Powering the South

A Clean & Affordable Energy Plan for the Southern United States

REPP

By Fredric Beck and Damian Kostiuk, Renewable Energy Policy Project,
Tim Woolf, Synapse Energy Economics and Virinder Singh

Powering the South Advisory Committee

Harvard Ayers - Appalachian Voices
Dennis Creech - Southface Institute
Richard Harkrader - North Carolina Solar Energy Association
Rita Kilpatrick - Georgians for Clean Energy
Stephen Smith - Southern Alliance for Clean Energy
Deb Swim - Legal Environmental Assistance Foundation

Authors

Fredric Beck is Research Director and **Damian Kostiuk** is Research and Communications Specialist at the Renewable Energy Policy Project.

Fredric Beck can be contacted at fbeck@repp.org, and Damian Kostiuk can be contacted at dkostiuk@repp.org. Both can be contacted at (202) 293-2898.

Tim Woolf was lead consultant for Synapse Energy Economics, and can be contacted at twoolf@synapse-energy.com or (617) 661-3248. He was assisted by **David White** and **Monserrat Ramiro** of Synapse. **Michael Brower** provided the assesment of renewable resources. **Tellus Institute** provided the assesment of industrial energy efficiency and biomass combined heat and power.

Virinder Singh is former Research Director of the Renewable Energy Policy Project, and can be reached at virindersingh@yahoo.com.

**Get Involved with Powering the South
@
www.poweringthesouth.org**

POWERING THE SOUTH: A CLEAN AFFORDABLE ENERGY PLAN FOR THE SOUTHERN UNITED STATES

CONTENTS

POWERING THE SOUTH: A CLEAN AFFORDABLE ENERGY PLAN FOR THE SOUTHERN UNITED STATES

by Fredric Beck and Damian Kostiuk, Renewable Energy Policy Project
Tim Woolf, Synapse Energy Economics, and Virinder Singh [†]

INTRODUCTION

Power is important in the South. It lights homes, schools, and businesses and it keeps industry running. Yet it also causes substantial damage to people's health and to the environment. It plunders land, flora, and fauna.

Southern voters are concerned about air pollution. A November 1998 survey of 1,600 voters in Florida, Georgia, Tennessee, and Virginia found that two-thirds of respondents considered air pollution a "somewhat serious" to "very serious" problem.[1]

Power generation in the South releases substantial amounts of pollution into the air. According to the U.S. Environmental Protection Agency (EPA), in 1998 Southern power plants released 480 million tons of carbon dioxide (CO_2), 1.4 million tons of nitrogen oxides (NO_x), and 3.2 million tons of sulfur dioxide (SO_2).[2] Table 1 indicates the amount of pollution produced by power plants in the South.[3] The region produced more air pollution per megawatt-hour (MWh) than the United States on average for both NOx and SO_2, though produced less CO_2 per MWh than the United States on average.

Table 1. Pollution for Each Megawatt-Hour of Energy Produced in the South, 1998

Pollutant	Pounds Per Megawatt-hour	% Difference from U.S. Average
Carbon Dioxide	1,314	-7.6% lower
Nitrogen Oxide	3.75	+5.4% higher
Sulfur Dioxide	8.86	+18.1% higher

Emissions from power plants in the South are likely to grow. Electricity consumption under the "business as usual" scenario—that is, without a meaningful improvement in energy efficiency—is expected to grow by 45% from 2000 to 2020. Since many new power plants will rely on natural gas, emissions per MWh should decline, but total emissions, particularly of carbon dioxide, will increase.

Powering the South offers a path to a clean, affordable power system, one that reduces the harmful pollution of the current power system while still assuring that power remains affordable and reliable. This path first shows that the resource potential exists and then carefully establishes the policy changes that will allow the technical potential to be realized. The Report shows that the technical potential for efficiency and renewable energy exists to replace a substantial portion of the "business as usual" generation. The results are startling. As shown in Table 2, the carbon dioxide, nitrogen oxide, and sulfur dioxide emissions in 2020 will be lower than the "business as usual" levels and actually significantly lower than emissions in 2000. These clean energy gains can be realized with no increase in the cost of electricity for the region as a whole.

Aggressive efficiency programs will reduce the annual growth in demand for electricity from 1.8% to 0.7%. As a result, 236 million MWh of new demand, or the equivalent of the output of 112 new power plants 300 MW each in size, can be avoided. Under the Powering the South plan, part of the savings from the efficiency programs will be used to increase the use of renewable generation. Under the plan, renewable resources will grow to provide 10% of the electricity generated in the region in 2020. Replac-

Table 2. Emission Reductions in 2020 Under the Powering the South Clean Energy Plan

Pollutant	2000 Emissions	2020 Business as Usual Emissions	2020 Powering the South Emissions	2020 Emission Reductions Compared to Business as Usual
Carbon Dioxide (tons)	482,000,000	645,000,000	438,600,000	-32% lower
Nitrogen Oxide (tons)	672,000	941,000	478,000	-49% lower
Sulfur Dioxide (tons)	2,883,000	3,023,000	2,132,000	-30% lower

ing the dirtiest generation with the efficiency and renewable package will dramatically reduce regional pollutants.

At this stage of the Project, the analysis and results are regional in nature and can be applied to each state only on a proportional basis. For the region as a whole, the Powering the South program can produce a package of energy efficiency and renewable generation that cleans the air and keeps electric bills constant. Whether each state, region, county, or household will achieve the average results will depend upon how aggressively they pursue the policy recommendations in the Report. It is important to note that the demand for a healthier environment, which means a cleaner energy system is not only technically achievable, it can be achieved with little or no increase in the electric bills of business and households.

CHAPTER 1. ENERGY AND THE SOUTHERN ENVIRONMENT

CONTENTS

Emissions from energy generation in the South cause air pollution, impact human health, contribute to global climate change, and affect land, water, and wildlife. A new path, the *Powering the South* Clean Energy Plan, will reduce these emissions and their impacts in the South.

AIR POLLUTION AND HEALTH
Air pollution impairs human health, particularly that of children and elderly people.

■ SO_2 is a prime contributor to fine particulate matter, which impairs breathing, particularly for those with existing respiratory or cardiovascular disease.

■ NO_x is also a prime contributor to fine particulate matter, and can pose respiratory problems even for healthy adults exposed to it for less than three hours. Others, such as asthmatics, the elderly, and children, face more severe problems.

■ NO_x mixed with organic hydrocarbons from automobiles in the presence of sunlight creates ground-level ozone (smog), which damages lungs, impairs the immune system, and lessens the ability to exercise. "Code red" days in the summer signal excessive ozone levels that endanger the health of children playing outside.

These impacts on human health are a serious concern in the South:

■ In 1998, 83 out of every 1 million people in *Powering the South's* six-state study region died of asthma.[4]

■ Excessive smog sent 4,500 people in Tennessee and 5,700 people in North Carolina to the emergency room in 1997.[5]

■ In Atlanta, EPA reports 45 days in 2000 when smog levels were unhealthy for healthy individuals as well as sensitive groups.[6] Atlanta's air quality is among the worst in the country. Data from Georgia's State Air Protection Branch shows that power plants contribute 46% of the NO_x emissions—a precursor to smog—in an 89-county region that includes Atlanta.[7]

Major sources of pollution in the South, including larger power plants, release 27% more mercury per capita than major sources nationwide.

MERCURY
Coal-fired power plants in the South are also a chief source of mercury. In the United States, power plants are responsible for a third of total mercury emissions.[8] "Major" sources of pollution in the South as defined by EPA and including larger power plants, release 27% more mercury per capita than "major" sources nationwide.[9]

Mercury accumulates in fish and therefore in people who eat fish regularly. It threatens the brain, kidneys, liver, and central nervous system, as well as the health of fetuses. According to the National Academy of Sciences, 60,000 American children may be born each year with neurological problems due to mercury exposure inside their mothers' wombs.[10]

GLOBAL WARMING AND THE SOUTH

Carbon dioxide emissions from power plants are one of the primary drivers of global warming. In the United States, power plants are responsible for a third of total CO_2 emissions. According to a recent report by the Intergovernmental Panel on Climate Change (IPCC), the leading international research body on the subject, greenhouse gases (of which CO_2 is currently the leading gas) released by human activities such as fossil fuel use are changing Earth's climate. The IPCC Third Assessment Report predicts a 1.4–5.8 degrees Celsius (2.5–10.4 °F) increase in globally averaged surface temperatures likely between 1990 and 2100. With associated higher sea surface temperatures, the likelihood of hurricanes should also increase.[11]

Global warming poses particular problems for the South. For example:

■ According to EPA, sea levels at Charleston, South Carolina, may rise by 19 inches between 2000 and 2100, compared with 9 inches the previous century. The potential for increased storm damage due to sea level rise is particularly high along the state's densely developed Grand Strand.[12]

■ A study involving several leading academic experts found that coastal areas in Florida face sea level rises of 8–16 inches, and possibly as high as 30 inches.[13]

■ In Alabama, water supplies in coastal communities such as Mobile might fall due to saltwater intrusion caused by higher sea levels.[14] Saltwater intrusion has also killed trees whose dead stems form new "ghost forests" along the Gulf of Mexico.[15]

Global warming poses a threat to human health, too, particularly for children, the elderly, and the poor.[16] Nighttime temperatures are likely to rise. Southerners seeking a respite from hot days may face little relief. Such sustained high temperatures can be fatal, particularly for infants and any elderly who lack adequate cooling in their homes.[17] Global warming may also create hotter and more humid conditions that support the spread of diseases such as arbovirus encephalitis, and may increase the likelihood of diseases such as malaria and dengue coming into the South with travelers returning from locations where such diseases are endemic.[18]

ENERGY'S IMPACT ON LAND, WATER, AND WILDLIFE

NITROGEN POLLUTION IN WATER

NO_x from power plants can cycle into surface waters and groundwater. The impacts of high nitrogen levels in water include excessive growth of plants such as algae, which consume so much oxygen that they starve other plants and animals and block out sunlight for species living at lower depths. Atmospheric nitrogen, including power plant emissions, represents over a quarter of total nitrogen in Sarasota and Tampa Bays in Florida, and more than third in the Newport coastal waters in North Carolina. Overall, the National Oceanic and Atmospheric Administration found high nitrogen concentrations in 11 of 21 South Atlantic estuaries, threatening wildlife and water quality.[19]

HAZE AND VISIBILITY

A variety of air pollutants—such as sulfur dioxide, nitrogen dioxide, and particulate matter—add to haze problems in the South. In Great Smoky National Park in Tennessee and North Carolina, visitors can see 14 miles at most on the haziest days, compared with 57 miles on the clearest days.[20] The Sipsey Wilderness in Alabama has witnessed declining visibility. In fact, northern Alabama has the highest sulfate concentrations in the nation.[21]

Sulfate particles from power plants and industry are the biggest contributors to poor visibility in these public lands. In fact, sulfates from SO_2 emissions in particular are deemed a top contributor to poor declining visibility in the Southeast in the summertime, when humidity and its ability to expand particles from air pollution are at their highest.[22] Nitrogen oxide emissions as well as hydrocarbons (from automobiles) are other contributors.

MOUNTAINTOP REMOVAL

The vast majority of coal burned at Southern power plants comes from the Appalachians. Increasingly, mines in these states are turning to "mountaintop removal" to obtain coal cheaply and with little labor. This involves slicing the tops of mountains and disposing of debris in nearby valleys. Such practices destroy habitats, alter water flow patterns in surrounding valleys, and flatten the surrounding terrain into a virtually unrecognizable form. Individual mining sites can occupy approximately 25,000 acres.[23] Kentucky, Ohio, and West Virginia all get more than a third of their coal from surface mining, as opposed to more traditional underground mining.[24]

WATER USE

Water use at power plants also affects the landscape and water availability for other users. Power plants represent the largest single category of water use in the eastern United States.[25] On average they return 98% of the water back to the source, though at a higher temperature (up to 40 degrees Celsius). In states such as Georgia, Alabama, and Florida, however, which are experiencing severe drought, adding new power plants that will make claims on scarce water supplies creates uncertainty about supply among other users, and must be considered carefully.

NUCLEAR POWER

Nuclear power has been a controversial and expensive source of power since the 1960s. It has received 95% of the total federal subsidies for nuclear, solar, and wind power since 1947. When adjusted for total power production, nuclear power has been 18 times more expensive than wind power in terms of subsidies received over the first 25 years of either technologies development. [26]

In the environmental realm, the most pressing issue facing nuclear power is radioactive waste. Currently 70 power plants around the nation house over 38,000 tons of high-level nuclear waste, mainly spent fuel rods. The total is expected to top 66,000 tons in 2010.[27] Spent nuclear fuel remains highly radioactive for hundreds of thousands of years, so it must be isolated from humans. Some nuclear power plants in the South have begun storing their high-level nuclear waste outdoors in dry casks.[28]

The federal government has proposed storing waste at Yucca Mountain in Nevada, but local opposition to the transport and deposit of waste has jeopardized the future of that project. Furthermore, studies have shown that if all exist-ing nuclear power plant in the United States run at full strength until 2035, they will produce much more waste than Yucca Mountain can legally store.[29]

Low-level waste, consisting of other replaceable parts of nuclear reactors, is another concern. A review of state and federal documents by REPP shows that all six low-level nuclear waste dumps ever used have leaked.[30] While the name "low-level" implies low risk, in fact exposure to unshielded, low-level nuclear waste can be lethal in less than one minute.[31]

Furthermore, catastrophic accidents—whether due to internal operations, natural events, or acts of terrorism—raise the risk of radiation to levels Americans are unwilling to tolerate, as injuries, deaths, and financial impacts could devastate an entire region.

A NEW PATH—THE *POWERING THE SOUTH* CLEAN POWER PLAN

With growing electricity demand and a reliance on fossil fuel and nuclear power, environmental problems in the South are only likely to grow without a concerted effort to change "business as usual" and advance a Clean Power Plan. Energy efficiency and renewable energy are ready to supply the South with energy services that support economic growth while reducing unacceptable environmental and health problems.

