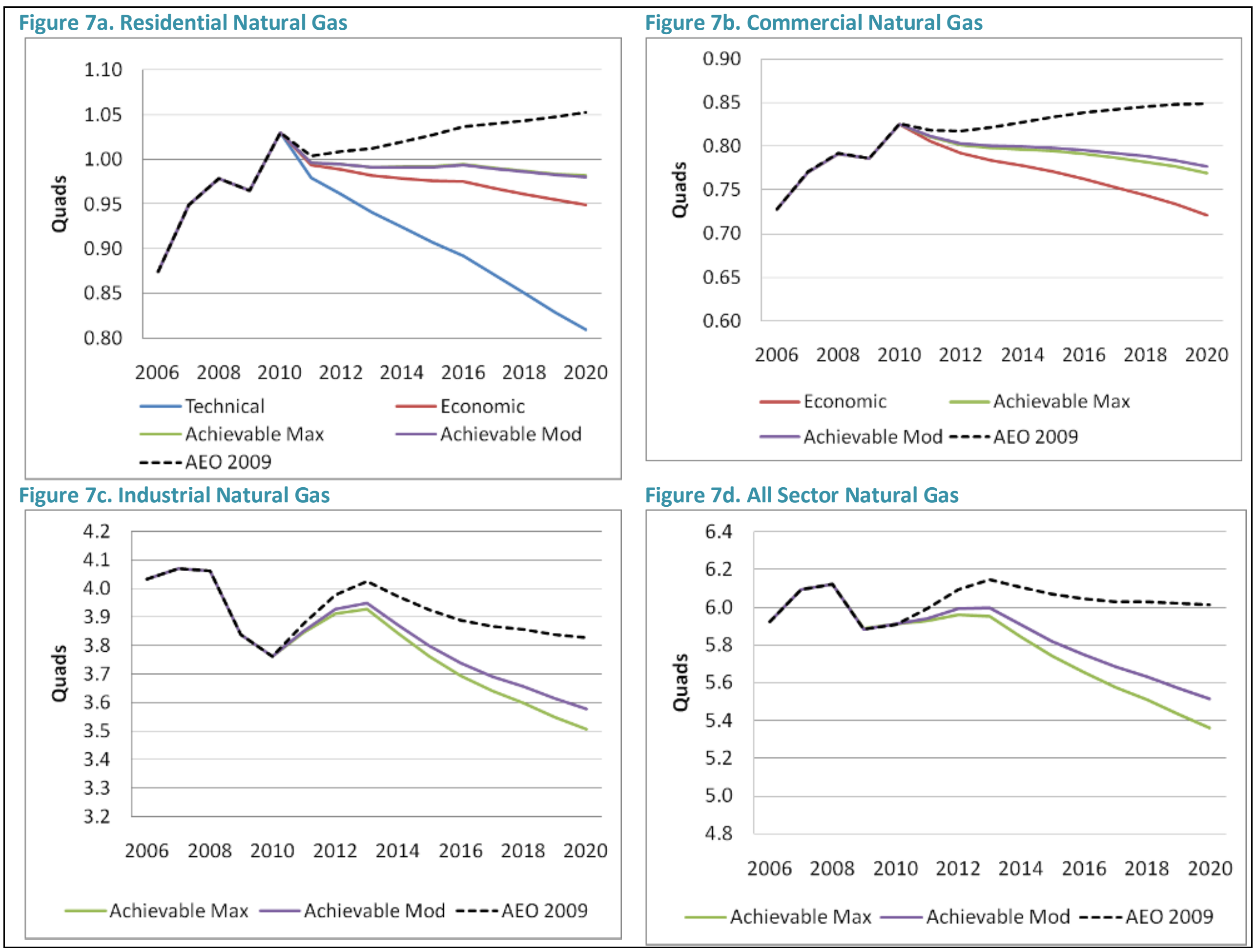
Figure 6. Maximum Achievable Electric Efficiency Potential, Residential, Commercial, and Industrial sectors, 2006-2020



5.2 Natural Gas

For natural gas, only the residential sector has an estimate of technical potential, and suggests that the rapid growth in residential natural gas consumption expected between 2006 and 2010 could be more than offset if all of the technically feasible efficiency approaches were deployed (Figure 7a). Only the residential and commercial building sectors have an estimate of economic potential, indicating that in both of these sectors it would be possible to reduce consumption by approximately 1 quad between 2010 and 2020. The achievable potentials for natural gas efficiency improvements are quite small, representing about one-fifth of a quad in the industrial sector, less than one-tenth of a quad in the commercial and residential sectors, and about half of a quad across all three sectors. For the industrial and total sectors, realizing the estimated maximum achievable potential could reduce natural gas consumption in 2020 to below 2006-2007 levels. For the residential and commercial sectors the reductions are not as steep and cannot offset the growth in consumption that takes place between 2006 and 2010.

