Chapter 12

Mitigation of Greenhouse Gases in the Southeast USA

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Although the Southeast is one of the largest emitters of CO_2 emissions in the United States, the region ranks low in policies and programs that promote efficient energy use. However, improvements are on the horizon due in part to the large potential for carbon sequestration, future cost-saving conservation efforts, and requirements of the 2009 American Recovery and Reinvestment Act.

Key Findings

- With 26% of the total population of the USA and 25% of the total CO_2 emissions, the Southeast (SE) emits more combustion-related CO_2 than any other region of the National Climate Assessment. The largest source of emissions is generation of electricity (41%) followed by transportation (35%).
- The SE has great potential for mitigating CO_2 emissions through carbon sequestration in soils and plant biomass. The average annual carbon storage in natural ecosystems is about 0.3 petagrams, 60% of which is stored in forests and the remainder in savannas. Protection of these natural carbon sinks in the face of development pressures is a critical issue for climate change mitigation in the SE.
- States in the SE consistently rank low for policies promoting energy-efficiency as is illustrated by the fact that electric utility energy efficiency program spending per capita in the SE was one-fifth the national average.
- Most states in the SE have outdated or non-existent energy code policies governing the energy efficiency of new buildings. This situation is improving, in part due to a provision of the 2009 American Recovery and Reinvestment Act that requires states receiving ARRA funds to adopt updated energy codes.
- These low energy efficiency rankings across the SE offer large potential for energy saving gains through cost-effective conservation measures. Moreover, there are several SE states that lead in energy conservation for the region and the nation. Florida, Virginia, Georgia, and North Carolina rank among the top 11 states for total numbers of Leadership in Energy and Environmental Design projects.
- Many corporations and in the SE are developing and instituting sustainability plans that include provisions to reduce their overall direct and indirect impacts on the environment through improved energy efficiency, increased use of renewable energy, and reduced GHG emissions.

12.1 Definitions

Climate change mitigation refers to activities that avoid or decrease the release of greenhouse gas (GHG) emissions from new and existing sources, or decrease atmospheric GHG concentrations, e.g., carbon storage in forests or soils, as compared to a specific historical point in time across a specific spatial boundary. This chapter briefly reviews the emissions of GHGs from sources in the SE, along with recent efforts undertaken to reduce emissions by southeastern businesses, governments, homeowners, and others. The ability of natural systems in the SE to sequester carbon is also reviewed. For purposes of this chapter, the Southeast is comprised of Louisiana, Alabama, Mississippi, Florida, Georgia, South Carolina, North Carolina, Virginia, Tennessee, Kentucky, Arkansas, Puerto Rico, and the US Virgin Islands. Unless otherwise noted, the statistics presented are focused on the 11 continental states.

12.2 Greenhouse Gas Emissions and Sinks in the Southeast

The southeastern USA is one of eight National Climate Assessment (NCA) regions, and is home to over 81 million people, which is about 26% of the USA population, including Puerto Rico and the US Virgin Islands (US Census Bureau 2012). At 25% of national emissions, the SE outpaces all other NCA regions as the largest emitter of carbon dioxide (CO_2) through combustion of fuels (Figure 12.1).

Greenhouse Gas Emissions

In 2009, southeastern sources alone were responsible for over 1,444 million metric tons (MMt) of CO_2 combustion emissions. The electric power sector accounted for 41% of these emissions, followed by the transportation sector (35%) and industrial sources (18%) as the largest contributors (Energy Information Administration 2011). A more comprehensive GHG emissions inventory for six SE states is provided in the next section. The US Environmental Protection Agency recently established a mandatory GHG Reporting Program will help stakeholders better understand where GHG emissions are coming from and will improve stakeholders' ability to make informed policy, business, and regulatory decisions (US EPA 2012a).

Among the southeastern states, all but Louisiana produce the greatest share of their combustion CO_2 emissions from the electric power and transportation sectors. Louisiana is anomalous, with industry contributing the greatest share of emissions. Florida leads all southeastern states with the greatest total amount of emissions (234 MMt CO_2 in 2009), with the majority of its emissions almost equally split between the electricity and transportation sectors (Figure 12.2).

Regional Trajectory for GHG Emissions

Of the eleven states in the SE, six—Arkansas, Florida, Kentucky, North Carolina, South Carolina, and Virginia—have begun a process to develop a climate change plan for their state, including an inventory of emissions and projections of emissions into the future, typically, for the 2020 to 2030 timeframe. Alabama's 1997 Climate Change Plan provides GHG projections only to 2010 and, so, is not included here. In most cases, these states estimated both gross emissions as well as net emissions in order to account for forestry and land use sinks. The emission sources and GHGs evaluated extend beyond those captured by Department of Energy (DOE) combustion CO_2 emission estimates discussed above. For example, state-specific estimates may have included emissions of methane (CH_4) from livestock operations and nitrogen dioxide from forest wildfires, collectively reported as carbon dioxide equivalents or CO_{2e}, a measure used to compare the emissions from various GHGs based on their global warming potential relative to CO_2. Most of these plans were developed with the assistance of the Center for Climate Strategies and a collection of these plans is available on their website (Center for Climate Strategies 2012).

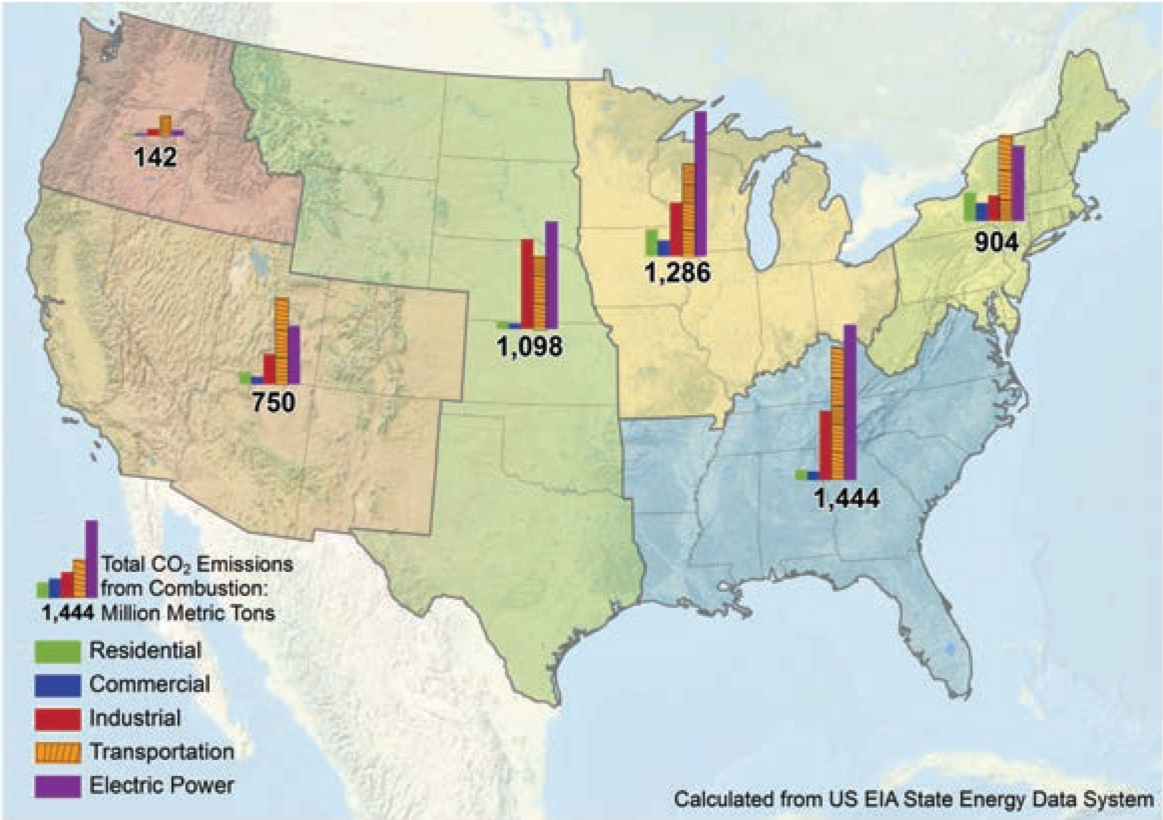

Figure 12.1 Total CO_2 emissions from combustion by sector by National Climate Assessment region (2009).