CHAPTER 2. THE TECHNICAL POTENTIAL FOR CLEAN ENERGY

CONTENTS

THE SOUTH'S ELECTRICITY INDUSTRY UNDER BUSINESS-AS-USUAL CONDITIONS

THE SOUTH'S ELECTRICITY INDUSTRY TODAY

The South currently relies heavily on coal and nuclear power for its electricity generation, with much of the remainder provided by oil and gas units. Figure 2.1 presents the mix of electricity generation sources in the South in 2000, and Figure 2.2 presents the amount of electricity generated by each fuel type in each state that year. These figures include generation from power plants that are owned by utilities as well as those that are not. The generation shares given below are based on power plants physically located in the six-state region, not on generation that may have been exported or imported to the region from other states:[32]

■ Coal plants generate roughly 55% of the region's electricity. The coal units have a capacity factor of 73% on average, indicating that they generally operate at high levels but could operate at even higher levels as electricity demand increases.[33] Approximately two-thirds of the coal plants in the region were built before 1970. These older units are relatively inefficient, operating at 28–32% efficiency on average, and many have not been upgraded with modern pollution control technologies.[34]

Figure 2.1 Sources of Generation in the South in 2000

Coal 55%

Other Renewables 1%

Hydro 5%

Gas/Oil 13%
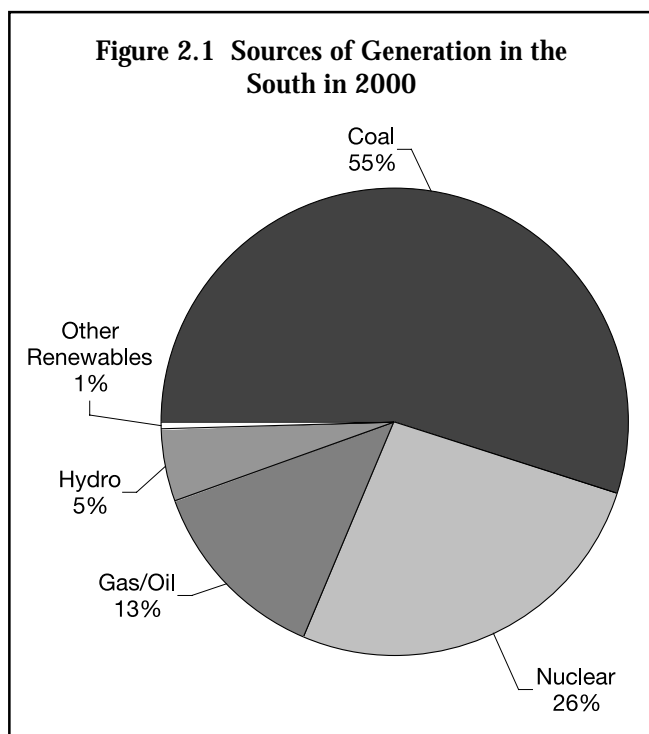
Nuclear 26%

■ Nuclear plants account for roughly 26% of the region's electricity. The nuclear units run as baseload whenever they are available, resulting in a capacity factor of 84%.

Figure 2.2 Sources of Generation in the South, by State, in 2000[35]

Generation
(Million MWh)
- Renewable
- Gas/Oil
- Nuclear
- Coal
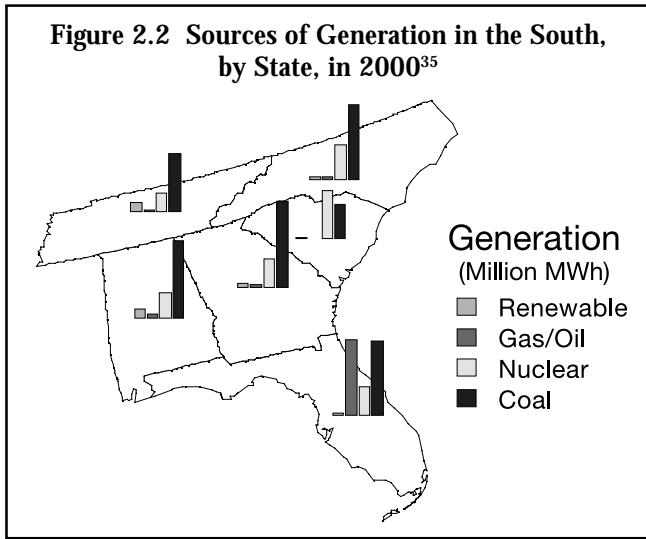
■ Oil and gas plants provide 13% of the South's electricity generation. Most of these facilities are used for cycling and peaking purposes, and maintain a relatively low capacity factor of 27% on average. Florida uses gas/oil plants to generate roughly 40% of its electricity, while the other states use very little gas/oil generation.

■ Renewable resources supply 6% of the region's electricity. These are almost entirely hydroelectric plants (providing roughly 5% of the region's electricity), with only one percent of regional generation currently being derived from the South's non-hydro renewable sources; biomass, wind, or solar photovoltaics (PVs).

THE ELECTRICITY INDUSTRY IN THE FUTURE UNDER BUSINESS-AS-USUAL CONDITIONS

A reference forecast has been prepared to indicate the future of the electric industry in the South under business-as-usual practice. The Business-As-Usual Case is intended to represent the future electricity industry in the absence of many of the policies and actions recommended in Chapter 3. This reference case is based primarily on the U.S. Department of Energy (DOE) forecast in the *2001 Annual Energy Outlook* (AEO 2001), as described later in this chapter.[36]

DOE forecasts that electricity demand in the region will grow at an average annual rate of roughly 2.3%

from 2000 to 2010, and at about 1.6% from 2010 to 2020. While this is lower than the rapid growth rates of the 1990s, it results in a 45% increase in electricity demand over 20 years. DOE forecasts that peak demand in the region will increase by 60,000 megawatts (MW) during this period, which is roughly equivalent to 200 power plants of 300 MW each.[37]

The primary results of the Business-As-Usual forecast are shown in Figure 2.3 and Table 2.1. There is a modest decline in coal capacity expected by 2020, as some older coal plants are retired. However, the operating coal plants' capacity factors will gradually increase from 73% to as much as 79%, as existing coal plants operate more in order to meet new load growth. The net impact is a steady increase in coal generation over the next 20 years. There is a slight decline in nuclear generation expected between 2010 and 2020, as some older units are retired when their operating licenses expire and they become uneconomical.[38]

The most significant change between 2000 and 2020 under Business as Usual is the addition of new natural gas facilities. However, due to natural gas price volatility, there has recently been increased interest in building new coal plants instead of new gas plants

---

The most significant change between 2000 and 2020 is the addition of new natural gas facilities. By 2020 new gas facilities will be the second largest source of generation in the South, providing up to 35% of all electricity. However, due to the volatile natural gas prices, there has recently been increased interest in building new coal plants instead
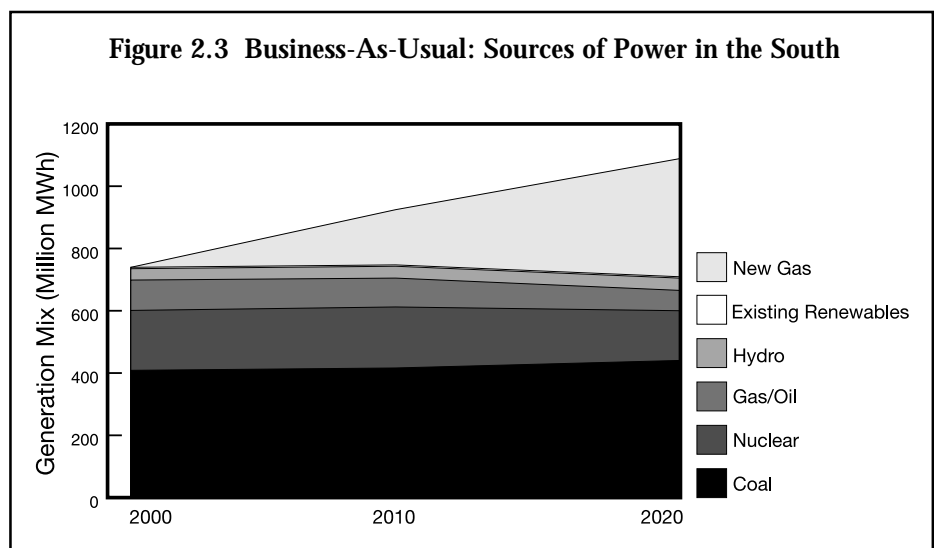
Figure 2.3 Business-As-Usual: Sources of Power in the South

Legend:
- New Gas
- Existing Renewables
- Hydro
- Gas/Oil
- Nuclear
- Coal

Table 2.1 Business-As-Usual: Sources of Power in the South in 2000, 2010, and 2020

Fuel Type / Year	Generation (Million MWh)			Share of Generation		
	2000	2010	2020	2000	2010	2020
New Renewables	0.0	0.0	0.0	0%	0%	0%
New Gas	0.0	177.3	379.9	0%	19%	35%
Existing Renewables	4.4	4.3	4.3	1%	0%	0%
Hydro	36.5	38.1	39.5	5%	4%	4%
Gas/Oil	98.2	92.7	65.2	13%	10%	6%
Nuclear	192.4	195.9	159.6	26%	21%	15%
Coal	408.7	416.3	440.5	55%	45%	40%
Total	**740.1**	**924.7**	**1,089.0**	**100%**	**100%**	**100%**

of new gas plants to meet future demand. If new coal plants are actually constructed in the future, they would most likely result in slightly higher costs and increased air emissions than assumed in this Business-As-Usual Case.

The combination of new load growth, retiring nuclear units, and new natural gas generation will result in much higher carbon dioxide (CO_2) emissions. Under Business-As-Usual practices, CO_2 emissions in the region are likely to increase from 482 million tons in 2000 to 645 million tons in 2020— a 32% increase. Sulfur dioxide (SO_2) emissions are expected to remain essentially level [39] as power plant owners comply with Phase II of the Acid Rain Program under the Clean Air Act.

This study assumes that many power plant owners in the region install nitrogen oxide (NO_X) controls to comply with the provisions of the Clean Air Act and the proposed regional NO_X State Implementation Plan (SIP) Rule. The costs of these controls are included in both the Business-As-Usual forecast and the Clean Power Plan. Despite these new controls, NO_X emission rates are forecast to increase by 40% during this study period.

THE SOUTH'S ELECTRICITY INDUSTRY UNDER THE CLEAN POWER PLAN

REGIONAL IMPACTS OF THE CLEAN POWER PLAN
The Clean Power Plan includes four major changes from the Business-As-Usual forecast:

■ Aggressive energy efficiency measures are implemented;

■ Additional non-hydroelectric renewable resources are installed;

■ Fewer new natural gas facilities are installed as a result of lower electricity demand and increased use of renewable resources; and

■ Some older coal plants are retired early.

(The methods and assumptions used in modeling the Clean Power Plan are described in greater detail at the end of this chapter.)

Figure 2.4 and Table 2.2 present the mix of electricity generation resulting from the Clean Power Plan. Electricity demand grows at roughly 0.7% per year, much lower than the 1.8% annual growth under Business As Usual from 2000 to 2020, as a result of the energy efficiency improvements. In the Clean Power Plan, electricity demand increases by only 85 million MWh over the study period, representing a savings of 236 million MWh relative to the 321 million MWh of new demand in the Business-As-Usual Case. In other words, the energy efficiency resources reduce demand enough to avoid roughly 112 new power plants of 300 MW each.

In the Clean Power Plan, coal generation declines over time due to retirements and the introduction of renewable energy sources with low operating costs. By 2020 the coal generation in the Clean Power Plan is roughly 31% below that of the Business-As-Usual Case. Nuclear generation remains the same as in the Business-As-Usual Case due to the same number of plant retirements. New renewable resources do not directly displace the retired nuclear power plants.

Generation from new natural gas plants is reduced significantly in the Clean Power Plan due to lower demand as a

Figure 2.4 The Clean Power Plan: Sources of Power in the South
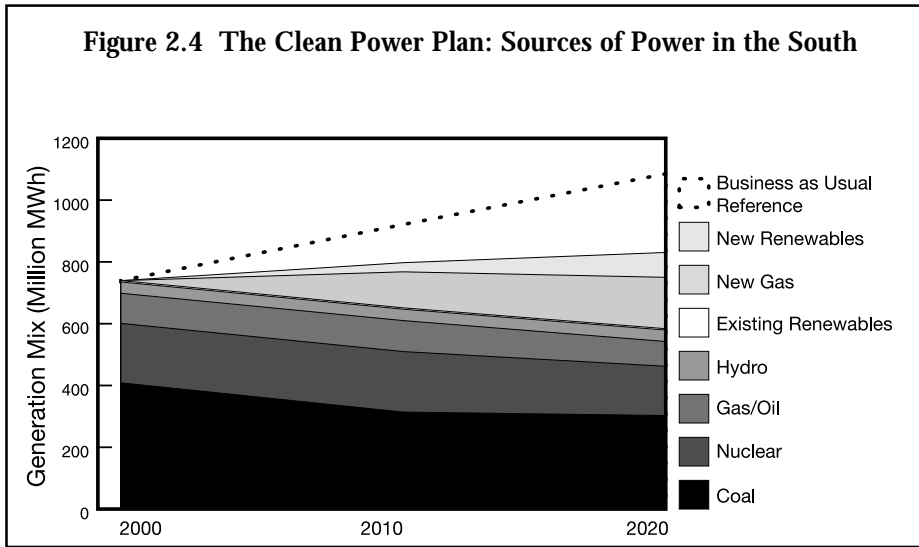
With the Clean Power Plan, by 2020, SO$_2$ emissions would be reduced by roughly 30%, NO$_X$ emissions by 49%, and CO$_2$ emissions by 32%

There is less air pollution in the Clean Power Plan, as shown in Figure 2.5. In the Business-As-Usual scenario, SO$_2$, NO$_X$, and CO$_2$ emissions increase over time due to increased generation from existing coal and new natural gas units. In the Clean Power Plan, air emissions are far lower due to lower growth in electricity demand, additional retired coal plants, and the increased use of renewables. By 2020, SO$_2$ emissions will be reduced by roughly 30%, NO$_X$ emissions by 49%, and CO$_2$ emissions by 32%. There will also be comparable reductions in emissions of mercury and particulates.

result of energy efficiency and new renewable resources. Generation from existing gas/oil plants goes up compared with the Business-As-Usual Case, as these facilities operate more often to make up for fewer existing coal and new gas plants.

Regional or national emissions of SO$_2$ and NO$_X$ will not be reduced as much as implied by Figure 2.5. SO$_2$ emissions are currently covered by a cap-and-trade system under the Clean Air Act, and NO$_X$ emissions in many southern states are likely to be covered by a similar system under the NO$_X$ SIP Rule proposed by the U.S. Environmental Protection Agency (EPA). When coal plants in the region reduce emissions of these pollutants, they may be able to sell the allowances to power plant owners in other states or regions. Nonetheless, citizens in the region will benefit from re-

With the Clean Power Plan non-hydropower renewable resources would provide roughly 4% of electricity generation by 2010 and 10% by 2020.