Figure 7. Natural Gas Efficiency Potential Estimate for the South, 2006-2020



5.3 All Fuels

"All fuels" estimates are only available for the maximum and moderate achievable potential.[9] Based on both levels of achievable potential, energy consumption across all sectors and all fuels in the South in 2020 could be reduced to below current levels. By definition, these levels of reduction are cost-competitive to the consumer. Specifically:

- Exploiting the maximum achievable potential for energy efficiency would cut consumption in 2020 by approximately 3 quads (2.81 to 3.12 quads, depending on whether the individual end-use sector estimates are added or if the estimate is derived from the estimates of "total" potential). This level of reduction represents a 10 percent decrease in energy consumption relative to EIA's business-as-usual forecasted consumption in 2020.
- Exploiting the moderate achievable potential would deliver approximately 1.5 quads of savings in 2020 (1.23 to 1.67 quads). This level of reduction represents a 5.4% decrease in energy consumption relative to EIA's business-as-usual forecasted consumption in 2020.

Based on the studies reviewed here, the South has the potential to save more electricity than natural gas. For both fuels, realizing this energy efficiency potential requires policies that target opportunities in all three sectors: residential buildings, commercial buildings, and industry.

5.4 Conclusions

This report reviews 19 published studies of energy efficiency potential applicable to the South. These studies contain more than 250 estimates of the energy efficiency potential for different fuels (electricity, natural gas, and all fuels), sectors of the economy (residential buildings, commercial buildings, and industry), and types of potential (technical, economic, maximum achievable, and moderate achievable).

Analysis of published studies of the potential for energy efficiency improvements in the South suggests that cost-effective opportunities exist, with greater potential for saving electricity than natural gas. In the South as a whole, a two percent annual reduction in energy consumption is technically feasible. Approximately three-quarters of that amount is cost-effective. A one percent reduction per year approximates the maximum achievable estimate assuming implementation of aggressive policies, and a 0.5 percent per year reduction could be achieved with modest policy interventions.

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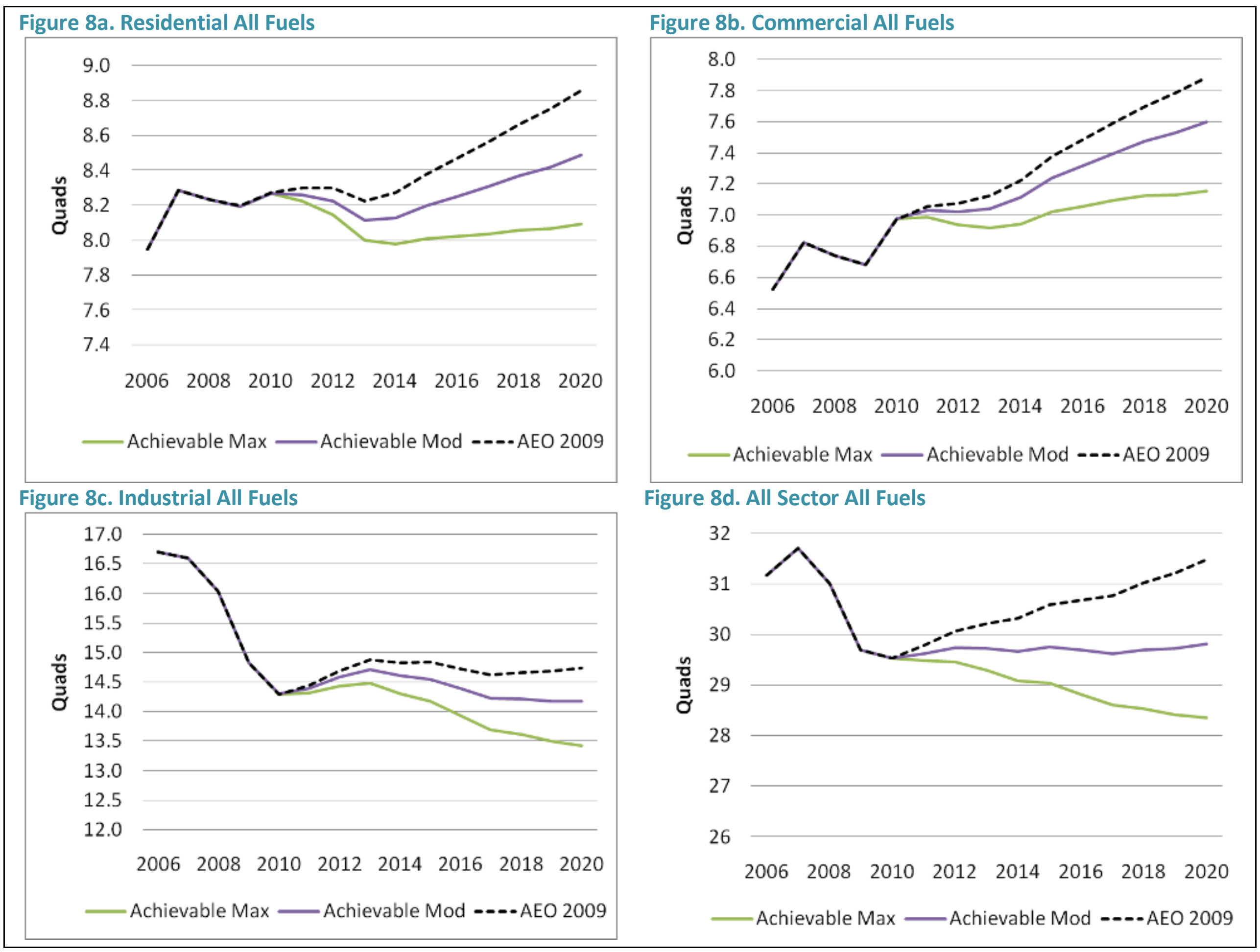
[9] Studies that present efficiency potential estimates for "all fuels" cover an array of energy resources in addition to electricity and natural gas, typically including fuel oil and kerosene and in a few cases motor gasoline.