A summary of the estimated out-year GHG emissions for these six states is provided in Table 12.1 and indicates an expected increasing trend in emissions over time. In reviewing these trends, keep in mind that the numbers may not be directly comparable from state to state because of state-specific assumptions used in the development of emissions estimates. The source document for each state should be consulted to evaluate these differences. Estimates of future emissions depend upon a host of variables, ranging from changes in technology and policy to how the economy develops.

Carbon Sinks

Generally speaking, carbon sequestration measures the rate of carbon removed from the atmosphere over a finite period of time (e.g., one month or one year) within a finite unit of space (e.g., an individual plant or one acre of land), while carbon storage measures the total mass of carbon accumulated within that finite space. For example, if something sequesters at a rate of 2 Mt CO_2/year but emits at a rate of 1 Mt CO_2/year via natural processes, then its carbon storage is only 1 Mt CO_2 after year one, 2 Mt CO_2 after year two, 3 Mt CO_2 after year three, and so on, until it reaches some internal saturation point or CO_2 is released in a pulse from a disturbance like a fire.

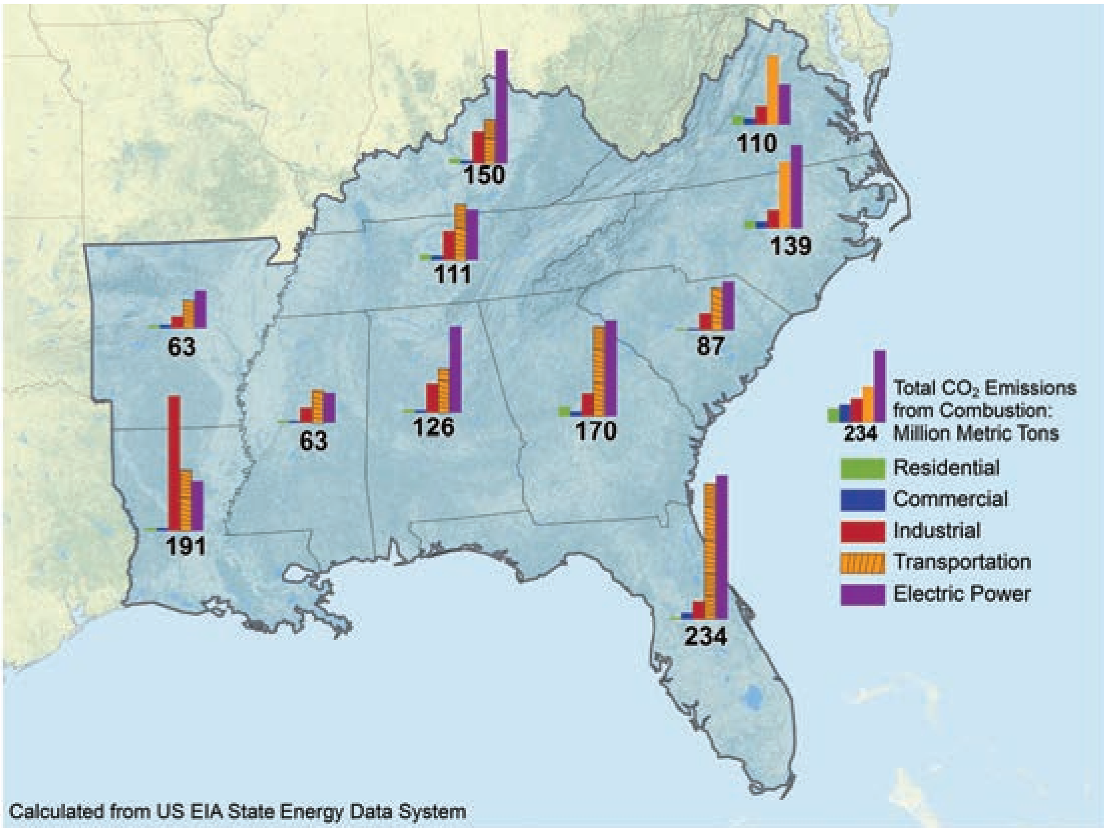

Figure 12.2 Total CO_2 emissions from combustion by sector in Southeast USA.

A 2007 study of terrestrial carbon storage in the SE and South-Central USA estimated the state-level terrestrial carbon storage as teragrams of carbon (Tg C) in Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Texas, and Virginia (Han et al. 2007). The study also projected the potential for terrestrial carbon sequestration in the region. The estimates of carbon storage for the SE are provided in Table 12.2. The estimate of annual terrestrial carbon sinks, or annual sequestration, in the SE is provided in Table 12.3. Of the southeastern states evaluated, Florida leads at nearly 25% of carbon storage, largely due to soil storage. In contrast, Arkansas leads with more than 20% of annual biomass carbon sink due to its high level of crop production.

Kentucky was not included in this evaluation and estimates of storage and annual sinks were not available for the commonwealth by the same methodology used for the other southeastern states. That said, approximately 10% of Kentucky is used for cultivated crops and 47% is covered by deciduous forests (Kentucky Renewable Energy Consortium 2009), indicating that terrestrial systems in Kentucky are expected to add substantively to the carbon sequestration totals shown in Tables 12.2 and 12.3. Other estimates of terrestrial sequestration for select southeastern states, including Kentucky, are discussed in the preceding section on regional trajectories of GHG emissions.

Table 12.1 Greenhouse Gas Inventory and Reference Case Projections (1990-2030).

$MMtCO_2e$	1990	2000	2005	2010	2015	2020	2025	2030
GROSS EMISSIONS ON A CONSUMPTION BASIS, EXCLUDING SINKS (INCREASE RELATIVE TO 1990)*								
Arkansas	65.8	86.8 (32%)	85.4 (30%)	93.5 (42%)	101.3 (54%)	107.5 (63%)	114.2 (74%)	n/c
Florida	248.8	315.0 (27%)	336.6 (35%)	362.6 (46%)	n/c	424.9 (71%)	463.3 (86%)	n/c
Kentucky	136.7	165.9 (21%)	183.1 (34%)	191.6 (40%)	205.1 (50%)	217.7 (59%)	232.3 (70%)	247.7 (81%)
North Carolina	136	180 (33%)	192 (42%)	214 (58%)	n/c	256 (88%)	n/c	n/c
South Carolina	67.2	87.8 (31%)	93.5 (39%)	102.2 (52%)	n/c	125.4 (87%)	n/c	n/c
Virginia	n/c	162.63	n/c	n/c	n/c	n/c	229.84 (41%)	n/c
NET EMISSIONS ON A CONSUMPTION BASIS, INCLUDES FORESTRY AND LAND USE SINKS (INCREASE RELATIVE TO 1990)								
Arkansas	27.3	66.0 (141%)	64.6 (136%)	72.6 (166%)	80.4 (194%)	86.6 (217%)	93.4 (242%)	n/c
Florida	230.9	288.3 (25%)	309.4 (34%)	335.3 (45%)	n/c	397.8 (72%)	436.2 (89%)	n/c
Kentucky	126.8	158.2 (25%)	175.5 (38%)	184.0 (45%)	197.6 (56%)	210.1 (66%)	224.8 (77%)	240.2 (89%)
North Carolina	112	156 (39%)	169 (50%)	191 (70%)	n/c	232 (106%)	n/c	n/c
South Carolina	34.0	56.8(67%)	62.3 (83%)	71.0 (109%)	n/c	94.1 (177%)	n/c	n/c
Virginia	n/c	n/c	n/c	n/c	n/c	n/c	n/c	n/c

* The Virginia baseline is 2000. MMtCO2e - Million metric tons of carbon dioxide equivalentn/c – Not Calculated

Sources: CAPAG 2008, Commonwealth of Virginia 2008, Strait et al. 2008a, Strait et al. 2008b, Strait et al. 2008c, Strait et al. 2010

Table 12.2 Total Terrestrial Carbon (C) Storage in the Southeast.