Non-hydropower renewable resources provide roughly 4% of electricity generation by 2010 and 10% by 2020. The majority of this renewable generation comes from biomass and wind facilities, with a small portion coming from solar photovoltaics.

Table 2.2 Clean Power Plan: Sources of Power in the South in 2000, 2010, and 2020

Fuel Type / Year	Generation (Million MWh)			Share of Generation		
	2000	**2010**	**2020**	**2000**	**2010**	**2020**
New Renewables	0.0	29.6	80.5	0%	4%	10%
New Gas	0.0	116.6	166.3	0%	15%	20%
Existing Renewables	4.4	4.3	4.3	1%	1%	1%
Hydro	36.5	36.9	37.2	5%	5%	4%
Gas/Oil	98.2	103.8	83.9	13%	13%	10%
Nuclear	192.4	195.9	159.5	26%	24%	19%
Coal	408.7	313.9	302.7	55%	39%	36%
Total	**740.1**	**801.1**	**834.5**	**100%**	**100%**	**100%**

Figure 2.5 Percent Reductions in Air Emissions in the South from the Clean Power Plan
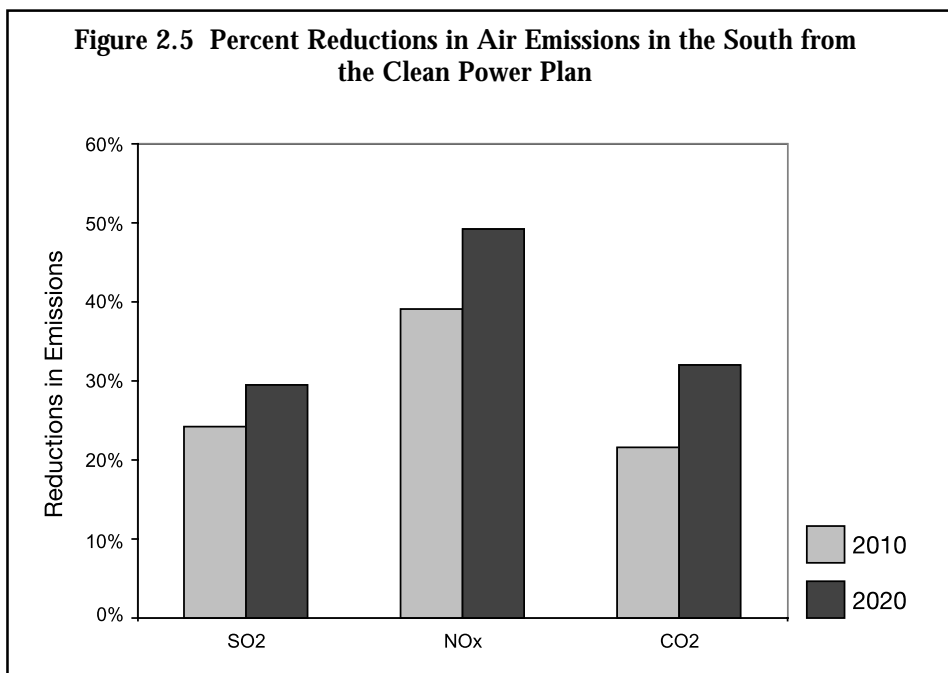
$293 million in 2010 relative to the Business-As-Usual Case—which represents a 0.6% cost increase on average. (All cost figures presented in this report are in 2000 dollars unless indicated otherwise.) By 2020, the Clean Power Plan will decrease total annual electricity costs in the region by $882 million relative to the Business-As-Usual Case—a 1.7% reduction.[40] The actual impact on a customer's electricity bill will depend on the extent to which the customer adopts energy efficiency measures, as well as future regulatory policy and market behavior regarding electricity rates and prices.

STATE-BY-STATE IMPACTS OF THE CLEAN POWER PLAN

duced SO_2 and NO_X, because reduced emissions means fewer local health and environmental problems.

As shown in Figure 2.6, the Clean Power Plan enables the electricity industry in the South to reduce and stabilize CO_2 emissions. However, this plan alone will not be enough to achieve regionally the national Kyoto Protocol target that CO_2 emissions be reduced to 7% below 1990 levels by 2010.

This section provides an overview of the modeling results for the entire six-state region. Chapter 5 describes the state-by-state results in greater detail.

Figure 2.7 shows the energy savings from efficiency measures per state by 2020 by comparing the Business-As-Usual Case demand to the Clean Power Plan demand. The total

> **By 2020, the Clean Power Plan will decrease total annual electricity costs in the region by $882 million relative to the Business-As-Usual Case—a 1.7% reduction**

This cleaner, more-efficient energy future is achieved with only a modest increase in electricity costs. Many energy efficiency measures cost far less than conventional power sources, thereby offsetting any increased marginal costs associated with renewables. The Clean Power Plan is projected to increase total annual electricity costs in the region by

Figure 2.6 CO_2 Emissions in the South: Business-As-Usual Case Versus Clean Power Plan

Figure 2.7 Demand in the South in 2020 by State: Business-As-Usual Case and Clean Power Plan

Demand
(Million MWh)
■ Clean Case
▨ Reference
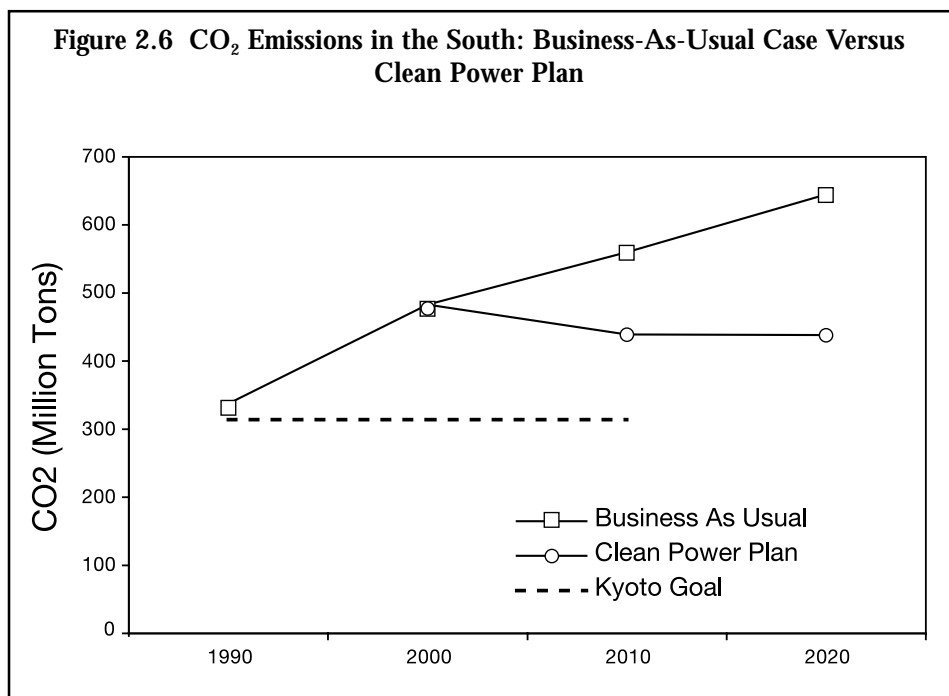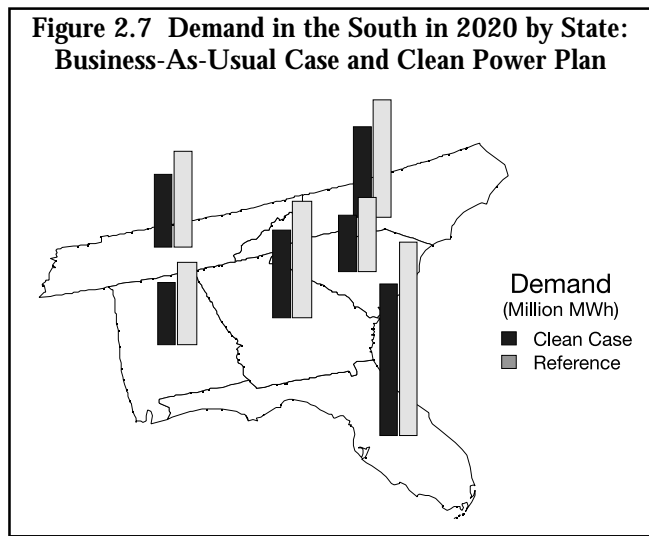
amount of saved energy is greater for states with more electricity demand. Hence, electricity savings are largest for Florida and North Carolina.

Figure 2.8 summarizes new renewable capacity additions by state in 2020. North Carolina has the largest amount of new wind resources, with most of the remainder in Tennessee, South Carolina, and Georgia. All states have biomass co-firing opportunities because of the distribution of coal plants in the region. The states have slight variations in biomass combined heat and power (CHP) opportunities due to the current distribution of pulp and paper mills, which represent the vast majority of CHP opportunities in the South. Florida is the only state with significant amounts of solar PV installations assumed during this time period.

Figure 2.8 New Renewable Capacity Additions in the South, by State, in 2020

New Renewables
Capacity (MW)
▨ Photovoltaic
▨ CHP-Biomass
☐ Biomass Co-Fire
■ Wind

With the Clean Power Plan the majority of new renewable energy generation is from biomass co-firing and biomass CHP. Wind turbines, both on- and off-shore, represent about 40% of the total renewable generation by 2020.

Table 2.3 presents a summary of the new renewable generation facilities that are installed in the Clean Power Plan. The majority of new renewable energy generation is from biomass co-firing and biomass CHP. Wind turbines, both on- and off-shore, represent about 40% of the total renewable 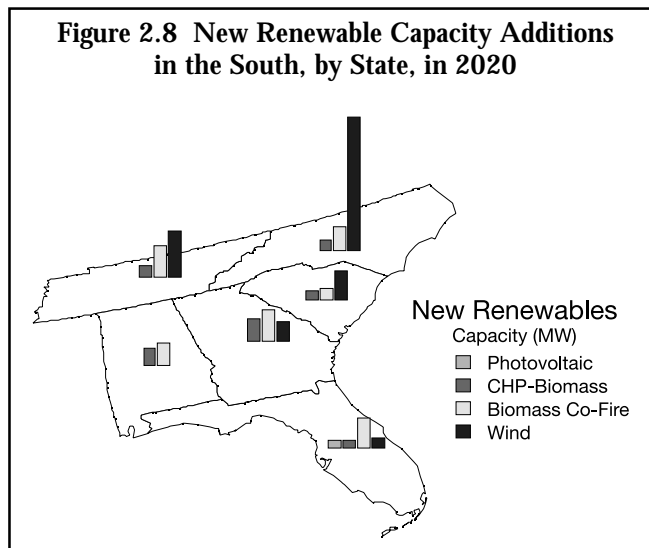generation by 2020. Solar photovoltaics represents a very small portion of the total renewable generation due to its relatively high cost, but this technology is expected to play a larger role in the future.

Table 2.3 New Renewable Resources in the South Under the Clean Power Plan, 2010 and 2020

Generator Type	2010				2020			
	Installed Capacity (MW)	Capacity (% of all fuels)	Generation (1000 MWh)	Generation (% of all fuels)	Installed Capacity (MW)	Capacity (% of all fuels)	Generation (1000 MWh)	Generation (% of all fuels)
Biomass Co-Firing	2,386	1.4%	15,278	1.9%	5,102	2.8%	33,427	4.0%
Landfill Methane	162	0.1%	1,364	0.2%	338	0.2%	2,857	0.3%
BiomassCHP	1,566	0.9%	8,231	1.0%	3,300	1.8%	17,345	2.1%
PhotoVoltaic	30	0.0%	49	0.0%	549	0.3%	929	0.1%
Wind Turbines	2,489	1.5%	8,018	1.0%	8,491	4.7%	29,360	3.5%
Total Renewables	**6,633**	**3.9%**	**32,940**	**4.1%**	**17,780**	**9.9%**	**83,917**	**10.1%**

Note: The wind turbine information is for both on-shore and off-shore turbines. Off-shore turbines represented 327 MW of capacity in 2010 and 2,880 MW of capacity in 2020.

Figure 2.9 Generation Fuel Mix in the South, by State, in 2020: Clean Power Plan

Generation
(Million MWh)
☐ Renewable
◫ New gas
☐ Gas / Oil
◼ Nuclear
■ Coal

Figure 2.10 CO$_2$ Emissions in the South in 2020: Business-As-Usual Case and Clean Power Plan
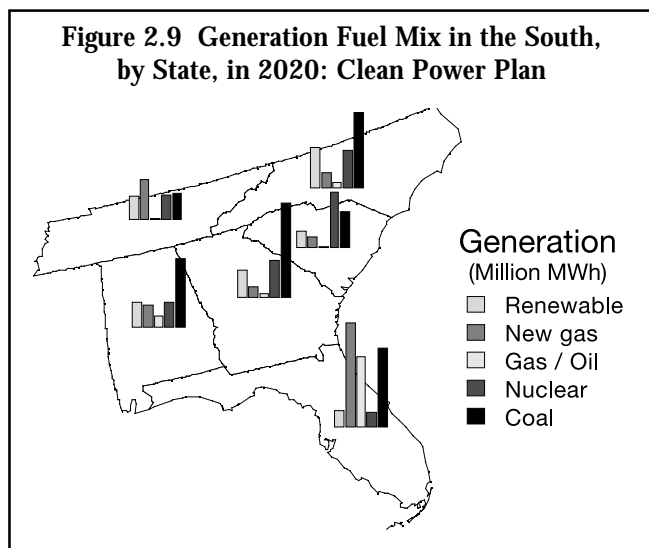
CO2 Emissions
1000 Tons
■ Clean
◼ Reference

Figure 2.9 illustrates electricity generation in the Clean Power Plan for 2020 by fuel types. Florida ends up with a larger share of new gas plants because it has fewer renewable opportunities. Conversely, North Carolina, South Carolina, and Georgia have smaller shares of new gas plants because they have more renewable opportunities. Figure 2.10 summarizes CO$_2$ emissions in 2020, comparing the Business-As-Usual forecast and the Clean Power Plan.