Since electricity consumption in the South is expected to grow at approximately 0.84 percent annually between 2007 and 2020, the maximum achievable potential could offset the forecast growth in demand in the region as a whole. For natural gas, which is expected to experience no significant growth in consumption in the South, the achievable potential for energy savings could produce significant reductions in consumption over time. Of course, states with more rapidly growing electricity and natural gas demand will need to either push harder on energy efficiency or expand their energy resources. For both fuels, realizing this energy efficiency potential requires policies that target opportunities in all three sectors: residential buildings, commercial buildings, and industry (Figure 8). Reaching the maximum achievable energy consumption suggested by the reviewed studies could bring energy consumption in 2020 down nine percent below projected levels.

Figure 8. All Fuels Efficiency Potential for the South, 2006-2020



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Appendix A: Utility-level Studies in the South Census Region

Below are summaries, in chronological order, of the five utility-level studies in the South that include estimates that could be calculated as percent of end-year savings. These utility level studies only deal with electricity savings.

- KEMA. 2004. City Public Service Technical and Economic Energy Efficiency Potential Study. Prepared for City Public Service, San Antonio, TX. October. http://www.cleanenergyfortexas.org/downloads/KEMA_EE_2004.pdf

This study was commissioned to develop a comprehensive energy efficiency plan for the utility City Public Service (CPS), an electric and gas utility serving San Antonio and some surrounding areas. KEMA (2004) found that both the base efficiency scenario (with CPS' current program funding) and the advanced efficiency scenario (with about an 80% increase in program funding) are cost effective with a TRC of 1.97 and 1.96, respectively. All measures in all years that are applied in this study have a first year cost of less than $.03/kwh except residential new construction, which ranges from $0.04/kwh to $0.074/kwh depending on the year and scenario (base or advanced).

- GDS Associates. (2007). Electric Energy Efficiency Potential Study for Central Electric Power Cooperative, Inc. Prepared for the Electric Cooperatives of South Carolina, September. http://w*ww.energy.sc.gov/publications/**GDS**%20Energy%20Efficiency%20Final%20Report%2009-25-2007-REV%20A.ppt*

Estimate the technical and achievable potential for electric energy savings from energy efficiency in the CEPCI service territory (the Electric Cooperatives of South Carolina). The study found that with a broad selection of measures across sectors, there is a significant potential for electric energy efficiency - on par with similar studies.

- Nexant, Inc. 2007. Achievable Energy Efficiency Potential Assessment: Final Study for Georgia Power. Public Disclosure. Prepared for Georgia Power and presented to the Georgia Public Service Commission.