State	Soil Organic C	Biomass C			Total Terrestrial C
		Forest	Crop*	Pasture*	
	Tg C	Tg C	Tg C	Tg C	Tg C
Alabama	535	489	1.3	1.3	1,027
Arkansas	814	482	22	2.9	1,321
Florida	3,504	252	0.3	0.7	3,757
Georgia	1,232	514	3.7	1.6	1,751
Louisiana	1,100	376	8.7	0.7	1,485
Mississippi	457	450	7	1.3	915
North Carolina	1,761	517	7.4	1.8	2,287
South Carolina	888	262	1.9	0.7	1,153
Tenessee	408	389	5.2	4.7	807
Virginia	516	455	6.3	3.2	981
Total	**11,215**	**4,186**	**63.8**	**18.9**	**15,483.7**

*On an annual basis

While coastal wetlands have been estimated to contain about 10% of the total soil carbon (Armentano 1980, Schlesinger 1977, Schlesinger 1995), no comprehensive studies estimating the carbon sequestration and storage capabilities for the coastal areas of the NCA SE could be located.

A recent study found that the ability of SE ecosystems to act as a net carbon sink, also called Net Ecosystem Productivity (NEP), varied greatly across the region due to differences in ecosystem types and climate (Figure 12.3). NEP can be approximated by net ecosystem exchange (NEE), a research term that focuses on field measurements of ecosystem carbon sequestration. By convention, NEE = -NEP; thus, negative values of NEE represent a carbon sink, while positive values represent a carbon source. The ability to act as a net carbon sink can have large inter-annual variability due to fluctuations in precipitation and drought in the region. The mean regional NEP is about 0.3 petagrams of carbon (a carbon sink) per year, of which about 60% is from forests and the rest from lands classified as savannas (Figure 12.3, based on Xiao et al. 2011).

Table 12.3 Annual Terrestrial Biomass C Sinks in the Southeast.

State	Biomass C (Tg C/year)			Total Terrestrial C as Biomass (Tg C/year)
	Forest	Crop	Pasture	
	Tg C	Tg C	Tg C	Tg C
Alabama	8.7	1.3	1.3	11.3
Arkansas	6.5	22	2.9	31.4
Florida	5.4	0.3	0.7	6.4
Georgia	11	3.7	1.6	16.3
Louisiana	5.9	8.7	0.7	15.3
Mississippi	7.8	7	1.3	16.1
North Carolina	8.5	7.4	1.8	17.7
South Carolina	3.7	1.9	0.7	6.3
Tenessee	4.3	5.2	4.7	14.2
Virginia	6.3	6.3	3.2	15.8
Total	**68.1**	**63.8**	**18.9**	**150.8**

12.3 GHG Emission Reduction Activities

Southeastern businesses and consumers are showing an increasing interest in and ability to invest in cleaner energy options. Energy efficient home appliances, highly efficient combined heat and power technology, increasingly more stringent building energy codes, improved fuel efficiency and alternative fuel infrastructure for cars and trucks, clustered and transit oriented development, and renewable energy sources are only a few of the ways the SE is working to modernize its energy landscape and to cut its GHG emissions. In addition, federal and state policy makers, electric and gas utilities, research institutions, and others are working to identify, design, and implement clean energy policy and technology solutions that deliver important environmental and economic benefits. This section discusses some of the many activities that are helping to reduce GHG emissions in the SE over time.

Transportation

As noted in chapter 4 (Energy), the SE uses more petroleum fuel and has more vehicle miles traveled than any other NCA region. Transportation alone in the SE makes up 35% of combustion-related CO_2 emissions.

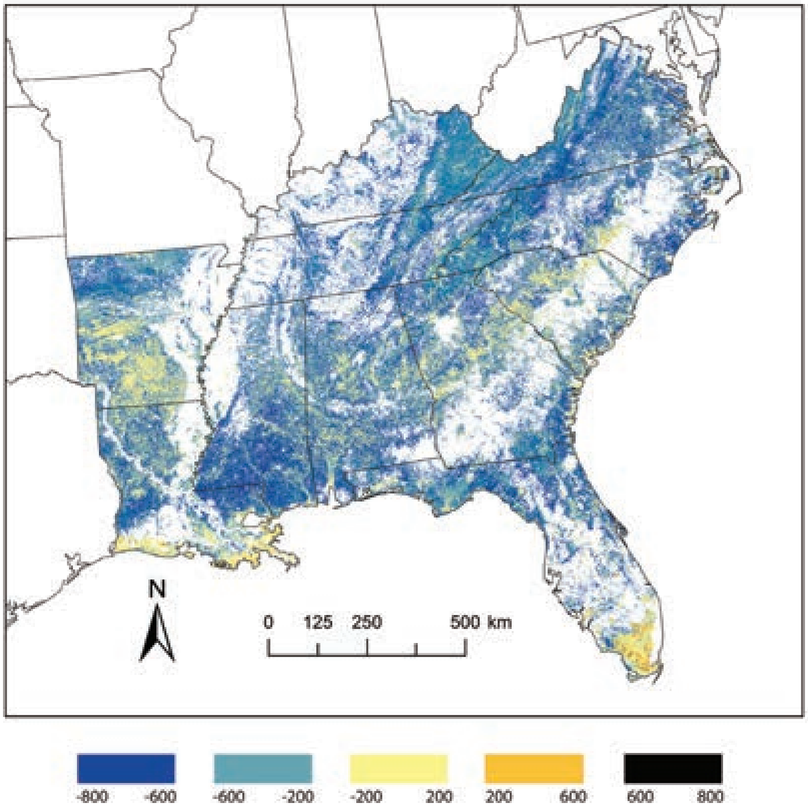

Figure 12.3 Mean annual net ecosystem exchange (NEE) for the Southeastern USA for the period 2001 to 2006. Units are $gCm^{-2}\ yr^{-1}$. Positive values indicate carbon release, and negative values indicate carbon uptake (croplands, urban areas, water bodies, and non-vegetated areas excluded).

The SE has an extensive network of highway, rail, and navigable transportation corridors and is home to five of the top 30 busiest airports in the USA by passenger boarding (FAA 2012) and seven of the top 30 freight gateways in the USA handling international merchandise, whether by water, air, or land (Research and Innovative Technology Administration 2009). A wide array of government and other stakeholders in the SE are working to improve the efficiency of the region's transportation network through such efforts as smart growth, congestion relief and commuter programs.

A noteworthy effort to reduce petroleum use in the SE is the Southeast Diesel Collaborative (SEDC 2012). The SEDC focuses on reducing the impacts of diesel emissions through strategies such as replacing older vehicles with newer, more fuel efficient vehicles, repowering existing engines to reduce emissions and to improve fuel usage, encouraging strategies to eliminate wasteful idling, and retrofitting long haul trucks with aerodynamic improvements to increase fuel economy. SEDC also works to reduce the impact of freight movement at ports and airports. For example, an SEDC project in Tennessee is installing auxiliary power units on tractor trailers to reduce fuel usage when idling. The effort is projected to save over 9 million gallons of fuel over the life of the project and eliminate over 100,000 tons of CO_2 (TDEC 2011).

Case Study: Arkansas Clean Cities Coalition

The US Department of Energy's Clean Cities Program advances the nation's economic, environmental, and energy security by supporting local actions to reduce petroleum consumption in transportation. Fourteen cities in the Southeast participate in the program.

The primary mission of the Arkansas Clean Cities Coalition is to advance the energy, economic, and environmental security of Arkansas through government-industry partnerships that contribute to the reduction of petroleum consumption in the transportation sector.

Coalition Statistics:
Population: 2,911,045
Area: 53,179 sq mi

Boundaries: Entire state of Arkansas
Designated: October 25, 1995
Alternative Fueling Stations:

- Biodiesel (B20 and above): 5
- Natural Gas: 6
- Ethanol (E85): 20
- Electric: 5
- Propane: 49

http://www1.eere.energy.gov/cleancities/ http://arkansasenergy.org/ar-clean-cities.aspx

http://www.afdc.energy.gov/cleancities/coalition/arkansas

SEDC is also working to create "green corridors" along interstates to promote the availability of less carbon intensive fuels and "idle-free" options for truckers during rest periods, e.g., truck stop electrification. SEDC is promoting this effort nationally and is working with other regional diesel collaborative organizations along the east coast to develop Interstate 95 into a green corridor. To date, the SE hosts over 1,500 alternative fuel locations, including biodiesel, compressed natural gas, propane, and E85 options (Alternative Fuels Data Center 2012).