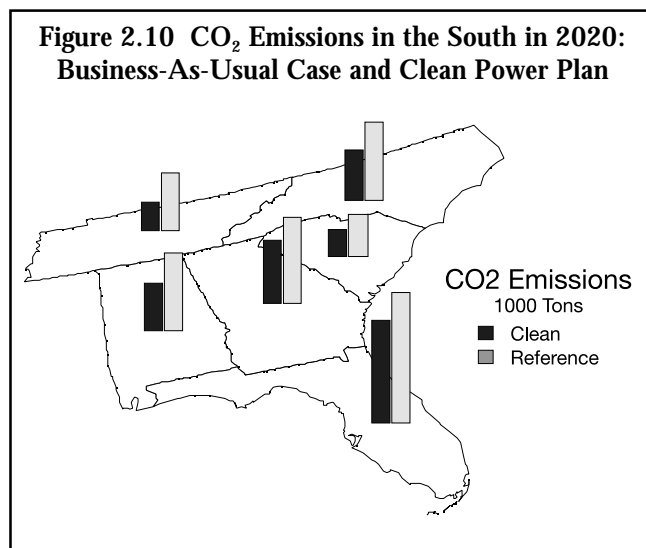## EFFICIENCY AND RENEWABLE RESOURCE POTENTIAL

ENERGY EFFICIENCY POTENTIAL IN THE SOUTH

Residential and Commercial Sectors
The residential and commercial sector energy efficiency assumptions are based primarily on the November 2000 Clean Energy Futures (CEF) Study from the Interlaboratory Working Group and its precursor, the 1997 Five Labs Carbon Reduction Study.[41] These comprehensive, nationwide studies investigate the cost and performance of energy efficiency technologies and their potential to reduce CO$_2$ emissions.

The two studies rely on DOE's *Annual Energy Outlook* for a forecast of energy under a "business-as-usual" or reference scenario. They then identify the efficiency savings that are technically achievable and cost-effective, relative to this reference scenario. The AEO reference scenario forecasts used by these studies include reductions in electricity demand due to naturally occurring efficiency improvements (that is, improvements that occur through technological development, without public policy intervention), as well

as reductions due to efficiency standards, building codes, and utility demand-side management programs. As a result, the efficiency savings identified by these studies are above and beyond the improvements that can be expected under current efficiency policies.

The Five Lab and CEF studies identify hundreds of technically and commercially available efficiency measures that can be installed when existing electricity end-use measures naturally reach the end of their useful lives. Efficiency measures also include technologies, designs, and practices that can be applied when buildings are renovated or when new buildings are constructed. The studies assume that at times of stock turnover or building renovation, the most efficient cost-effective measures available at the time of the study are implemented rather than measures that represent the typical practice.

Each study then estimates how much of the techno-economic efficiency potential can be achieved through specific efficiency policies. The 1997 Five Labs Study roughly estimated that by 2010, 35% of the potential could be achieved under a modest policy scenario, and 65% under an aggressive policy scenario. (It did not quantify the amount of efficiency potential available in 2020.) The 2000 CEF Study included a more detailed policy analysis and was more cautious about how much of the techno-economic potential could be achieved through efficiency policies. In the aggressive scenario, CEF assumes that 38% of the techno-economic potential could be achieved in 2010, and that roughly 64% could be achieved by 2020. However, the CEF Study does not include a comprehensive set of efficiency policies, and its authors are quick to note that

additional savings are available from additional policies. The key policies assumed in the CEF study that affect electricity efficiency include efficiency standards for equipment, building codes, voluntary labeling of appliances, voluntary agreements with industry and industry trade associations, government procurement, and accelerated R&D.

The Five Labs and CEF studies do not account for certain currently available cost-effective efficiency measures, such as duct sealing, commercial office equipment, commercial building shell measures, advanced cooking technologies, and advanced heat exchangers. In addition, neither study accounts for any new efficiency measures that have become available since the study or that will become available over the next 20 years. Furthermore, neither study accounts for substantial efficiency savings available from retrofitting existing end-uses.

The *Powering the South* Clean Power Plan is based on slightly higher levels of efficiency savings being achieved in the South through more aggressive efficiency policies and through currently available efficiency measures that were not included in the Five Labs and CEF studies. *Powering the South* assumes that 60% of the current techno-economic potential is achieved by 2010 and 70% is achieved by 2020. It also includes additional efficiency potential available from residential solar water heaters, commercial building shell measures, and commercial office equipment.

The Industrial Sector
The forecast of the industrial sector end-use efficiency savings is based on the Long-Term Industrial Energy Forecast (LIEF) model developed at Argonne National Laboratory. This model was used to estimate industrial efficiency in the Five Labs and CEF studies, as well as several previous studies, including *Energy Innovations* and *America's Global Warming Solutions*.[42]

The LIEF model is based on fits to historic data on industrial energy investments and usage, using a variety of parameters, including energy prices, hurdle discount rates (which reflect the cost of money, capital constraints, and various market barriers) and capital recovery period (together reflected in capital recovery factors), and the implementation rate for efficiency measures. These fits result in a different relationship (e.g., elasticity) between these factors for both electricity and fossil fuel use for each industry analyzed. The industry specification broadly follows the two-digit standard industrial classification (SIC), but departs somewhat by groupings into energy-intensive, fast-growing, and general manufacturing. These are then re-aggregated to the usual SIC groupings and the totals summed up for each state.

The Clean Power Plan analysis includes a range of efficiency technologies that cut across process- or product-specific operations in the industrial sector, including improved motor systems, more-efficient heating and cooling technologies, better maintenance, greater process control, and increased feedstock recycling.

With the Clean Power Plan, the South's electricity consumers could save roughly 13% of electricity demand through efficiency measures by 2010, and 23% by 2020.

The LIEF model was applied to each state in the region, using that state's electricity prices, the electric intensity for each sector (based on national data per unit of economic activity), each sector's current economic activity (its contribution to the gross state product), and each sector's forecasted growth in the state. The hurdle discount rate of 27.8% was used in the Business-As-Usual Case projections for each state's industrial sector electricity demand. This rate was also used to benchmark the national industrial electricity demand to DOE's AEO projection. This resulted in a region-wide projection in agreement with AEO projections for the region.

To estimate the potential for electricity efficiency improvements, the industrial customer hurdle discount rate is reduced. The lower rate represents reduced market barriers, fewer capital constraints, and lower transaction costs as a consequence of aggressive policies to promote energy efficiency. The LIEF model is neutral on which policy mechanisms are used to achieve these savings or how they are implemented.

Summary of Efficiency Potential
Table 2.4 summarizes this study's efficiency savings estimates for the South, by customer sector. Under the Clean Power Plan, the South's electricity consumers could save roughly 13% of electricity demand through efficiency measures by 2010, and 23% by 2020. Average electricity demand would increase by 0.7% per year from 2000 to 2020, instead of 1.8% per year under the Business-As-Usual scenario. By 2020, efficiency savings will avoid the need for 236 Million MWh of generation—roughly equivalent to the output of 112 power plants at 300 MW each.

Implementing these energy efficiency measures is highly cost-effective. On average, the energy efficiency opportu-

Table 2.4 Summary of Efficiency Savings in the South Under the Clean Power Plan

	2010 Savings (percent)	2010 Savings (1000 MWh)	2020 Savings (percent)	2020 Savings (1000 MWh)
Residential	13.5	48,040	22.0	95,924
Commercial	13.6	36,443	22.9	72,770
Industrial	14.5	33,841	26.9	67,572
Total	**13.5**	**118,324**	**22.9**	**236,267**

nities in the Clean Power Plan cost 2.5¢ per kilowatt-hour (kWh). That is significantly less than the cost of generating, transmitting, and distributing electricity to consumers. By 2020, the proposed energy efficiency measures save $10.1 billion in power plant and distribution system costs in return for a $5.9-billion investment, as indicated in Figure 2.11. The result is $4.2 billion in net benefits, or savings of $1.69 for every $1.00 invested in energy efficiency. These savings will be directly enjoyed by electricity customers through lower electric bills. The totals here do not include the additional economic, societal, and environmental benefits of energy efficiency.

RENEWABLE GENERATION POTENTIAL IN THE SOUTH

Wind

The wind resource potential varies significantly throughout the study region. Figure 2.12 depicts the geographical distribution of this resource from DOE's *Wind Energy Resource Atlas of the United States*.[43] The map assigns areas a range of predicted average annual wind speeds. With today's wind technology, most utility-scale wind plants are being installed in class 4, 5, and 6 areas. Two improvements in the future will affect the potential for wind power in the South. First, the size of wind turbines or individual wind towers will continue to increase from the 1 MW sizes today to 1.5 MW and 2 MW (or greater) sizes. This will increase the wind power potential for any given area. Second, future wind turbines will be able to operate economically at lower average wind speeds, making class 3 wind areas also potential wind development sites. The windiest areas in the South are in the mountains of North Carolina, eastern Tennessee, and northern Georgia. There is also considerable off-shore wind potential, which is not fully depicted in this map.

On-shore wind energy projections for each state were developed starting from estimates of the windy land area in each resource class.[44] We assumed that only 20% of the

land in each class would be available for development, while the rest would be excluded because of inaccessibility, environmental concerns, or other constraints. Wind development was then based on our analysis of wind's economic potential in each state. We chose aggressive, yet reasonable and feasible economic cost targets. It was further assumed that 6 MW of wind capacity would be installed on each square kilometer of available land. For the 2001–10 period, only class 4, 5, and 6 sites were assumed to be developed. For 2010–20, class 3 sites areas were included.

To these on-shore totals we added projections of off-shore wind development. Off-shore wind speeds were estimated from analyses of satellite radar measurements.[45] According to these data, off-shore winds are exceptionally strong (class 6 or 7) off the North Carolina and South Carolina coasts, but even off the coasts of Georgia and Florida class 5 and better winds may be found at the height of off-shore wind turbines (65–100 meters). Several off-shore wind projects have been successfully developed in Europe, and off-shore projects have recently been proposed in the United States as well.
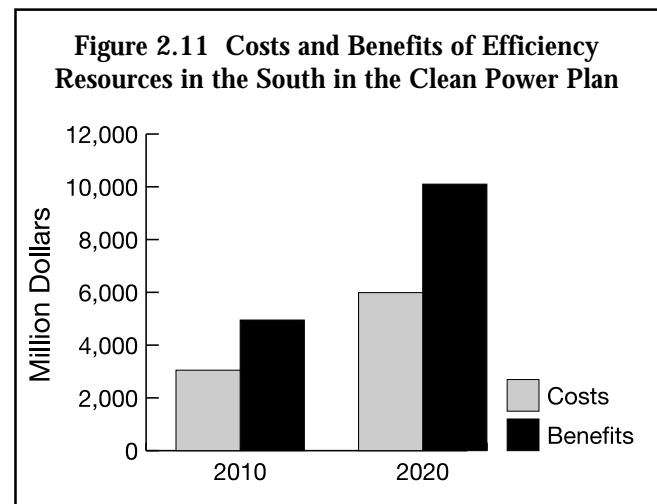
Figure 2.11 Costs and Benefits of Efficiency Resources in the South in the Clean Power Plan

Figure 2.12. Wind Resource Map of the United States

UNITED STATES ANNUAL AVERAGE WIND POWER
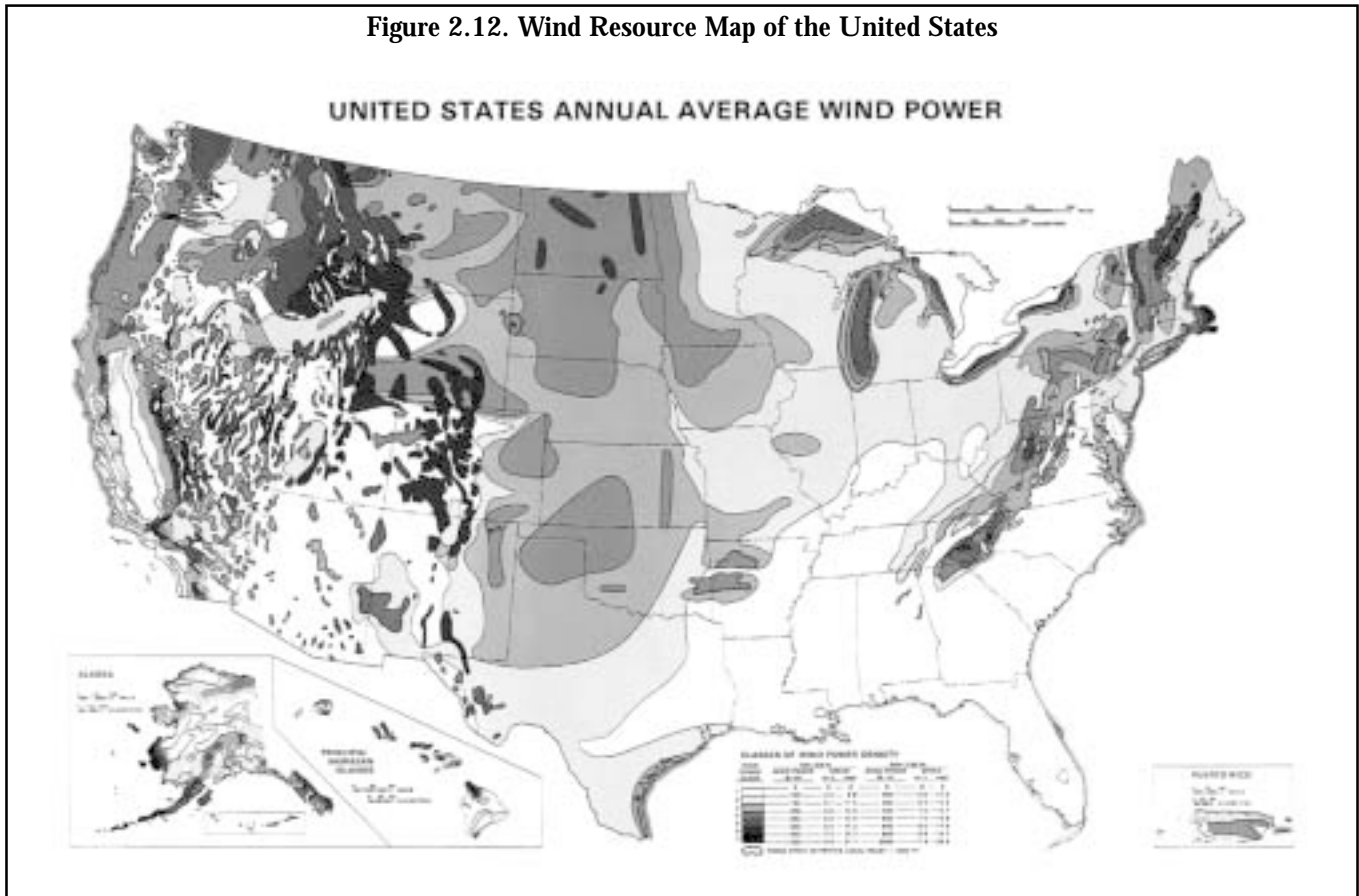
The estimated costs and performance of wind power plants were based on recent industry experience and projections of current trends. Capital costs are projected to decline from around $1,000 per kilowatt (kW) today to $810/kW in 2010 and $660/kW in 2020, mainly thanks to economies of scale in production of turbines. Capacity factors (the average plant output per unit of capacity) are projected to increase with improvements in turbine efficiency as well as with taller towers that enable turbines to tap stronger winds. However, the combined capacity factor of all on-shore wind plants is projected to decline slightly after 2010 as poorer-quality class 3 wind sites begin to be developed.