This report was prepared to fulfill a requirement for the Georgia Public Service Commission under docket number 22449-U by including an assessment of cost-effective achievable savings with Georgia Powers 2007 Integrated Resource Plan filing. Nexant, Inc. followed the approach used by ICF Consulting during the 2005 assessment of efficiency potential for the state of Georgia (see Jensen & Lounsbury, 2005). The study found that efficiency could meet 1.7% (with a minimally aggressive 25% incentive level) to 6.2% (with an aggressive 100% incentive level) of the company's forecast sales by 2010; estimates were developed to 2015, but achievable savings were only reported to 2015 in the study.

- OG&E Energy Efficiency Potential Study (2008). Technical, Economic and Achievable Potentials for the Residential, Commercial and Industrial Customer Base. Prepared by

Frontier Associates LLC for Oklahoma Gas & Electric. http://www.occeweb.com/Divisions/PUD/Collaborative/OGE_EnergyEfficiencyPotential_FinalReport%2010-02-08.pdf

This report examines the potential for Oklahoma Gas and Electric Company to reduce electric energy use and lower peak demand through energy efficiency initiatives. Savings detail (energy savings and demand reduction) is provided on estimates by sector and end-use. The study finds that the maximum achievable potential by 2018 is 8% of forecast sales.

- PSO Energy Efficiency Potential Study (2008). Technical, Economic and Achievable Potentials for the Residential, Commercial and Industrial Customer Base. Prepared by Frontier Associates LLC for Public Service Company of Oklahoma. http://www.occeweb.com/Divisions/PUD/Collaborative/PSO%20Report%20Final%2010-01-08%20compatible%20version.doc

This report examines the potential for Public Service Company of Oklahoma to reduce electric energy use and lower peak demand through energy efficiency initiatives. Savings detail (energy savings and demand reduction) is provided on estimates by sector and end-use. The study finds that the maximum achievable potential by 2018 is 8% of forecast sales.

This meta-review excludes the substate (utility) studies summarized above and in Table A from its overall analysis. However, these studies would not substantially change the results. The utility studies raise the average electricity savings potential for all technical and economic estimates; however, the utility studies present a lower estimate for maximum achievable and moderate achievable estimates.

Table A. Summary of Percent Electric Efficiency Reduction of Forecast End Year Consumption in Utility Studies

	San Antonio TX	CEPCI Service Territory, SC	OGE service territory	PSCO service territory	Ga Power Service Territory
Study Ref	KEMA (2004)	GDS Associates (2007)	OG&E (2008)	PSO (2008)	Nexant, Inc. (2007)
End Year	2014	2017	2018	2018	2018
Length (years)	10	10	10	10	11
		Technical			
Residential	30	--	36.9	35.3	33
Commercial	18	--	30.1	32.2	33
Industrial	13	--	32	32.9	26
Total	22.5	--	33.1	34	31
		Economic			
Residential	17	--	26.9	27.3	22
Commercial	11	--	20.4	22.2	25
Industrial	8	--	21.2	21.9	25
Total	13.7	--	23	24	24
		Maximum Achievable			
Residential	1.1	22.45	7.4	6.6	9
Commercial	0.8	23.2	6.1	6.9	11
Industrial	1.9	13	10.8	8.2	10
Total	1	20.95	8.2	7.5	10
		Moderate Achievable			
Residential	0.6	12.05	2.8	2.2	--
Commercial	0.4	14.5	2.2	2.6	--
Industrial	1	8.15	3.9	3.7	--
Total	0.53	11.95	3	3	--

-- Estimate not presented in report

Appendix B: Baseline Forecast of Energy Consumption for States in the South

This Appendix describes the methodology 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 2003 study of the energy efficiency and renewable energy potential in North Carolina.

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 (South Atlantic, East South Central, and West South Central). 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 calculate 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 approximate 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 allocate out the regional AEO projections to each state.

Appendix C: Acknowledgements

Funding for this research was provided by the Energy Foundation (under the direction of Meredith Wingate) and the Turner Foundation (under the direction of Judy Adler). The support of these sponsors is greatly appreciated. Two Graduate Research Assistants at the Georgia Institute of Technology contributed to completion of this report. Youngsun Baek provided baseline energy consumption data and an explanation of the baselining methodology for Appendix B. Joy Wang provided statistics on state energy consumption and production. Their assistance is also appreciated.

Valuable comments on a previous draft of this report were received from Etan Gumerman (Duke University), Stan Hadley (Oak Ridge National Laboratory), Ben Taube (Southeast Energy Efficiency Alliance), John Wilson (Southern Alliance for Clean Energy), and Michael Halicki (Ahmann Communications). Feedback during presentations of the study's results was also provided by members of the project's advisory committee, numerous electric utility representatives, and public service commission staff. The authors are grateful for their willingness to engage in a dialogue about the potential to expand demand-side resources in the South.