Energy Efficiency in Buildings and Manufacturing

Energy efficiency is one of the most cost-effective ways to reduce GHG emissions of various end-use sectors, including residential, commercial, and industrial. Innovative, climate specific building designs, such as passive solar orientation, daylighting, high quality thermal and air barriers along the building envelope, and improved building occupant conservation behaviors can complement energy efficiency and help avoid new GHG emissions. While barriers to energy efficiency projects do exist, such as the upfront costs, many energy efficiency projects have a negative cost per ton of CO_2 avoided through reduced expenditures on fuel or electricity, though this negative cost depends on the temporal boundary of cost analysis and the useful life of the particular efficiency measure (McKinsey & Company 2009).

The reliable flows, estimated future stocks, high densities, and low costs of the Southeast's fossil fuel derived energy sources has made it difficult to promote energy conservation and efficiency improvements in the region. Market penetration data for energy efficient products such as Energy Star® appliances are lower-than-average and polling data suggest a weak conservation ethic in the southeastern United States (Brown et al. 2011).

According to the American Council for an Energy Efficient Economy (ACEEE 2012), states in the SE consistently rank towards the bottom of the list based on policies promoting energy-efficiency (Figure 12.4). This is illustrated by electric utility energy efficiency program spending per capita in the SE, which was just one-fifth the national average as of 2002 (Misuriello and Gillespie 2006). However, ACEEE did identify North Carolina and South Carolina as two of the most improved states in the 2012 ranking.

An exception is the ongoing implementation of the 2009 Presidential Executive Order (EO 13514) on Federal Leadership in Environmental, Energy, and Economic Performance (White House 2009). This order directs federal agencies to reduce greenhouse gas pollution, eliminate waste, improve energy and water performance, and leverage federal purchasing power to support innovation and entrepreneurship in clean energy technologies and environmentally-responsible products. The General Services Administration, along with Federal Agency partners, is working to implement this order in more than 140 federally owned buildings comprising more than 17 million rentable square feet of space in the SE USA (US General Services Administration 2012).

Although some states in the SE have already adopted fairly progressive energy codes, other states have outdated or non-existent energy code policies governing the

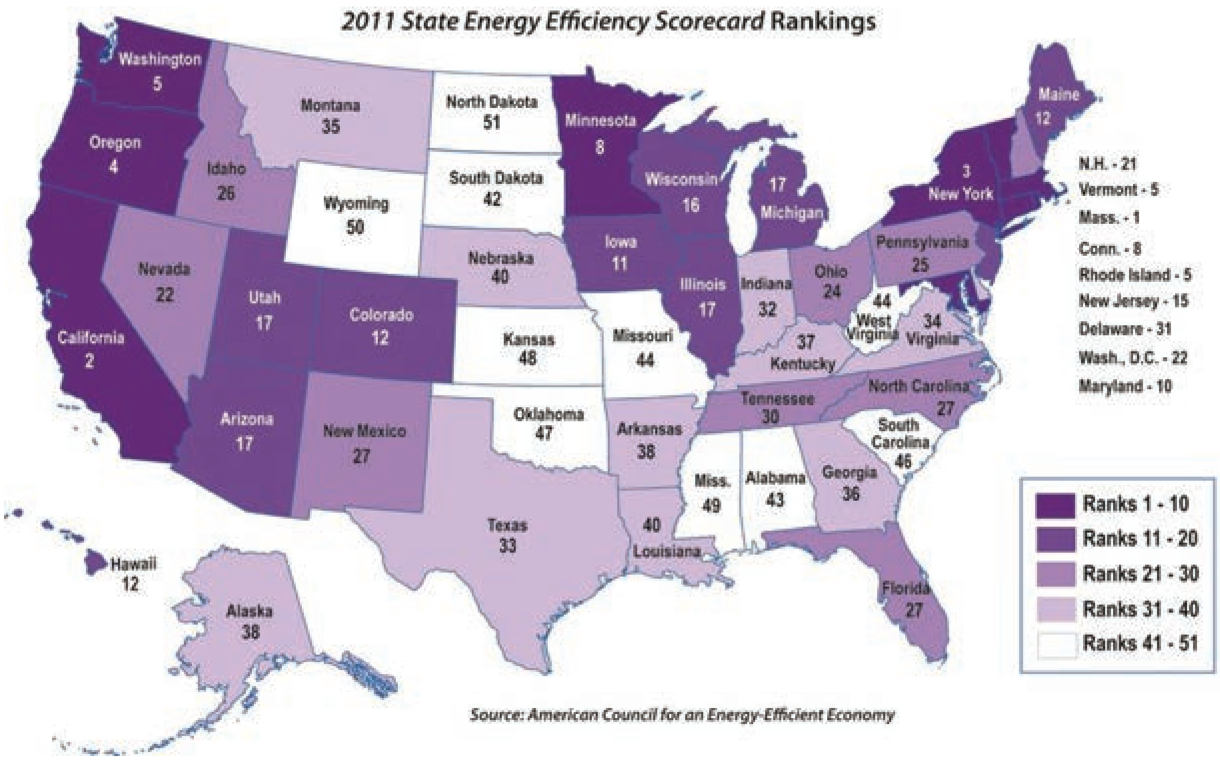

Figure 12.4 2011 ACEEE energy efficiency scorecard rankings.

energy efficiency of new buildings. This situation is improving, in part due to a provision of the 2009 American Recovery and Reinvestment Act (ARRA 2009) requiring states receiving ARRA funds to adopt updated energy codes. According to the ACEEE Scorecard, Georgia and Florida rank among the top 10 states for both the stringency of their energy codes and energy code compliance efforts. In April 2010, the Southeast Energy Efficiency Alliance was granted $20 million from the US Department of Energy Better Buildings Program to help upgrade businesses and homes in 13 cities in eight southeastern states and the US Virgin Islands. DOE expects that this project "will create program models and best practices to transform the market for energy efficiency across the Southeast" (USDOE 2012a).

Case Study: Beneficial Electrification of Motors and Vehicles

Research indicates that the electrification of transportation vehicles could provide significant benefits to the environment and the economy. Plug-in hybrid electric vehicles (PHEVs) and battery-only electric vehicles (EVs) are two types of vehicle electrification. PHEVs, unlike EVs, can operate seamlessly on gasoline or electricity. One promising technology to introduce the use of electricity as a transportation fuel is through the development of PHEVs.

The Natural Resource Defense Council (NRDC) and the Electric Power Research Institute (EPRI) recently analyzed how the deployment of PHEVs could change greenhouse gas emissions in the USA over the period 2010 to 2050. Various scenarios were evaluated which tracked the "emissions from the generation of electricity to the charging of PHEV batteries and from the production of motor fuels to their consumption in internal combustion vehicles." The scenarios represented different mixes of electric generating technologies and PHEV penetration levels. For each scenario, annual and cumulative GHG emissions were reduced. In 2050, annual reductions ranged between 163 and 612 million metric tons of GHGs. Cumulative GHG emissions reductions from 2010 to 2050 ranged from 3.4 to 10.3 billion metric tons. Each scenario reduced GHG emissions in each region of the country.

Vehicle electrification is not without challenges, which include higher vehicle costs, driven largely by the battery costs; the lack of available public charging infrastructure; the need to enable successful connection between vehicles and the electric grid; and a lack of mainstream consumer acceptance of electric powered vehicles.

For example, a growing fleet of EVs or PHEVs may bring an unusually high burden to areas of the Southeast requiring upgrades to the local utility distribution network to meet this new demand. In particular, transformers serving charging facilities may be insufficient to support the simultaneous charging of multiple vehicles. Utilities serving the Southeast will need access to information and regulatory support to deal with these and other issues.

Duvall, M. Plug-In Hybrids on the Horizon: Building a Business Case. Spring 2008. http://mydocs.epri.com/docs/CorporateDocuments/EPRI_Journal/2008-Spring/1016422_PHEV.pdf

EPRI and NRDC. "Environmental Assessment of Plug-In Hybrid Electric Vehicles Volume 1: Nationwide Greenhouse Gas Emissions." July 2007. http://mydocs.epri.com/docs/CorporateDocuments/SectorPages/Portfolio/PDM/PHEV-ExecSum-vol1.pdf

Electrification Coalition. Fleet Electrification Roadmap: Revolutionizing Transportation and Achieving Energy Security. November 2010. http://projectgetready.com/wp-content/uploads/2010/12/EC-Fleet-Roadmap-screen.pdf

An upside to these generally low energy efficiency rankings across the SE is the large untapped potential for energy saving gains through cost-effective conservation measures. This potential was illustrated in a recent study on the effect of implementing key energy efficiency polices in the industrial, residential, and commercial sectors in the SE (Brown et al. 2010). The geographic area in this study included states outside the NCA SE; the values reported below are estimates for only the NCA SE states.