The capital costs of off-shore wind projects are assumed to be $700/kW higher than those of on-shore projects because of the extra costs of underwater cabling and turbine foundations. Capacity factors for off-shore project will be substantially higher than for on-shore projects, however, because of the superior off-shore wind resource.

Table 2.5 shows the cost of wind power as well as other renewable energy technologies discussed in this section. Costs are levelized and provided in terms of cents per kWh in order to allow for comparison across the different types of resources. These unit costs might vary slightly by state—for instance, wind will cost slightly less in regions with greater wind resources. The assumptions and methodologies used in developing these costs are discussed in detail in Chapter 4.

Table 2.5 Unit Costs for New Resources in the South in the Clean Power Plan (cents/kWh)

Resource Type	2010	2020
Biomass Co-firing	4.02	3.74
Biomass CHP	3.31	3.76
Wind Onshore	3.65	3.27
Wind Offshore	4.84	4.01
Photovoltaics	21.2	16.3
Landfill Methane	3.85	3.85
Average Renewables	**3.82**	**3.77**

Biomass

Estimates of the amount of each type of biomass that would be available at different prices were taken from research by the Oak Ridge National Laboratory (ORNL) and the Antares Group, a research firm.[46] The same organizations provide biomass resource estimates for the National Energy Modeling System (NEMS) used by the Energy Information Administration to prepare the *Annual Energy Outlook*. The ORNL data encompassed energy crops and agricultural residues. The Antares Group data focused on other biomass residues, including urban wood waste and mill residues.

Using these data, a combined cost-supply curve for biomass was developed for each state. The Clean Power Plan was then assumed to include a level of biomass generation resources that is both aggressive and feasible.

This study assumes that three types of biomass feedstocks are available for electricity generation: mill and urban wood wastes, dedicated energy crops, and agricultural residues.

■ Mill and urban wood wastes include primary mill residues, yard trimmings, and construction wastes.

■ Dedicated energy crops include herbaceous crops such as switchgrass. Currently, dedicated energy crops are not produced in the United States but could be if they were sold at a price that ensured the producer a sufficient profit. The ORNL POLYSYS model was used to estimate the quantities of energy crops that could be produced at various energy crop prices. POLYSYS is an agricultural sector model that includes all major agricultural crops (wheat, corn, soybeans, cotton, rice, grain sorghum, barley, oats, alfalfa, other hay crops); a livestock sector; and food, feed, industrial, and export demand functions.

■ Agricultural residues include the residual matter that can be gathered from existing farms without affecting crop production. The ORNL analysis of agricultural residues was limited to the two most important sources of feedstock in the South: corn stover and wheat straw. (Although many acres in the South are dedicated to soybean and tobacco production, these products produce little or no residues of significance to energy production.) The amount of corn stover and wheat straw theoretically available in each state was estimated by first calculating the total quantities of residues produced and then calculating the amount that could be collected without harming soil quality and erosion control. The estimated prices of corn stover and wheat straw include the cost of collecting the residues, a premium paid to farmers to encourage participation, and transportation costs.[47]

The vast majority (82%) of the biomass resources in this study are from energy crops. Most of the remainder (17%) are from mill and urban wood wastes. Agricultural residues contribute only 1% to the total biomass feedstocks.

> **This study assumes that three types of biomass feedstocks are available for electricity generation: mill and urban wood wastes, dedicated energy crops, and agricultural residues.**

This study explicitly limits the biomass feedstock potential to mitigate environmental impacts. In particular, energy crops are limited to perennial species such as switchgrass that minimize erosion; wood wastes are limited to only "clean" wood waste that contains no wood preservatives, paint, or other contaminants; agricultural residue removal is limited, to minimize soil erosion; and forest residues are entirely excluded.

Furthermore, the same strict pollutant emissions limits were assumed for biomass-fueled plants as for conventional power plants. Sustainably produced biomass provides significant environmental advantages because it generates no net CO_2. In some cases, however, the assumptions that assure sustainability may require specific regulations to ensure compliance.

Biomass Co-Firing. For biomass co-firing potential, this study assumes that all coal units that have not been retired and with capacity above 100 MW would use biomass fuel to co-fire 5% of their generation by 2010 and 10% by 2020. In practice, coal plants can use biomass to co-fire 15% or more of their generation. This study's estimates are based on the assumption that some coal units will not co-fire at all, while others will co-fire at 15% or more, and that the region-wide average will thus be 5% and 10%.

The potential for co-firing is large in the South because of its many coal-fired power plants. Counting only newer and larger coal plants that are likely candidates for co-firing (because they tend to run more often, allowing quicker recovery of an investment in conversion), there are 150 coal plants with a total capacity of 51,020 MW that could be adapted to co-fire biomass. Assuming an average co-firing fraction of 10%, that equates to a potential of 5,102 MW, representing a feedstock demand of around 20 million dry tons of biomass per year.

Biomass Combined Heat and Power. Because the pulp and paper industry produces large quantities of biomass waste each year, it has traditionally been the industrial sector with the highest rate of biomass fuel use. Installed CHP capacity in the pulp and paper industry currently accounts for about a third of all CHP capacity in the region. Most of these plants burn some combination of fossil fuels (generally coal in older CHP plants and gas in the newer ones) and biomass. This study assumes that biomass provides about 60% of the fuel consumed at CHP facilities in the pulp and paper industry.

Biomass CHP in the pulp and paper industry represents the vast majority of the region's current biomass use for electric generation. Potential exists in the region for both increased usage of biomass CHP and replacement of existing CHP systems with modern, more-efficient systems that can provide additional electric output for onsite usage or for exports to the grid.

Projections of biomass-based CHP use in the Clean Power Plan are based on national process steam load and energy projections in the pulp and paper industries. This study assumes that the national pulp and paper industry mix of 40% steam-only and 60% CHP holds for each state. The study further assumes that existing steam-only facilities at an average 70% efficiency would be switched to CHP at 75% efficiency with a 40:60 steam-electric ratio. This analysis assumes that 25% of the existing steam-only plants are converted to CHP in this manner by 2010, and twice that share by 2020.

As for facilities that already co-generate electricity, this study assumes that existing co-generation facilities with the 70% average efficiency and just 17% electric output are replaced by units with 75% overall efficiency and 37% electric output. Half are assumed to make this conversion by 2010, and the remaining half converting by 2020.

Landfill Methane. Estimates of landfill methane potential were obtained from inputs to the NEMS model used to produce the EIA's Annual Energy Outlook.

Animal Manure Gasification. Estimates of energy production potential from farm animal wastes were not included in the *Powering the South* model. However, the following table shows that potentially between 320 MW and 840 MW of peaking capacity could result from use of all current hog, chicken, and turkey manure from the six-state region for energy generation, depending on the overall efficiency of the conversion process (see Table 2.6). Development of

these levels of capacity could result in generation of between approximately one million MWh and 2.5 million MWh of electricity annually. Regional hog and turkey manure resources are based primarily in North Carolina (with 90% of the region's hogs and 80% of the region's turkeys), while chicken litter resources are spread more evenly throughout the region, with Georgia holding the largest share (40%) of the region's chickens. Depending on when and if these resources were developed fully and what overall conversion efficiencies were achieved, the use of farm animal manure for energy production could potentially increase renewable energy generation in the region by one to seven percent.

Solar Photovoltaics

The South's solar resource is virtually unlimited. In theory, solar power systems or solar power plants covering just 0.1% of the region's land area could generate as much energy as thirty-five 1,000 MW power plants. Solar energy is presently more expensive than other energy resources, however, both renewable and fossil, and this is the main constraint on its use.

Since the emphasis of this study is power generation, we focused on solar PV systems, which generate electricity directly from sunlight. However, other solar technologies, including solar water and space heating, are also available and with appropriate policies could find wider use in the future. (The efficiency analysis in this study includes some electricity demand reductions available from solar hot water heaters.) Current and future PV system costs were estimated based on industry and government sources.[48] We then made projections of feasible PV system deployments by 2010 and 2020 by comparing the estimated PV cost and availability with those of other resources. The majority of PV systems are expected to be installed in Florida, which has limited on-shore wind and biomass resources but an excellent solar resource. This study assumed an aggressive but feasible level of regional market growth: 33% per year from 2010 to 2020, compared with a global industry growth rate of 20%.

Because of the relatively low amount of direct normal solar radiation available in some parts of the South, this study considers only flat-plate systems. Furthermore, in the interest of allowing for the widest possible variety of PV applications, the output of fixed flat-plate systems suitable for a variety of rooftop mountings was modeled.

Finally, the study considers only grid-connected PV systems. As noted, off-grid applications are the most promising

Table 2.6 Animal Manure Capacity and Generation Potential in the South

Animal	Head	Energy Content (BTU/head/day)		Energy Production (MMBTU/day)		Conversion efficiency	Peak Capacity (MW @ 8hr/day)		Annual Production (1000 MWh/yr)	
	(1000)	Gross	Net	Gross	Net*		Gross	Net	Gross	Net
Hog	10,805	2300	1500	24,852	16,208	50%	455	297	1,329	867
						40%	364	238	1,063	694
						30%	273	178	798	520
Chicken	75,787	180	110	13,642	8,337	50%	250	153	730	446
						40%	200	122	584	357
						30%	150	92	438	268
Turkey**	54,075	140	85	7,543	4,610	50%	138	84	403	247
						40%	111	68	323	197
						30%	83	51	242	148
All	High efficiency					50%	**843**	534	**2,462**	1,559
	Medium efficiency					40%	675	427	1,970	1,248
	Low Efficiency					30%	506	**320**	1,477	**936**

*   Net BTU production is based on an assumed use of 35% of gross energy to operate the digester.

** Turkey waste is assumed to have the same energy content per dry pound as chicken waste, but BTU/head is reduced because turkeys produce 31 lbs/waste/year while chickens excrete 40 lbs/waste/year.

Data Sources: Alabama Agricultural Statistics Service <www.aces.edu/department/nass>; North Carolina Department of Agriculture & Consumer Services <www.ncagr.com/stats>; U.S. Department of Agriculture (USDA), National Agricultural Statistics Service <www.usda.gov/nass>; USDA Economics and Statistics System <http://usda.mannlib.cornell.edu>. All viewed November 21, 2001.

market in the near term, but to displace substantial amounts of fossil fuels, PV must begin to penetrate the grid-connected market. Initial deployments of grid-connected systems will be of intermediate size (10–100 kW) and designed to provide support to the grid in areas of heavy peak summertime loads. This could include rooftop systems on buildings in cities as well as systems located near heavily loaded electrical substations. As the market for PV expands and costs decline, residential rooftop PV systems will become more attractive and more important in the energy mix.

MODELING METHODOLOGY

THE PROSYM MODEL

The electric power system in the South was simulated using the PROSYM model. PROSYM is a chronological model that represents the operation of more than 1,200 individual generating units in the South to serve customer electricity demand on an hourly basis. As a general matter, the units with lower operating costs have priority in the dispatch over higher cost units, so that the total cost of operating the system is minimized. The model also recognizes generator operating constraints such as minimum down time and maximum ramp rates as well as transmission constraints between each of the individual "transmission areas" in the study region. In PROSYM, the electric industry is divided into a number of interlinked transmission areas, which correspond to the utilities' transmission capabilities and geographic boundaries; there are 21 transmission areas in the six-state region used in this analysis.

The years 2010 and 2020 were used to perform simulations to provide two snapshots of the way that the electric industry in the South is likely to evolve over this period. These two years were simulated in both a Business-As-Usual Case and a Clean Power Plan. A simulation of 2000 was also performed as a benchmark of this study's assumptions.

The PROSYM model was used to analyze two North American Electric Reliability Council (NERC) electricity regions: the Southeastern Electric Reliability Council (SERC) and the Florida Reliability Coordinating Council (FRCC). The FRCC includes the majority of Florida, but no other states. SERC includes the remainder of Florida plus the other five

states in this study region. SERC also includes portions of Mississippi and Virginia. While these two adjoining states were included in the modeling analysis, the results from these states were removed from the results presented in this report.

State-by-state modeling also requires allocating the electricity load and generation of the NERC regions to the six southeastern states of interest. Electricity generation, as well as associated costs and emissions, is allocated to states based on the physical location of power plants. Thus a plant's generation and impacts are assigned to the state where it is sited, even if its output crosses state boundaries. Electricity demand is allocated based on each state's historic fraction of demand in the NERC regions and utility transmission areas.

It is useful to note that most states show a difference between electricity demand and electricity generation. Some states will be net exporters, where electricity generation exceeds demand; others will be net importers.

THE BUSINESS-AS-USUAL CASE

The Business-As-Usual Case assumptions were based primarily on DOE's AEO 2001, in order to represent a likely future based on widely accepted forecasts. For example, the Business-As-Usual Case PROSYM inputs were set to match AEO 2001 projections of fossil fuel prices and electricity demand in SERC and FRCC.

Existing Coal Plants

In the Business-As-Usual Case, a small amount of existing coal generation is retired. It was assumed that by 2010 all coal plants that were installed before 1950 (that is, those over 60 years old) are retired. This includes 20 units, equal to 940 MW of capacity—roughly 2% of the existing coal fleet in the South. There are no additional coal retirements assumed between 2010 and 2020. This is roughly consistent with AEO 2001, and appears to be consistent with the way that coal plant owners will view the economics of retirement under business-as-usual conditions. That is, in the absence of explicit policies to the contrary (such as a carbon or multipollutant reduction policy), most of the existing fleet of coal plants is expected to operate through the study period.

Existing Nuclear Plants

We assume that several nuclear units are retired, based on AEO 2001. That study includes an economic analysis of each nuclear unit once it becomes 30 years old, and every 10 years thereafter. It assumes that uneconomical nuclear

units are retired, while economical units continue to operate with extended operating licenses. According to AEO 2001, there are no nuclear retirements in the South between 2000 and 2010, but between 2010 and 2020 eight units will be retired, which is equal to 4,812 MW, roughly 18% of the nuclear fleet in the region.

New Power Plants

In the Business-As-Usual Case, new power plants must be added in order to meet growing demand and replace retiring nuclear generation. DOE, like most industry forecasters today, assumes that natural gas power plants will be the primary source of new generation to meet future load growth. Combined-cycle natural gas power plants are much more efficient, cost less to build, and produce fewer air emissions than conventional coal power plants. The DOE forecast indicates that nearly all of the new generation in the region's states between 2000 and 2020 will be from natural gas power plants, in the form of combined cycle and combustion turbine technologies.

For this study, it was assumed that the only type of new power plants added to the region are natural gas combined cycle and natural gas combustion turbine units. Some of these new units are already planned and under construction, while the rest are generic units (without a specific owner or site). It was assumed that new gas units would be installed in order to maintain a 15% reserve margin in both 2010 and 2020 in each transmission area. It was also assumed that roughly 50% of this new capacity would be combustion turbine capacity and 50% would be combined-cycle capacity.

This study does not assume significant natural gas price spikes over time in either the Business-As-Usual or Clean Power Plan cases. Such spikes might cut the number of expected gas power plants and lead to more coal power plants, more renewables, or more energy efficiency. Table 2.7 summarizes the assumptions used in modeling the new gas power plants. These assumptions are based primarily on AEO 2001.

NO$_x$ Emission Controls

AEO 2001 does not assume that NO$_x$ emission controls will be installed to comply with the proposed EPA State Implementation Plan Rule. However, the Business-As-Usual Case does include these controls in order to represent a more realistic forecast. It was assumed that combustion controls are installed on all plants, and that post-combustion controls, primarily selective catalytic reduction technologies, are installed on the newer plants (post-1960).

Table 2.7 Cost and Operating Assumptions for New Gas Plants.

	New Gas: Combined Cycle	New Gas: Combustion Turbine
Capital Cost ($/kW):		
2010	553	444
2020	479	360
Heat Rate (Btu/kWh):		
2010	6,927	9,133
2020	6,350	8,000
Fuel Price ($/MMBtu)		
2010	3.2	3.2
2020	3.8	3.8
Fixed O&M ($/kW-yr)	14.12	8.94
Variable O&M ($/MWh)	0.51	0.10
Typical Size (MW)	400	120
SO_2 Emission Rate (lb/MMBtu)	0.0	0.0
NO_X Emission Rate (lb/MMBtu)	0.02	0.80
CO_2 Emission Rate (lb/MMBtu)	117.2	117.2
Capital Recovery Factor	12.9%	14.7%

Note: all costs are in constant 2000 dollars.

Plants in Florida are not assumed to have these NO_X controls installed, because Florida is not subject to the proposed SIP Rule.

THE CLEAN POWER PLAN

As noted earlier, the Clean Power Plan includes four major changes from the Business-As-Usual Case:

■ Aggressive energy efficiency measures are implemented,

■ Additional non-hydroelectric renewable resources are installed,

■ Fewer new natural gas facilities are installed as a result of lower electricity demand and increased renewable resources, and

■ Some older coal plants are retired early.

The energy efficiency measures and renewable resources assumed in the Clean Power Plan are described in the preceding section. The new natural gas units are installed in the Clean Power Plan to maintain a 15% reserve margin, consistent with the approach used in the Business-As-Usual Case.

Coal Plant Retirements

The additional coal plant retirements are assumed to be due to a targeted CO_2 policy. It was assumed that by 2010 all coal plants that were installed before 1960 (that is, over 50 years old) are retired. Relative to the Business-As-Usual Case, this means that retirements include those units installed between 1950 and 1959. This includes 108 units equal to 11,566 MW of capacity—18% of the existing coal fleet in the South. These older coal units were chosen for retirement because they tend to be the least-efficient, most expensive units with the highest level of CO_2 emissions per MWh of generation. There are at least three CO_2 policies that could lead to the coal retirements assumed in the Clean Power Plan: multipollutant regulations that include CO_2, a CO_2 cap-and-trade policy (similar to SO_2 and NO_X systems in place today), or some form of forced early retirement.

As in the Business-As-Usual case, the Clean Power Plan assumes that there are no additional coal retirements between 2010 and 2020. While there might be coal retirements during this period, they have not been included based on the assumption that there will be some form of CO_2 policy in place by 2010 and that the worst plants will retire early while others might be upgraded to comply with the regulations and will be less likely to retire afterwards.

Nuclear Plant Retirements

We assume that nuclear plants will retire on the same schedule as in the Business-As-Usual Case. Consequently, the nuclear capacity and generation are essentially the same in both cases, and therefore the environmental and cost impacts of the Clean Power Plan are not affected by the nuclear plants in the South.

Calculation of Cost Impacts

Our model calculates all of the "going-forward" costs (that is, costs to be incurred in the future) associated with the production of electricity from 2000 through 2020. Included in this category are the costs to build new power plants, the fuel and O&M costs associated with running those plants, the costs of installing emission control costs and purchasing emission allowances, and the costs of any transmission and distribution upgrades that are necessary. The going-forward costs also include the costs of implementing efficiency initiatives, including administration costs, utility costs, and customer costs. The difference in going-forward costs between the Business-As-Usual Case and the Clean Power Plan indicates the additional costs (or savings) associated with the Clean Power Plan.

Going-forward costs do not represent the total cost of providing electricity. The total cost also includes "embedded" costs that are necessary to recover past expenditures. The price of electricity is based on total costs, in order to allow utilities to recover both embedded costs and going-forward costs.

We estimate the impact on total electricity system costs of the Clean Power Plan by making a simplifying assumption about embedded costs. First, embedded costs in 2000 are estimated as the difference between 2000 total costs and 2000 going-forward costs. Then it is assumed that embedded costs will decline slightly from 2000 through 2020. Embedded costs will be the same in the Business-As-Usual

Case and the Clean Power Case, by definition. Finally, the estimated embedded costs are added to the going-forward costs from the model to determine total costs in 2010 and 2020. The percentage difference in total costs between the Business-As-Usual Case and the Clean Power Plan indicates the impact on total costs of the Clean Power Plan.

The total costs include expenditures to reflect distribution system upgrades that will be necessary to meet load growth over the next 20 years. It is assumed that distribution upgrades will cost on average $500/kW ($64/kW-year) to cover the additional peak load over the study period. This rate is roughly half of the rate that U.S. electric utilities spent on transmission and distribution upgrades from 1979 through 1998. (Distribution costs were roughly 75% of transmission and distribution costs over this period; a lower distribution cost was chosen in order to be conservative.) These distribution upgrade costs are included in both the Business-As-Usual Case and the Clean Power Plan.

However, this study assumes that under the Clean Power Plan there will be less need to invest in distribution upgrades as a result of the energy efficiency savings. The savings estimate is conservative. It is assumed that the distribution upgrade costs will be 20% less in the Clean Power Plan than in the Business-As-Usual Case. This is likely to be an underestimate of the distribution costs avoided by energy efficiency measures. Distributed generation technologies, such as microturbines, fuel cells, PVs, and wind clusters, might result in additional avoided distribution costs.

CHAPTER 3. RECOMMENDATIONS OF THE CLEAN POWER PLAN

CONTENTS

The South has tremendous opportunities to realize the environmental and economic benefits of the Clean Power Plan by using policy and market-based measures at the federal, state, and local level. This chapter outlines these opportunities as they relate to energy efficiency and renewable energy.

POLICIES TO ADVANCE ENERGY EFFICIENCY

As the results of the Clean Energy Plan show, energy efficiency will save money, improve the environment, and eliminate the need for at least 112 fossil fuel plants between now and 2020.

CREATING AN ENERGY EFFICIENCY FUND

Each state should create a Public Benefits Fund (PBF) that supports expanded markets for energy-efficient products and services. The fund is based on a small surcharge of 0.2¢ per kilowatt-hour (kWh) on electricity delivered to customers—that is, a charge per kilowatt-hour that shows up on a customer's electricity bill, just as other utility charges do. The surcharge would cover half of the investment costs for energy efficiency up to 2010.[49] If the fund is adopted by the state public utility regulators, it would apply to customers in territories originally served by investor-owned utilities. Funds passed by the state legislature may also include territories served by rural electric co-operatives and municipal utilities.

As of August 2001, 14 states had already established $3.5 billion in PBF's for efficiency, as well as renewables and low-income energy support, across the United States.[50]

The fund should leverage private funds on at least a 2:1 ratio, so that most participants benefiting directly from it (homeowners, businesses, and homebuilders, for

example) all contribute financially to their own energy efficiency efforts.

A third-party, independent, highly capable administrator should manage the fund. The administrator can be a not-for-profit organization, a foundation, or an appropriate public agency. A board including environmental and consumer organization representatives, state energy officials, and energy efficiency industry representatives should oversee the Energy Efficiency Administrator.

Third-party administrators avoid the conflicting incentives that utilities and power generators face. They can consider the successful development and implementation of aggressive efficiency programs to be the central mission and overriding business objective. Although some utilities have implemented energy efficiency programs in the past, financial incentives for reducing energy consumption through sufficient energy efficiency measures are currently lacking. In fact, many utilities still have a strong financial incentive to maximize electricity sales at almost all times other than peak.

That is why, for example, Wisconsin is transferring the management of energy efficiency and renewable initiatives from the utilities to public agencies and organizations. The Vermont Public Service Board also recently approved the creation of an Energy Efficiency Utility that would provide uniform energy efficiency programs throughout the state, using a single delivery mechanism.

The Public Benefits Fund can support many of the efforts outlined here.

PROMOTING EDUCATION AND MARKET TRANSFORMATION

State legislatures and utilities should channel funds toward enabling consumers to buy and suppliers to sell energy-efficient products and services. One of the primary barriers to energy efficiency is lack of information among both consumers and producers.

For example, homeowners looking for an affordable purchase may choose a home with low "up-front" costs, but with hidden high running costs due to energy-inefficient features—uninsulated walls, windows that are not properly sealed, poor natural lighting, and inefficient washers and dryers, among other features.

And homebuilders may be uninterested in supplying energy-efficient homes because they do not believe consumers value efficiency, because it is complicated to work with buildings trades and contractors to design efficient homes, or because efficient homes are new products whose economics and technical features can initially elicit confusion from buildings codes inspectors and realtors.

Educating both consumers and suppliers is a daunting task that, so far, has not attracted private capital alone. For consumers, public funds are required to educate consumers and producers about the economic benefits of energy efficiency, existing products and services, and financial options that support efficiency, such as federal Energy Star mortgages that roll efficiency features of a home into a low-interest financing package.

For suppliers, funds are required to educate the different parts of an industry's value-chain (such as architects, contractors, building code inspectors, and realtors within the housing industry) about best practices and about case studies featuring energy efficiency.

The building industry in the South should support education, training, and stronger certification and testing programs from members of the buildings trades. For buildings, the focus should be on duct sealing, HVAC (heating, ventilation, and air conditioning) installation and maintenance, insulation, and house sealing—all areas with large opportunities for energy use reductions.

State energy offices and state industrial and agricultural extensions should invest more in educating industries on near- and medium-term opportunities to cut energy use and improve performance. A number of studies clearly show that better technologies and practices provide multiple benefits to firms.[51] State agencies should provide relevant information specific to sectors (metals, textiles, semiconductors, and so on) on best practices and technologies, as well as financial incentives and information on possible suppliers and designers.

Federal agencies such as the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Energy should expand their education efforts in the South. Both agencies should expand the Energy Star buildings program to include a greater emphasis on training builders and contractors in the full range of efficiency technologies and practices available.

REWARDING EFFICIENCY THROUGH TAX INCENTIVES

State governments should support tax incentives that reduce the financial barriers that many customers face when purchasing equipment, as well as stimulate the develop-

ment of advanced technologies that have not yet reached commercialization. To be effective, incentives need to have several qualities:

■ Tax incentives should be big enough to influence the decisions of residential and commercial customers.

■ Tax incentives should complement other efforts such as the federal Energy Star program and state market transformation efforts.

■ Tax incentives should target opportunities that have a high potential market in the South, have some private-sector interest, and are cost-effective once they are adopted widely.

TIGHTENING BUILDINGS CODES AND APPLIANCE STANDARDS

State governments should apply more-stringent energy efficiency standards, while state and local governments should apply more-stringent buildings codes throughout the South. Commercial lighting improvements, more energy-efficient windows, daylighting, and HVAC efficiency are some of the most cost-effective opportunities for better environmental performance in the South. Each of the southern states should evaluate its current efficiency standards and building codes, upgrade outdated codes and standards, and establish monitoring and enforcement practices to ensure that revised standards and codes are implemented.

States should coordinate their efforts to provide regional consistency, which is essential to enable the mass production of energy-efficient products and services rather than products custom-made to meet the requirements of each state.

Efficiency standards are essential for new appliances and other electricity-consuming equipment bought on a mass basis. Ratcheting up the efficiency of refrigerators and air conditioners, for example, can produce huge overall energy savings. Similarly, building code reforms that set minimum efficiency standards for the design and construction of new and renovated buildings target some of the biggest opportunities for energy savings.

A recent study estimated that the six states in this study can achieve electricity savings of roughly 7,700 megawatts (MW) of peak generation by 2010 and 23,000 MW by 2020 by updating the federal efficiency standards for seven key electricity end-uses: clothes washers, fluorescent ballasts, central air conditioning and heating pumps, water heaters,

transformers, commercial air conditioners and heat pumps, and commercial furnaces and boilers. Upgrading these efficiency standards would create a net economic savings of $3.6 billion in 2010 and $8.2 billion in 2020 for the six states.[52]

Efficiency standards and building codes directly transform the market for energy-efficient products, designs, and services. Over time, they can permanently remove certain inefficient products and practices from the market. They encourage all manufacturers, designers, architects, and builders equally and simultaneously. They also encourage all customers, not just those who are better informed, more motivated, or more concerned about energy consumption and environmental impacts. They create a technology pull on the market for more-efficient products, and they immediately overcome many of the market barriers to energy efficiency.

There are significant opportunities to improve existing efficiency standards and building codes in the South. While the federal government has already established efficiency standards for some appliances and products through the National Appliance Energy Conservation Act of 1987 (NAECA) and the 1992 Energy Policy Act, these standards can often become out-of-date as technologies improve.