The study found that policies promoting process improvements, utility plant upgrades, combined heat and power in the industrial sector, equipment standards and retrofits in the commercial sector, and home energy retrofits, building energy codes, energy-efficient appliances and an expanded residential weatherization allocation program are estimated to save 2,100 trillion BTUs (Tbtu) in 2020 (an 11% reduction in total energy consumption from a reference year of 2010) and 3,376 Tbtu in 2030 (a 16% reduction in total energy consumption from a reference year of 2010). In 2030, these energy savings are estimated to mitigate the emissions of approximately 100 MMt of CO_2. These policies would also have a net positive impact on the economy in the region, generate an estimated 220,000 jobs, avoid $24 billion of utility bills, and save 5 billion gallons of freshwater in 2020. For an example of one important energy efficiency technology that is already being used to some extent in the SE, see the following case study on combined heat and power (Kaufmann and Chittum 2011, Brown et al. 2011a, Brown et al. 2011b, Cox et al. 2011, US EPA 2012b).

Case Study: Combined Heat and Power (CHP)

Combined heat and power (CHP), also known as "cogeneration," is an efficient, clean, and reliable approach to generating power and thermal energy from a single fuel source. CHP can greatly increase a facility's operational efficiency, decrease energy costs, and decrease greenhouse gas emissions.

According to the Energy Information Administration (EIA) 2011 Annual Energy Outlook, 49% of industrial energy consumption occurs in the Southeast. CHP, therefore, is an important technology to help reduce this level of consumption. The Southeast has 416 CHP facilities that represent almost 20 GW of capacity. While bulk chemicals, food processing, and pulp and paper represent half of these CHP plants in the Southeast, a number of small applications have been added in the past ten years. The Southeast is also home to four large-scale natural gas combined cycle facilities in Alabama, Florida, Mississippi, and South Carolina.

Progressive policies that promote environmental technologies such as CHP have been shown to promote positive economic and environmental outcomes. For example, national analyses of output-based regulations and portfolio standards that include CHP have shown the potential to avoid tens of millions of tonnes of CO2 emissions, save 1.4 to 2.4 quadrillion BTUs of energy, and provide billions of dollars of net social benefits on an annual basis.

With few exceptions, such as North Carolina's 35% investment tax credit, such policies are largely nonexistent in the Southeast. For example, no Southeastern state has output-based regulations. Likewise, Arkansas and Florida both have public service commission-established energy efficiency goals, but neither includes provisions to encourage greater development of CHP.

Several southeastern states are leading in specific energy efficiency areas even though the SE as a region is lagging in overall energy-efficiency policies. According to US Green Building Council's 2010 ranking, four SE states—Florida, Virginia, Georgia, and North Carolina—rank in the top 11 of all 50 states for total number of US Green Building Council Leadership in Energy and Environmental Design (LEED) projects (US Green Building Council 2012). Georgia and Virginia are also among the top states in the country for promoting affordable green housing. Their qualified allocation plan policy provides incentives for energy efficiency, smart growth, resource conservation, and health (Global Green USA 2010). Organizations in several SE states are active in the areas of research, development, and demonstration for energy efficiency, including the Florida Solar Energy Center, the Florida Energy Systems Consortium, the North Carolina Solar Center, the Southeast Energy Efficiency Alliance, and Southface Institute, which conducts research and training on energy efficient housing and communities.

Case Study: North Carolina RPS

In 2007, the governor of North Carolina, Mike Easley, signed into law S.L. 2007-397, which establishes a Renewable Energy and Energy Efficiency Portfolio Standard for the state. By 2021, investor-owned utilities must meet 12.5% of retail electricity demand through renewable energy or energy efficiency measures. Electric membership corporations and municipalities that sell electric power in the state have to meet a standard of 10% by 2018. Resources that can be used to meet the standard include solar energy, wind energy, hydropower, geothermal energy, ocean current or wave energy, biomass resources, and energy efficiency measures.

The law also includes provisions to encourage the use of solar energy, swine and poultry wastes, as well as implementation of energy efficiency programs.

http://www.c2es.org/what_s_being_done/in_the_states/rps.cfm

Renewable Portfolio Standards

A Renewable Portfolio Standard (RPS) provides states with a mechanism to increase renewable energy generation using a market-based approach that is administratively efficient. An RPS requires electric utilities and other retail electric providers to supply a specified minimum amount of customer load with electricity from eligible renewable energy sources and other clean energy approaches, such as energy efficiency and combined heat and power. The goal of an RPS is to stimulate market and technology development so that renewable energy will eventually be economically competitive with conventional forms of electric power. States create RPS programs because of their benefits to energy security, economy, and environment, including reduction of GHG emissions (US EPA 2012c).

In the SE NCA Region, only North Carolina, Puerto Rico, and the US Virgin Islands have legally binding RPSs (North Carolina Utilities Commission 2008, Energy Affairs Administration 2010, USDOE 2012b). Several solar electricity facilities have subsequently been built, including a 17 MW solar farm in Davidson County, NC (Whitmore 2011). Two states—Virginia and Florida—have established renewable portfolio goals and Florida's Public Service Commission has approved inclusion of 110 MW of solar capacity in its ratemaking plan (Florida Public Service Commission 2008). The remaining SE states have not established either a mandatory or voluntary RPS. Additional renewable energy and energy efficiency policies and programs have likewise been established unevenly across the SE. Programs such as public benefit funds, net metering, green pricing programs, decoupling policies, energy efficiency resource standards, and various financial incentives vary from state to state (Center for Climate and Energy Solutions 2012).

Carbon Capture and Storage

Carbon capture and storage (CCS) is the process of capturing and storing CO_2 before it is emitted from stationary sources that would otherwise release CO_2 into the atmosphere. Although currently expensive and in the early stages of development, CCS technologies offer one technological solution to mitigating CO_2 emissions from stationary sources. For example, Mississippi Power's advanced integrated gasification combined cycle power plant being built in Kemper County, MS, will initially capture 65% of generated CO_2, much of which will be sold for enhanced oil recovery (Mississippi Power 2012).

Case Study: The City of Gainesville, FL

Gainesville joined the International Council for Local Environmental Initiatives the (ICLEI) Cities for Climate Protection Campaign in 2002. Three years later, the community joined cities across the nation and pledged to reduce carbon. The city's goal was to reduce carbon emissions to 7 percent below 1990 levels. Gainesville is set to reach this target in 2013.

Gainesville Regional Utilities, (GRU), a multiservice utility owned by the City of Gainesville, has played a key role in the process. As the fifth largest municipal electric utility in Florida, GRU serves approximately 90,000 retail and wholesale customers in Gainesville and surrounding areas with electric, natural gas, water, wastewater, and telecommunications services.

Strategic GRU programs and projects to reduce carbon emissions include monitoring and controlling emissions; improving energy efficiency; improving power generation efficiency, and increasing the use of renewable energy sources. GRU also has the first-in-the-nation feed-in tariff for solar electricity.

When a new local biomass power plant comes online in 2013 the city will exceed their goal of 7% below 1990 emissions for government operations, including the municipal utility (essentially all of community-wide emissions excluding transportation).

https://www.gru.com/OurCommunity/Environment/AirQuality/

It should be noted that CCS has an associated "energy penalty," which is the fraction of fuel that must be used to run the CCS process. A recent study found that the energy penalty associated with pulverized coal power plants provided an absolute lower bound of 11%, with an easily achievable value of 40% and 29% as a "decent target value" (House et al. 2009).

The US DOE is investigating a variety of cost-effective technological approaches for CCS, including geologic carbon storage. Of particular interest is storage in saline formations, oil and gas reservoirs, coal areas that cannot be mined, organic-rich shales, and basalt formations. An example of potential deep saline geologic formations for CCS in the SE is shown in Figure 12.5 (NETL 2010).

The US DOE Carbon Sequestration Program is comprised of three key elements for CCS technology development and research: (1) core R&D, (2) infrastructure, and (3) global collaborations. The primary component of the infrastructure element is the Regional Carbon Sequestration Partnerships, a government/academic/industry cooperative effort tasked with characterizing, testing, and developing guidelines for the most suitable technologies, regulations, and infrastructure for CCS in different regions of the USA and several provinces in Canada.