Similarly, many states have efficiency-related building codes on the books, but most are behind the times. The Energy Policy Act requires all states to adopt at least a "good practice" commercial building code, and to consider upgrading their residential building code to meet or exceed the "good practice" code. Nevertheless, not all states have complied with the act's requirements and suggestions. Furthermore, these codes do not always incorporate the best efficiency practices, and often officials do not adequately monitor or enforce them.

Efficiency standards and codes are most effective when they cover a broad region, thus applying consistent requirements to manufacturers and easing the education and training of designers, builders, and building code officials. That is why it is preferable, and likely to be more cost-effective, for the southern states to coordinate their efforts. Still, individual states can adopt more aggressive standards and codes on their own. California's groundbreaking 1974 efficiency standards paved the way for other states to adopt similar requirements, and eventually for today's national standards.

Efficiency standards and building codes are cost-effective means of achieving energy savings. They increase the economies of scale for producing efficiency measures by making efficient products and designs the norm. One study found that by 2015, the U.S. efficiency standards required by NAECA and the Energy Policy Act would reduce U.S. annual energy use by 4.3%, save energy consumers approximately $140 billion (in 1993 dollars), and eliminate the need for roughly 80,000 MW of new generation capacity. The benefit-cost ratio of these standards is more than 3:1— that is, $3 of energy savings are produced for every $1 spent on more-efficient measures. The energy savings from the federal efficiency standards are among the highest of any conservation policy pursued in the United States.[53]

REQUIRING BETTER UTILITY PLANNING

In regulated states, public utility regulators should require utilities to perform integrated resource planning (IRP) before deciding on new infrastructure investments such as power plants and power lines. Under IRP, utilities determine the most cost-effective source of new electricity service. For example, when utilities propose building a new power plant, they must determine whether that plant truly represents the cheapest, cleanest way to offer reliable power service. To do so, they must compare the plant to cutting demand elsewhere through energy efficiency, which can free up a similar amount of power as the plant would produce, plus save money on new power lines. While the IRP process makes financial and environmental sense, it has not been standard practice in the South or elsewhere.

MAKING GOVERNMENT MORE EFFICIENT

Federal, state and local government agencies should implement smart and sensible energy efficiency technologies and practices to save electricity. Government as a whole is the largest single consumer of energy and electricity in the nation. While the federal government is the largest power consumer overall, state governments appear to consume more power per resident in their respective states than the federal government, and therefore they may be prime candidates for more efficient operations.[54]

Public agency investments in energy efficiency can catalyze industry development in the South, including the early infrastructure for manufacturing, distributing, installing, and operating efficiency products. Government investments in energy efficiency can save taxpayers money by reducing energy bills and can produce environmental benefits that are enjoyed by all citizens but that tend to be undervalued in the electricity market.

ESTABLISHING DEMAND-ADJUSTED PRICING

In addition to the measures just described, public utility regulators should design power pricing so that it recognizes changes in supply and demand and therefore reflects the cost of supplying power for different times of the day and the year. Currently, many pricing schemes charge less for each kilowatt-hour consumed after a certain threshold, even though higher consumption can strain power supplies and require more power plants. Pricing does tend to charge more in the summer months, when demand strains supply, than in the winter months, when demand is lower.

Public utility regulators need to extend this concept from a seasonal basis to a daily and even hourly basis, so that customers who consume more energy pay the right price at the right time. Accurate prices will transmit accurate price signals. Once consumers receive these signals, they will have a greater incentive to make their daily operations more energy-efficient. Utilities will also face pressure to either increase supply or reduce demand. With these measures in place, efficiency should be the preferred option in many cases.

Public utility regulators should exempt low-income customers from demand-adjusted pricing. On average, low-income households consume less electricity than other households. At the same time, energy bills represent a larger portion of household income, making price increases particularly difficult for this customer class.[55]

POLICIES TO ADVANCE RENEWABLE ENERGY

Renewable energy can play a much more prominent role in the South. According to the Clean Power Plan, renewables can meet up to 10% of the South's power needs in 2020. State legislatures, public utility regulators, utilities, and local governments all have a role to play in advancing renewable energy in the six states covered in *Powering the South*. This section highlights the key policies required if renewable energy is to help clean the environment, contribute to a diversified energy portfolio, and meet energy needs effectively now and in the future.

ESTABLISHING THE RENEWABLE PORTFOLIO STANDARD

Each state in the South should pass a Renewable Portfolio Standard (RPS) that requires all retail electricity suppliers to include renewable energy as a specified portion of the overall power mix. Legislators or public utility regulators should require private retail power suppliers to install renewables so that the region as a whole meets 4% of in-state power production in 2010 with renewable energy, moving

up to 10% in 2020. (Data on renewable energy potential in specific states, which serve as a basis for individual states' RPSs, are provided in Chapter 5.)

Suppliers covered by the RPS would trade renewable energy credits among themselves. Each credit would represent a unit of renewable energy generation. Suppliers that install and generate more renewable energy than they require can sell credits representing the "excess" renewable energy to those that do not meet their requirement. Thus a supplier in North Carolina who exceeds its requirement can sell excess credits to another supplier in that state who has not yet met its requirement.

The credit system would make the renewable energy market in the South flexible, fluid, and cost-effective, since development occurs where the resources are the best. The system would also require a tracking system to verify that the credits represent actual renewable energy production, thereby helping all states ensure compliance with their RPSs.

If the cost of the RPS is in question, a cost cap for credits can be established in each state. The cost cap must be high enough to allow for genuine competition among renewable energy developers. An analysis by the National Association of Regulatory Utility Commissioners mentions a price of 2.5¢ per kWh (the price difference between renewable power and the remaining mix of nonrenewable power) as a reasonable price cap, but each state must evaluate its renewable energy technology options to arrive at a reasonable cap. When credits exceed this price on the market, the state RPS administrator can offer regulated suppliers "proxy credits" at the capped price to regulated suppliers.[56]

If citizens and policymakers are concerned that their local suppliers will rely too much on buying credits from out-of-state suppliers rather than developing in-state renewable energy, the RPS policy can state that only the renewable energy projects that provide clear benefits to the state—be it through direct displacement of dirty power or clear financial benefits to in-state consumers due to resource diversity and price stability from fuel-free renewables—can qualify under the RPS. This will ensure that communities in all states will benefit from the environmental, energy, and economic development strengths of renewables. Explicit requirements for projects to be in the state may not pass constitutional scrutiny.[57]

So far, 11 states in the country—including those that have deregulated and others that have not—have adopted RPSs.

In Texas, the legislature has required that in-state suppliers develop 2,000 MW of renewable energy by 2009. The result has been a rush of wind power development—bringing jobs, tax revenues, and, most important, the foundation of a vibrant local clean energy industry that can contribute to environmental quality and resource diversity for years to come.

CREATING A RENEWABLE ENERGY FUND

Each state should create a Public Benefits Fund that supports renewable energy development. As with the fund on efficiency, this would be based on a small surcharge of 0.2¢ per kWh on electricity delivered to customers. The purpose of the fund is to channel public support to financing for specific renewable energy projects and programs.

The fund is a complement to the renewable portfolio standard since, unlike the RPS, the fund:

■ Supports renewable energy technologies such as solar photovoltaics (PV) that would not prevail under an RPS but that are close to commercialization, require additional development, and face barriers due to their location close to the user;

■ Leverages private investment for renewable energy development;

■ Supports essential efforts such as consumer education and supplier education (such as training installers of solar PV, farmers supplying biomass to power plants, or farmers who host wind turbines on their property); and

■ Targets technologies that have significant long-term potential for particular states.

So far 14 states have established $3.5 billion in funds across the United States. These funds have contributed to almost 1,200 MW of new renewable energy capacity, with more to follow. (The funds also support energy efficiency and low-income energy programs, so the ratio of funds to megawatts is lower than it appears.) In California alone, the state "buydown" program supported by surcharges supported 549 MW of new renewable energy projects over a three-year period, covering solar PV, geothermal, biomass, and wind projects that were the few to offer stable prices during the state's recent energy crisis.[58]

As in the efficiency fund, a third-party, independent, and highly capable administrator should manage the renewable energy fund—a nonprofit organization, foundation, or ap-

propriate public agency. The board should include environmental and consumer organization members, state energy officials, and renewable energy industry representatives.

Third-party administrators must avoid overriding influence from utilities that might be resistant to innovative renewable energy technologies. Their central mission and main business objective should be the successful development and implementation of aggressive renewable energy programs.

The administrator must establish and follow prudent criteria that targets the most promising technologies for the market in ways the genuinely develop markets.

MAKING THE MARKET MORE FAIR FOR RENEWABLES WITH TAX INCENTIVES

Tax incentives are an important component to renewable energy development. Southern states should design tax policies that support both producers and consumers of renewable energy.

Tax Incentives for Producers

Producers of renewable energy face a higher tax burden than owners of gas-based power plants. The burden is primarily due to the fact that many renewables do not use fuel. Instead, taxes focusing on capital investments and neglecting fuel purchases translate into tax payments, particularly by wind and solar producers.[59] Fortunately, it is clear that certain tax policies can play a crucial role in attracting investment to renewable energy development.

State governments should pass a Production Tax Credit (PTC) for renewable energy. The federal production tax credit has helped catalyze affordable renewable energy development. Established by the Tax Policy Act of 1978, this provides 1.5¢ per kWh of power produced by renewable energy such as wind and certain forms of biomass. While the PTC alone has not spurred renewable energy, in concert with other policies it has attracted private investment. A good example of its impact is found in Texas, where the RPS has led to wind energy development, but the federal PTC that was to expire at the end of 2001 encouraged a "wind rush" that will help Texas meet its 2009 goals well before the deadline.

It is important for southern states to understand the timing and coverage of the federal PTC. Up to 2001, coverage did not include key technologies such as biomass co-firing or biomass energy sourced from urban wood waste screened for toxics. Southern governments can complement federal efforts by passing legislation that offers state production

tax credits for all renewable energy technologies with a promising future in their state. Further, state governments can time their PTCs to complement the federal PTC. For example, if a federal PTC expires at a given year, the state PTC can come into effect thereafter for technologies that qualify for the federal PTC. State officials should make sure the PTC lasts long enough to give producers time to site, design, and install projects without fear of elimination of tax credits. Short-term tax credits will have little value in catalyzing smart projects with community support.

Local governments can play an important role in spurring local economic development by reducing local property taxes to renewable energy producers. Some level of property tax should benefit the host community, but the tax burden for renewables should not exceed that for fossil fuel plants on a per-kWh basis.

Tax Incentives for Consumers

State governments should offer consumer tax credits for small-scale technologies such as solar PV. Small-scale renewables often are more akin to appliances than to large industrial operations. Credits should offer buyers incentives that reduce the "up-front" cost of the product. For example, block rebates (based on a dollar amount per installed watt of capacity) can go to the consumer upon purchase of a renewable energy system.

There should be little red tape for the consumer, who should be able to learn about the incentive, apply for it, roll it into the financing of the product, and realize its value with little hassle. Otherwise, the value of the incentive will be low— several states have witnessed severely undersubscribed incentive programs, partly due to lack of publicity, among other issues.

Finally, state legislatures can pass legislation featuring accelerated depreciation measures that reduce the tax burden of efficient biomass combined heat and power (CHP) systems in the short term, thereby making CHP economics more attractive to financiers. Biomass CHP systems require fuel storage and fuel handling facilities compared to CHP based on fossil fuels. They may also require unique boilers. Thus their short-term payback (that is, their ability to pay for themselves in two to four years) may be less attractive.

ADOPTING FAIR TRANSMISSION POLICIES

Renewable energy faces two challenges when it comes to transmission. First, renewables such as wind and solar are intermittent—they run when the resource is available. Second, renewables must go where the resource is, which is

not necessarily always where the demand for power is. This means that the distance between the renewable power plant (for example, wind turbines in the Blue Ridge mountains of North Carolina) and the consumer (residents of the Raleigh-Durham metropolitan area) can be longer than for other power plants.

Fortunately, apart from technical solutions there are a number of policies that can address these challenges:

States should ensure affordable transport of power across different transmission territories. A new regional transmission organization (RTO), or its regional equivalent, should require "postage stamp pricing" in the South. The six states covered by this study represent integrated electricity markets. Access to these markets through access to transmission lines should be available for one price. The practice of individual utilities levying fees on power traveling through their lines ("pancaking") inhibits commerce, particularly when power crosses two or more utility transmission territories. Texas's ERCOT transmission organization and the California Independent System Operator are two transmission organizations that have adopted postage stamp pricing.

Wind and solar producers should not be penalized for producing less power than expected, yet receive no reward for producing more power than expected, particularly during a period of high power demand. Accordingly, an RTO or equivalent authority should create "real-time balancing markets"—markets where power generators can buy and sell firm transmission capacity based on fluctuations in power.

New renewable energy facilities may face barriers to transmission access while existing plants get priority access. An RTO or equivalent authority should allow renewable energy operators to bid for congested transmission capacity alongside all other power plant operators.

An RTO or equivalent authority should guarantee that ancillary services for renewable energy are reasonable—that is, services that provide higher value to each unit of power generated by complementing the power with services that ensures its value to the electricity system should be priced fairly.

For these changes to take place, the RTO or equivalent authority must include representatives from renewable energy generators and environmental groups that support renewables. The authority should not be guided solely by owners of fossil fuel power plants or transmission lines, both of whom have in-terests that may be too narrow to consider the importance of expanded clean energy markets.

ENABLING CUSTOMERS TO BENEFIT FROM DISTRIBUTED POWER

Uniform Safety and Quality Standards

Public utility regulators must adopt uniform product and service standards for technologies such as solar photovoltaics. As with any industry, manufacturers and installers of small-scale, distributed power systems such as PVs must face consistent standards. Such standards must address safety concerns—for example, fire safety and safety for power line workers—as well as ensure quality so customers get what they reasonably expect.

Standards that differ from state to state make it very difficult for an industry to offer affordable, standard products and services. Instead, custom products and services will increase costs of projects, making distributed energy unnecessarily out of reach for many customers.

Fortunately, a number of nationally recognized standards have emerged to address these issues—for example, Underwriters Laboratories (UL) standard 1741 and Institute of Electrical and Electronic Engineers (IEEE) standard 929 on safe interconnection of a PV system to the grid, and National Electric Code (NEC) guidelines on fire safety.

All that is required is for public utility regulators to officially adopt these standards, and actively enforce adherence to them by utilities within the state. Texas has moved in this direction, so that the reasonable interests of the renewable energy supplier, customer, and utility are all met.