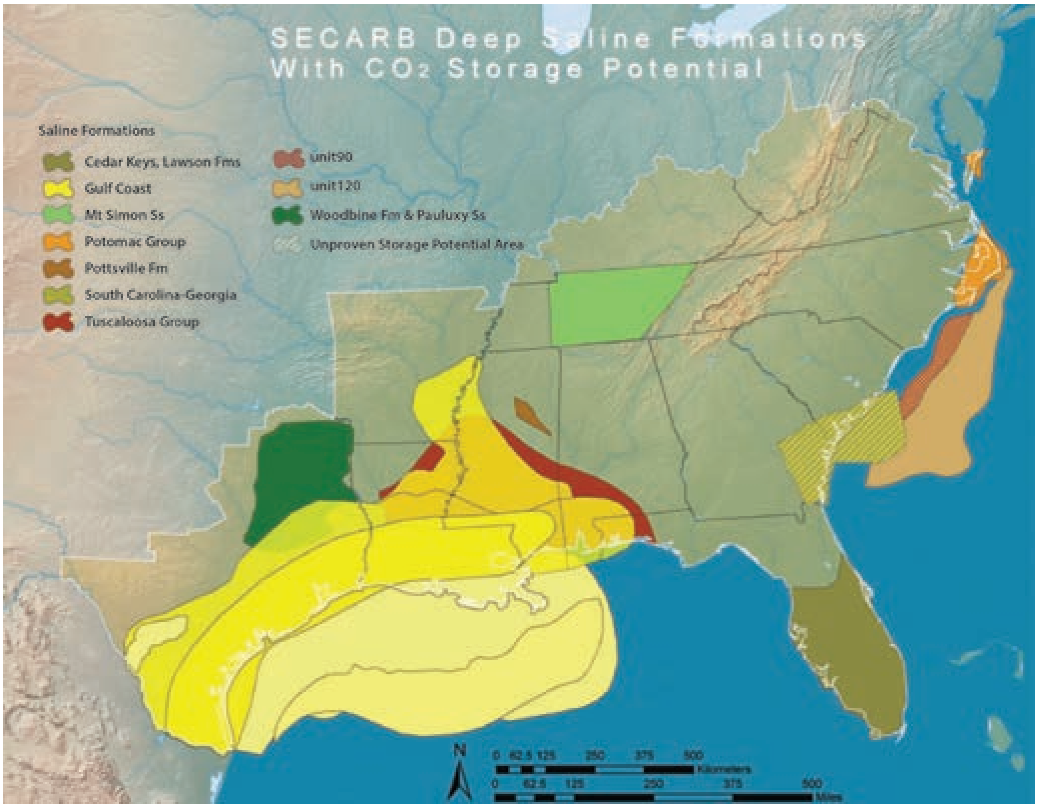

Figure 12.5 Southeast Regional Carbon Sequestration Partnership (SEACARB) map showing deep saline formations with CO_2 storage potential.

Case Study: Hickory Ridge Landfill

The Hickory Ridge Landfill in Conley, Georgia, is approximately 10 miles southeast of downtown Atlanta. The landfill opened in 1993 and is fitted with equipment to produce power from both solar photovoltaics and methane gas collection.

Hickory Ridge is one of the first landfills in the country to integrate flexible solar panels into a geomembrane cover being used to close a section of the landfill. Hickory Ridge is the largest solar landfill cover in the world, with 7,000 solar panels on 10 acres. The plant generates more than 1 million kWh of renewable electricity annually, enough to meet the needs of 224 homes. The solar project is being developed in tandem with a landfill methane-to-energy project, thereby increasing the power output of this one waste disposal facility and further reducing greenhouse gas emissions to the atmosphere.

http://www.alliedwaste.com/pr-90_000.html

http://www.georgia.gov/00/press/detail/0,2668,134245182_144576795_156569968,00.html

Photo courtesy of the Georgia Environmental Finance Authority.

The Southeast Regional Carbon Sequestration Partnership (SECARB), managed by the Southern States Energy Board, is the primary partnership investigating regional CCS opportunities (SECARB 2012). SECARB represents a 13-state region: Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Texas, and Virginia, as well as portions of Kentucky and West Virginia. The primary goal of SECARB is to develop the necessary framework and infrastructure to conduct field tests of CCS technologies and to evaluate options and potential opportunities for the future commercialization of CCS in the region. Estimates of storage capacity in the SECARB Region are provided in Table 12.4.

SECARB is currently designing and operating four small-scale and two large-scale CCS demonstration projects across the SE. In addition, SECARB continues to characterize the region's on- and offshore geologic storage options, identify barriers and opportunities for the wide-scale construction of CO_2 pipelines to storage areas, enhanced oil recovery, and other commercial uses, monitor federal and state regulatory and legislative activities, and support local, regional, national, and international education and outreach efforts related to the SECARB initiative.

Sustainability Plans

In addition to individual projects aimed at reducing emissions of GHGs from a particular source, such as CCS for a large power plant or switching that plant to fuels with lower carbon intensities per unit of output as energy or goods, many corporations and cities are developing and instituting plans to reduce their overall direct and indirect impacts on the environment. Energy efficiency, renewable energy, and GHG emission reductions are frequently central themes in corporate and local government sustainability plans.

A number of SE cities have also developed sustainability plans to help save energy and reduce their carbon footprint. For example, 206 southeastern mayors have signed on to the US Conference of Mayor's Climate Protection Agreement. Among other things, signatories strive for a 7% reduction in GHG emissions by 2012 based on 1990 levels through actions ranging from anti-sprawl land-use policies to urban forest restoration projects to public information campaigns (Mayors Climate Protection Center 2009).

Another example, Local Governments for Sustainability (ICLEI), is working with 83 local governments in the SE to develop GHG emission inventories, set realistic goals for reduction of GHG emissions, develop and implement an action plan to achieve those reductions, and measure results (ICLEI USA 2012). The National Association of Counties, through its Green Government Initiative, also provides assistance to cities and counties through seminars, best practices, modeling, and analytical tools to increase local government plans for reducing GHG emissions (National Association of Counties 2012). A number of private sector firms are helping governments and businesses get on a path toward more quantifiable and accountable sustainability planning.

Other types of organizations, such as universities, are also engaged in developing and implementing programs to reduce GHG emissions. For example, 105 southeastern colleges and universities are signatories to the American College and University Presidents' Climate Commitment (ACUPCC), which works to "eliminate net greenhouse gas emissions from specified campus operations, and to promote the research and educational efforts of higher education to equip society to re-stabilize the earth's climate" (ACU Presidents Climate Commitment 2012). Some leaders include the University of Florida (UF 2012), in Gainesville, FL, and Agnes Scott College in Decatur, GA (Agnes Scott 2012).

Table 12.4 Estimates of CO_2 Storage Capacity in the SECARB Region.

State	CO_2 Sources (Million Metric Tons)	CO_2 Storage Resource (Million Metric Tons)				Years Storage**
	Total	Oil and Gas	Coal and Shale*	Saline*	Total	
AL	80	344	1,944	12,900	15,188	190
AR	35	250	15,675	4,304	20,229	572
FL	143	109	1,275	16,725	18,109	127
GA	90			4,909	4,909	55
KY	94	14	68	400	482	N/A
LA	102	6,781	8,325	139,497	154,603	1,520
MS	34	399	5,400	46,427	52,226	1,546
NC	77			1,352	1,352	18
SC	40			1,995	1,995	49
TN	66			500	500	8
VA	46	10	231	159	400	9
†Federal OffShore		17,754		484,996	502,750	N/A
Total	**807**	**25,661**	**32,918**	**714,164**	**772,743**	

*Low estimates used

**Years of CO_2 storage at the current emission rates (State CO_2 storage resource/State annual emissions)

†Includes storage in the Gulf of Mexico off the coast of TX

In 2006, UF was the first institution in the USA to sign the ACUPCC. Since 2001, UF has required all new buildings and major renovations to meet LEED certification, increasing the minimum certification threshold to silver in 2006, and more recently to a minimum of gold. UF now has 21 LEED certified buildings including the first platinum and gold certified buildings within Florida. In 2009, UF recycled 50% of its waste including construction debris and ambitiously aims for zero waste by 2015. Over 95% of all UF campus outdoor irrigation is supplied by reclaimed water from the university's on-campus treatment plants. UF was also named one of the nation's "Best Workplaces for Commuters" by the US EPA. Approximately 29% of all UF students, faculty, staff, and visitors travel to campus as pedestrians or bicyclists with another 39% arriving on the public bus system, which runs on a 20% biodiesel fuel blend and is partially subsidized by student fees. By 2011, UF earned the honor as the top school on the Roberts Environmental Center's sustainability reporting of the top US universities. Other aspects of the UF sustainability vision include research, curriculum, and engagement.

Agnes Scott has received funding for "green" renovations of several campus buildings, an energy audit, the purchase of utility sub-metering equipment for five buildings, the development of an energy master plan, and hiring a sustainability fellow. They are also working with the city of Decatur on sustainability initiatives in the broader community, have created an environmental and sustainability studies minor, and have established a policy that all new construction and renovation projects aim to follow LEED guidelines.

Universities are also using creative financing mechanisms such as Green Revolving Funds to promote energy efficiency improvements on campus. One example in the SE is the revolving fund at Georgia Tech, which has enabled the school to update physical plant infrastructure including boiler upgrades, efficient lights, variable-speed motors and pumps, and high-efficiency upgrades to chillers (Sustainable Endowments Institute 2011).

Additional activities. In addition to the activities discussed above, a number of additional and varied projects are in place and planned throughout the SE to reduce GHG emissions. Southeastern states, for example, currently have 135 active landfill projects under EPA's Landfill Methane Outreach Program, a voluntary assistance program that helps to reduce methane emissions from landfills by encouraging the recovery and beneficial use of landfill methane as an energy resource. In addition to the active projects, 186 additional landfills in the SE have been identified as possible candidates for methane capture (US EPA 2012d). Other examples include efforts by farmers to convert animal waste to useable energy, with 14 anaerobic digester systems currently operating at SE commercial livestock farms (US EPA 2012e), and efforts by municipalities, such as Hoover, AL and St. Johns County, FL, to collect waste grease for conversion to biodiesel (City of Hoover 2012, St. Johns County Government 2012).

12.4 Research Needs and Uncertainties

As the country moves from fossil fuels to renewable fuels, such as ethanol/gasoline blends and biodiesel, the resulting changes and impacts of radiative forcing agents need to be examined. For example, the US Congress has mandated that EPA evaluate on a three-year cycle the current and potential future environmental and resource conservation impacts associated with increased biofuel production and use, with the first report published in 2011 (US EPA 2011). Impact of emissions from biomass burning is another important consideration (Leahy et al. 2007, IPCC 2007, Marley et al. 2009, Marley et al. 2008, Gaffney and Marley 1998, Gaffney and Marley 2011).

Some of the numerous ongoing focus areas for research on GHG mitigation include the following:

- Renewable electricity conversion and delivery systems
- Renewable fuels formulation, delivery, and storage

- Efficient and integrated energy systems
- Strategic energy analysis
- Carbon capture and storage
- Vehicle electrification
- Personal and organizational behavior among the diversity of energy consumption end-use sectors
- Approaches to making substantial investments that do not lead to technology lock-in, given the uncertainties in technology development pathways and future conditions of climate, economic growth, and other factors

12.5 References

ACU Presidents Climate Commitment. 2012. http://www.presidentsclimatecommitment.org/

Agnes Scott. 2012. *Sustainability at ASC.* http://legacy.agnesscott.edu/about/sustainability

Alternative Fuels Data Center. 2012. Washington, DC. http://www.afdc.energy.gov/

American Council for an Energy Efficient Economy. 2012. *State Energy Efficiency Scorecard.* Washington, DC. http://www.aceee.org/sector/state-policy/scorecard

American Recover and Reinvestment Act. 2009. http://www.recovery.gov/About/Pages/The_Act.aspx

Armentano, T.V. 1980. Drainage of organic soils as a factor in the world carbon cycle. *BioScience,* 30 (12): 825-830.

Brown, M.A., E. Gumerman, X. Sun, Y. Baek, J. Wang, R. Cortes, D. Soumonni. 2010. *Energy Efficiency in the South*. Southeast Energy Efficiency Alliance. Atlanta, Ga.

Brown, M.A., E. Gumerman, X. Sun, G. Kim, K. Sercy 2011. Working Paper. Myths and Facts about Electricity in the U.S. South. *Energy Policy* 40: 231-241.

Brown, M.A., R. Jackson, M. Cox, R. Cortes, B. Deitchman, M.V. Lapsa. 2011a. *Making industry part of the climate solution: Policy options to promote energy efficiency*. Oak Ridge, TN: Oak Ridge National Laboratory. http://info.ornl.gov/sites/publications/Files/Pub23821.pdf

Brown, M.A., M. Cox, R. Jackson, M.V. Lapsa. 2011b. *Expanding the pool of federal policy options to promote industrial energy efficiency*. Niagara Falls, NY: American Council for an Energy-Efficient Economy. http://www.aceee.org/files/proceedings/2011/data/papers/0085-000016.pdf

CAPAG (Climate Action Plan Advisory Group). 2008. Recommended mitigation options for controlling greenhouse gas emissions. Washington, DC: Center for Climate Strategies.

Center for Climate and Energy Solutions. 2012. U.S. State Climate Policy Maps. Arlington, VA. http://www.c2es.org/what_s_being_done/in_the_states/state_action_maps.cfm

Center for Climate Strategies. 2012. State and Local Climate Blackboard. Washington, DC. http://www.climatestrategies.us/policy_tracker/state/

City of Hoover. 2012. *Fleet management*. Hoover, AL: City of Hoover. http://www.hooveral.org/Default.asp?ID=114

Commonwealth of Virginia. 2008. *Inventory and projection of greenhouse gas emissions (2000-2025).* Richmond, VA: Department of Environmental Quality–Air Division.

Cox, M., M.A. Brown, R. Jackson. 2011. *Regulatory reform to promote clean energy: The potential of output-based emissions standards*. Niagara Falls, NY: American Council for an Energy-Efficient Economy. http://www.aceee.org/files/proceedings/2011/data/papers/0085-000017.pdf

Energy Affairs Administration. 2010. *Renewable portfolio standard*. San Juan, Puerto Rico: Green Energy Fund.

EIA (Energy Information Administration). 2011. State Energy Data System, 1960-2009 Estimates. Washington, DC. http://www.eia.gov/state/seds/seds-data-complete.cfm

EIA (Energy Information Administration). 2009. *Renewable portfolio standards fact sheet*. Washington, DC: U.S. Environmental Protection Agency.

FAA (Federal Aviation Administration). 2012. Passenger Boarding (Enplanement) and All-Cargo Data for U.S. Airports. Washington, DC. http://www.faa.gov/airports/planning_capacity/passenger_allcargo_stats/passenger/

Florida Public Service Commission. 2008. *PSC approves solar projects' cost recovery eligibility*. Tallahassee, FL: Florida Public Service Commission. http://www.psc.state.fl.us/home/news/index.aspx?id=419

Gaffney, J.S. and N.A. Marley. 1998. Uncertainties of aerosol effects in global climate models. *Atmospheric Environment* 32 (16): 2873-2874.

Gaffney, J.S and N.A. Marley. 2011. Climate impacts from agricultural emissions: Greenhouse species and aerosols. In *Understanding greenhouse gas emissions from agricultural management*, ed. L. Guo, A. Gunasekara, and L. McConnell, 275-295. Washington, DC: Agricultural Research Service.

Global Green USA. 2010. *Green Building Criteria in Low-Income Housing Tax Credit Programs: 2010 analysis*. Santa Monica, CA: Global Green USA. http://globalgreen.org/docs/publication-164-1.pdf

Han, F.X., M.J. Plodinec, Y. Su, D.L. Monts, Z. Li. 2007. Terrestrial carbon pools in southeast and south-central United States. *Climatic Change* 84 (2): 191-202.

House, K.Z., C.F. Harvey, M.J. Aziz, D.P. Schrag. 2009. The energy penalty of post-combustion CO_2 capture & storage and its implications for retrofitting the U.S. installed base. *Energy & Environmental Science* 2 (2): 193-205.

ICLEI USA. 2012. http://www.icleiusa.org/about-iclei/

IPCC (Intergovernmental Panel on Climate Change). 2007. *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, ed. S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller. New York and United Kingdom: Cambridge University Press.

Kaufmann, N. and A. Chittum. 2011. State barriers to CHP development. Paper presented at the Proceedings of the 2011 Industrial Energy Technology conference, New Orleans, Louisiana, May 17-19, 2011. http://txspace.di.tamu.edu/bitstream/handle/1969.1/94798/ESL-IE-11-05-21.pdf?sequence=1

Kentucky Renewable Energy Consortium. 2009. *Kentucky forum on carbon sequestration through agriculture and forestry management*. Louisville, KY: KREC. https://louisville.edu/kppc/krec/krec-publications/Carbon%20Forum%20Summary%20web%2012-17-09.pdf

Leahy, L.V., T.L. Anderson, T.F. Eck, R.W. Bergstrom. 2007. A systhesis of single scattering albedo of biomass burning aerosol over southern Africa during SAFARU 2000. Geophys. Res. Lett. 34:5p.

Marley, N.A., J.S. Gaffney, M.J. Tackett, K. Hardy, N.C. Sturchio, L. Heraty, N. Martinez, A. Marchany-Rivera, T. Guilderson, A. MacMillan, K. Steelman. 2008. The impact of biogenic carbon emissions on aerosol absorption in Mexico City. *Atmospheric Chemistry and Physics* 8 (5): 18499-18530.

Marley, N.A., J.S. Gaffney, T. Castro, A. Salcido, J. Frederick. 2009. Measurements of aerosol absorption and scattering in the Mexico City metropolitan area during the MILAGRO field campaign: A comparison of results from the T0 and T1 sites. *Atmospheric Chemistry and Physics* 9 (1): 189-206.

Mayors Climate Protection Center. 2009. *Mayors Leading the Way on Climate Protection*. Washington, DC: U.S. Conference of Mayors. http://www.usmayors.org/climateprotection/revised/

McKinsey&Company. 2009. *Pathways to a low carbon economy: Version 2 of the global greenhouse gas abatement curve--January 2009*. Washington, DC: McKinsey&Company.

Mississippi Power. 2012. *Kemper Energy Facility*. http://www.mississippipower.com/kemper/home.asp

Misuriello, H. and K. Gillespie. 2006. *New energy efficiency policy initiatives and advances in the southeast United States*. Niagara Falls, NY: American Council for an Energy-Efficient Economy. http://www.eceee.org/conference_proceedings/ACEEE_buildings/2006/Panel_8/p8_16/paper

National Association of Counties. 2012. *Green government initiative*. Washington, DC: NASo. http://www.naco.org/programs/csd/pages/greengovernmentinitiative.aspx

NETL (National Energy Technology Laboratory). 2010. *2010 carbon sequestration atlas of the United States and Canada: Third edition*. Washington, DC: US Department of Energy.

North Carolina Utilities Commission. 2008. *Renewable energy and energy efficiency portfolio standard*. Raleigh, NC: NC Utilities Commission.

Research and Innovative Technology Administration. 2009. *America's freight transportation gateways 2009*. Washington, DC: US Department of Transportation. http://www.bts.gov/publications/americas_freight_transportation_gateways/2009/pdf/entire.pdf

Schlesinger, W.H. 1977. Carbon balance in terrestrial detritus. *Annual Review of Ecology and Systematics* 8 (November): 51-81.

Schlesinger, W.H. 1995. An overview of the C cycle. In *Advances in soil science: Soils and global change,* ed. R. Lal, J.M. Kimble, E. Levine and B.A. Stewart, 9-26. Boca Raton, FL: CRC-Press.

SECARB (Southeast Regional Carbon Sequestration Partnership). 2012. http://www.secarbon.org/

SEDC (Southeast Energy Efficiency Alliance). 2010. Southeast Diesel Collaborative. 2012. Atlanta, GA http://southeastdiesel.org/

St. Johns County Government. 2012. *Biodiesel fuel program*. St. Augustine, FL: Biodiesel Fuel Department. http://www.co.st-johns.fl.us/PublicWorks/Biodiesel.aspx

Strait, R., M. Mullen, B. Dougherty, A. Bollman, R. Anderson, H. Lindquist, L. Williams, M. Salhotra, J. Schreiber. 2008a. *Final Arkansas greenhouse gas inventory and reference case projections, 1990-2025.* Washington, DC: Center for Climate Strategies.

Strait. 2008b. *Final Florida greenhouse gas inventory and reference case projections, 1990-2025.* Washington, DC: Center for Climate Strategies.

Strait, R., S. Roe, B. Dougherty, A. Bollman, H. Lindquist. 2008c. *Final draft South Carolina greenhouse gas inventory and reference case projections, 1990-2020.* Washington, DC: Center for Climate Strategies.

Strait, R., M. Mullen, B. Dougherty, R. Anderson, A. Bollman, V. Glenn, J. Maldonado, S. Roe, J. Schreiber, B. Strode, K. Pasko. 2010. *Final Kentucky greenhouse gas inventory and reference case projections, 1990-2030.* Washington, DC: Center for Climate Strategies.

Sustainable Endowments Institute. 2011. *Greening the bottom line: The trend toward green revolving funds on campus*. Cambridge, MA: Sustainable Endowments Institute. http://www.endowmentinstitute.org/gbl/Greening_the_Bottom_Line.pdf

TDEC (Tennessee Department of Environment and Conservation). 2011. APU Rebate Program. Final Report. Table 2 – Actual Results. Grant 2D-95422009.

UF (University of Florida). No Date. Reaching the Vision - Sustainable U.F. Gainesville, FL: UF Office of Sustainability. http://sustainable.ufl.edu/docs/ReachingtheVision-final.pdf

US Census Bureau. 2012. Washington, DC: US Department of Commerce. http://www.census.gov

USDOE (US Department of Energy). 2012a. Better Buildings Neighborhood Program. *Southeast Energy Efficiency Alliance--The Southeast Makes a Wise Investment in Energy Efficiency.* Washington, DC. http://www1.eere.energy.gov/buildings/betterbuildings/neighborhoods/seea_profile.html

USDOE (US Department of Energy). 2012b. U.S. Virgin Islands--Renewables Portfolio Targets. Washington, DC. http://energy.gov/savings/us-virgin-islands-renewables-portfolio-targets

US EPA (US Environmental Protection Agency). 2011. National Center for Environmental Assessment. *Biofuels and the environment: The first triennial report to Congress*. Washington, DC. http://cfpub.epa.gov/ncea/biofuels/recordisplay.cfm?deid=235881

US EPA (US Environmental Protection Agency). 2012a. Greenhouse Gas Reporting Program. Washington, DC. http://www.epa.gov/ghgreporting/index.html

US EPA (US Environmental Protection Agency). 2012b. Combined Heat and Power Partnership. *Environmental Benefits*. Washington, DC. http://epa.gov/chp/basic/environmental.html

US EPA (US Environmental Protection Agency). 2012c. Combined Heat and Power Partnership. *Renewable Portfolio Standards Fact Sheet*. Washington, DC. http://www.epa.gov/chp/state-policy/renewable_fs.html#fn1

US EPA (US Environmental Protection Agency). 2012d. Landfill Methane Outreach Program. Washington, DC. http://epa.gov/lmop/

US EPA (US Environmental Protection Agency). 2012e. AgStar Program. Washington, DC. http://epa.gov/agstar/

US General Services Administration. 2012. *Federal buildings/facilities*. Washington, DC: GSA. http://www.gsa.gov/portal/category/21459

US Green Building Council. 2012. *Top 10 U.S. states ranked by total number of LEED projects*. Washington, DC: U.S. Green Building Council. http://www.usgbc.org/ShowFile.aspx?DocumentID=7744

Virgin Islands Energy Office. 2009. Renewable Portfolio Standard.

White House. 2009. *Executive Order 13514 on Federal Leadership in Environmental, Energy, and Economic Performance*.http://sustainability.performance.gov/

Whitmore, C. Davidson county solar farm, North Carolina. *PV-Tech*, January 27, 2011. http://www.pv-tech.org/project_focus/davidson_county_solar_farm_north_carolina

Xiao, J., Q.Zhuang, B.E. Law, D.D. Baldocchi, J. Chen, A.D. Richardson, J.M. Melillo, et al. 2011. Assessing net ecosystem carbon exchange of U.S. terrestrial ecosystems by integrating eddy covariance flux measurements and satellite observations. *Agricultural and Forest Meteorology* 151 (1): 60-69.