Standard and Simple Interconnection Procedures

In addition to the adoption of standards, public utility regulators should require that utilities develop and rely on simple procedures for reviewing and approving applications by customers to connect their distributed power systems to the grid. Several studies have shown that many utilities impose unnecessarily complicated, inefficient procedures that result in excess paperwork, needless lawyer fees, and frequent discouragement on the part of the homeowner or small business interested in innovative, workable technologies.[60] Standard procedures should efficiently address insurance, indemnification, and siting issues. The best way to do this is to merely require the applicant to adhere to the safety and quality standards discussed above. For example, Rhode Island has a simple, one-page application form that specifically refers to UL, IEEE, and NEC standards.

Net Metering

Public utility regulators should reward owners of grid-connected distributed power systems for supplying power to the grid, which can occur whenever the power system produces power above the owner's requirements. Net metering, a policy adopted by over 30 states, allows customers to subtract from their utility bill the power sent to the grid. Ideally, the utility should pay the customer the same rate as the customer pays the utility for power. Georgia is the first state in the region to adopt a form of net metering that includes simplified interconnection standards (see Box 3.1).

Public utility regulators should make sure that net metering limits do not unfairly exclude worthy candidates. States that have adopted net metering have established limits on the size of a qualifying distributed system and the total size of distributed power systems in the state that can qualify for net metering. As positive examples, Minnesota has passed legislation allowing systems up to 10 MW to quality for net metering. California recently lifted an overall cap of 50 MW that could qualify throughout the state for net metering, primarily to encourage more distributed generation as a way to address its power crisis.

Utility Charges

Finally, public utility regulators should ensure that utilities do not impose needless charges on owners of distributed power. Utilities frequently impose exit fees (fees for leaving the grid and therefore reallocating grid maintenance costs to the remaining grid-connected customers) and standby fees (fees that cover the cost to the utility to maintain back-up power in case the distributed power system fails). Minimizing such fees is essential to maximize the benefits of distributed power to both the owner and the entire grid.

TRANSFORMING THE PRIVATE MARKET

As with energy efficiency, state legislatures and utilities should channel funds toward enabling consumers to buy and suppliers to sell renewable energy products and services. Market transformation entails changing the behavior of consumers and producers in order to make clean energy technologies more mainstream in the private marketplace. Unlike the renewable portfolio standard, which requires installation of renewable energy by law, market transformation involves strategic actions that provide incentives and educate private actors to install renewable energy.

For renewables, market transformation is most relevant for distributed generation technologies such as solar and small wind. State governments, including state energy offices,

---

Box 3.1 Georgia's New Distributed Generation Policy

Georgia is the first state in the South to pass net metering legislation. The Cogeneration and Distributed Generation Act of 2001 allows owners of fuel cells, small wind systems, and PVs to connect to the grid and receive payment from the utility for access generation. The bill caps eligible systems at 10 kilowatts (kW) for residents, and 100 kW for commercial owners. In all of Georgia, all eligible systems combined cannot exceed 0.2% of the peak power supplied by in-state utilities.

Owners merely have to meet UL, IEEE, and NEC standards for safety and quality. They do not have to buy additional liability insurance. Owners can install a bi-directional meter that measures power flows in and out of their property, or they can connect directly to the grid and sell some of their power to it, rather than use a portion of it themselves.

The Georgia bill is not strictly a net metering bill. Instead, the utility will buy power from owners of distributed generation to sell as a green pricing product that others can purchase voluntarily at a small premium. Thus, the bill combines the concepts of net metering and green power.[61]

---

state agriculture agencies, state commerce agencies, and even business schools at state universities, should work with renewable energy suppliers to make renewables well-understood, mainstream products.

State governments should also create a Market Development Fund (MDF). The appropriate Fund Administrator within the government can select a private firm (including an industry consortium, public relations firms, or a combination) to implement the fund based on transparent performance criteria. The MDF could perform several essential market-building tasks, including:

■ Marketing products to relevant retail customer segments (such as farmers for solar or wind water pumping systems, and individual homeowners) as well as key suppliers, such as Home Depot, that have strong reach to retail consumers;

■ Assuring customers and vendors that renewable energy products are reliable by providing information on standards such as Underwriters Laboratories and by showing real-life, local examples of successful projects; and

■ Providing easy-to-understand information on funds and incentives that are available to consumers.

Ideally, an MDF can create Web sites and telephone hotlines that can help customers integrate rebate programs, tax credits, and net metering opportunities into their purchase of a renewable energy product. Renewable energy firms and advocates should integrate these informational resources within their own marketing efforts to ensure broad reach throughout the state.

Bringing Green Power Choices to All

The Clean Power Plan requires substantial public policies to advance renewable energy. Even with these policies in place, southern consumers should still have the option to support more renewable energy development voluntarily. Green power purchasing gives consumers this option, whether in a regulated electric system or a deregulated one.

All utilities should offer green power options to their consumers. The Tennessee Valley Authority (TVA) has led the South in green power offerings. Working with distribution utilities in Tennessee and Alabama, as of July 2001 TVA's program had attracted over 4,100 business and residential customers who want to do more for renewables. As a result, a new 2-MW wind farm, 11 new solar PV installations, and one new landfill gas power plant are now in place.[62] The TVA program is in essentially a regulated utility environment, showing that other utilities throughout the South can achieve the same success with or without deregulation.

For states such as Florida that are moving toward deregulation, state legislatures must craft market structures that allow for new competitors, rather than protecting the incumbent utility and squelching competition. In Pennsylvania, deregulation effectively encouraged customer switching. Now over 2% of all residential consumers have moved to green power providers. In contrast, California's deregulation effectively precluded new competition. The "default" price of electricity was set at the wholesale price, so that new retail competitors could not make a profit from their sales. While some green power marketers fared decently due to state financial incentives, the poor competitive market squandered a promising opportunity for burgeoning green power markets and consumer activism.

Any green power program in the South should meet Green-e standards at a minimum, and preferably exceed these standards by supporting as much new renewable energy as possible. For any green power effort to be meaningful, it must meet minimum standards for product content. Green power products should not mislabel fossil fuel or overly polluting technologies as "green." They must support new renewable energy installations, rather than sell power from existing plants only at a premium. The Green-e label is one program that establishes minimum standards for green power programs. These are minimum standards, however, and thus earnest green power efforts should exceed them primarily by including new renewable energy as a bigger portion of its supply portfolio.

POLLUTION CONTROL POLICIES

The electricity industry is a top source of air pollution in the South. The Clean Power Plan directly addresses this issue through pollution control policies.

Regulating Carbon Dioxide

State environmental agencies, even in concert with the federal Environmental Protection Agency, should regulate carbon dioxide (CO_2)—a proven greenhouse gas. Since power plants are responsible for over one-third of CO_2 emissions nationwide, any effective CO_2 policy will have to target power plants. In the South, each megawatt-hour of power generated by plants in the six-state region covered by *Powering the South* plus Virginia and Mississippi produces 1,441 pounds of CO_2, essentially equal to the national average.[63]

One way to set CO_2 limits is to place a total emissions cap on an entire region, allocate emissions allowances to individual pollution sources, and permit trading among sources. This system features flexibility when compared with percentage cuts required for all power plants. Under the "cap-and-trade" system, costs increase for higher polluting power plants relative to less polluting ones, thereby giving a fair competitive boost to cleaner plants.

Delaying limits to CO_2 in the face of increasingly robust predictions of climate change is dangerous for the South, the United States, and the world. Like other greenhouse gases, CO_2 will remain in the atmosphere long after it is released. The cumulative effect of greenhouse gases in the atmosphere requires immediate efforts to begin cutting emissions. The longer the wait, the steeper and more expensive the required emissions cuts.

Ending the Grandfathering of Coal Power Plants

State environmental agencies should eliminate unfair preferences for old coal power plants in current air regulations, to the point of closing many of these plants and opening the way for a modern fleet of power plants in the South. According to one study using EPA data, average emissions of sulfur dioxide and nitrogen oxide are higher for older

31

plants than for younger ones, with a remarkable pattern of consistency—plants built in the 1950s emit more than those built in the 1960s, plants built in the 1960s emit more than those built in the 1970s, and so on.[64] In the six-state region covered in this study, of the fossil fuel plants built up to 1996, more than half (53%) had begun operations on or before 1960, while more than two-thirds (69%) began on or before 1970.[65]

Under the current Clean Air Act, old, inefficient coal plants face far less stringent air pollution reduction requirements. Not only does this represent a subsidy to fossil fuel plants, but it also makes it difficult for states to bring in more-efficient plants that have lower air emissions.

The Clean Energy Plan includes efforts to retire old coal power plants in the South. Closure can take many forms:

■ Negotiated closures for individual power plants,

■ Tight caps on air pollutants based on output-based emissions standards, and

■ Distribution of emissions allowances under cap-and-trade programs through auctions rather than through "grandfathered" allowance distribution that again favors existing plants that are large sources of emissions.

SETTING OUTPUT-BASED EMISSIONS STANDARDS

When setting state-wide and regional pollution limits from power plants, state environmental agencies should base limits on output-based criteria rather than input-based criteria. Under past and current air pollution policies, regulators set emissions limits for power plants based on emissions per unit of heat input to the plant. Many analysts, however, believe that basing limits on emissions per unit of power generated from the power plant is more appropriate. Such a standard rewards more-efficient plants rather than compensating inefficiency by giving higher emissions limits to plants that use excessive amounts of coal.

The Generation Performance Standard (GPS) is a faithful application of the output-based standard. The GPS places a uniform emissions limit on power plants based on a region-wide ratio of emissions to power production (for example, tons of nitrogen oxide emissions released by power plants divided by the power generated by those same plants). Power plants that fall below this standard (that is, higher tons of nitrogen oxide per megawatt-hour of power generated) will either need to make their operations more efficient or pay for emissions credits earned by other power plants that exceed the standard. In effect, the GPS penalizes inefficient plants and rewards efficient ones, thereby protecting the environment, encouraging innovation, and moving the South to a more modern fleet of power plants.

ESTABLISHING ENVIRONMENTAL STANDARDS FOR DISTRIBUTED GENERATION

State legislatures should require state environmental agencies to establish stringent limits on air pollution from distributed generation. While some of the most well known examples of distributed generation—fuel cells, microturbines, and solar PV—are relatively clean sources of power, the most dominant form of distributed generation—diesel generators—is perhaps the dirtiest sources of power available. Thus policies to advance distributed generation will do little for the local environment if they are not coupled with emissions limits based on power output (that is, pounds of pollution per kWh).

Diesel generators nationwide released almost 300,00 tons of nitrogen oxide and over 13 million tons of CO_2 in 1996, equivalent to all the power plants in New York, New Jersey, and Pennsylvania.[66] Compounding this is the fact that generators run most often in the summer, when construction and back-up power runs the most, and also when the ground-level ozone bedevils metropolitan areas desperate to avoid federal penalties for summertime air violations. California recognized this problem when it passed legislation requiring emissions standards comparable to "best available technology" for "permitted central station power plants in California." A recent study showed that only wind, solar, and certain forms of fuel cells will meet this criterion.[67]

THE TVA IN THE CLEAN POWER PLAN

While many of the recommendations in *Powering the South* pinpoint public utility regulators and state legislatures, TVA is not answerable to these institutions. (See Box 3.2.) Rather, changes within TVA must come from either the three-person commission that runs the agency or from the U.S. Congress. Policies such as a renewable portfolio standard, integrated resource planning, and the system benefits charge can also come from Congress

Policies affecting environmental regulations—such as coal power plants, CO_2 controls, and output-based emissions standards—still can come from EPA and state environmental agencies.

In addition to the recommendations in other sections of this report, TVA should make two changes to its

---

Box 3.2 What is the TVA?

The Tennessee Valley Authority is a federal corporation that is the largest producer of power in the South. It owns almost 30,000 MW of power plants and serves a 80,000-mile region covering most of Tennessee plus parts of Alabama, Georgia, and North Carolina, as well as parts of Mississippi, Kentucky, and Virginia.

The U.S. Congress created the TVA in 1933 under the TVA Act. The act called for TVA to improve the standard of living of residents in the impoverished Tennessee Valley. Specific duties included rural electrification and improved navigation for commerce.

Building dams fit both responsibilities. By 1975, TVA had built 25 dams and now has 49 running. In the 1950s, however, the TVA began to build a multitude of coal plants, so much so that coal exceeded hydro as TVA's main electricity source by 1954. With demand still growing, TVA embarked on nuclear plant construction in the 1970s. Now coal represents 61% of TVA's power mix, with nuclear at 31% and hydro at merely 6%. Mainly due to its coal plants, TVA released 700,000 tons of sulfur dioxide to the atmosphere in 2000.[68]

TVA does not sell power directly to most consumers. Rather, it supplies wholesale power to 159 municipal utilities and rural cooperatives, which then distribute the power to their retail customers. TVA does contract directly with 62 large industrial and government customers.

Until 1959, TVA was funded by congressional appropriations. Then Congress amended the TVA Act to allow the corporation to sell bonds to finance its operations. TVA currently receives all its funding from revenues from power sales and bond proceeds. A three-person commission appointed by the President heads the TVA.

---

operations to open markets for renewable energy and energy efficiency:

■ TVA should eliminate burdens faced by renewable energy suppliers to connect their power plants into the TVA-run grid. Burdens include technical interconnection requirements, as well as complex power purchase agreements with TVA. Renewable energy suppliers do not have the extensive financial resources that traditional power plant firms have. Thus, simple and reasonable procedures that address safety and quality concerns and that reasonably address the financial interests of both parties while promoting clean energy in the South are warranted.

■ TVA should pass on rates to its distribution utilities that more accurately reflect supply and demand. If TVA delivers power during a time when demand is so high than expensive power plants must run, then wholesale prices should be high enough to send signals to customers to use energy more efficiently, thereby reducing overall costs and overall environmental impact. Of course, safeguards for low-income customers are necessary in this pricing system, as in others.

CHAPTER 4. TECHNOLOGY PRIMER

CONTENTS

ENERGY EFFICIENCY OPTIONS

Making energy-efficient technologies commonplace in industrial, commercial, and residential sectors is critical to the success of the Clean Power Plan. Reducing electricity loads through energy efficiency eliminates the need for 112 power plants by 2020.

Improving energy efficiency in these sectors also avoids significant capital costs by averting the need for new generation, and it directly reduces pollution and associated environmental impacts. According to numerous studies, the average cost of energy-efficient technology is below the cost of almost all new and conventional power generation technologies. For example, based on Electric Power Research Institute data, the Safe Energy Communication Council found that improvements in energy efficiency could replace at least 20% of the nation's electricity at a cost of 2.4¢ per kilowatt-hour (kWh).[69] It has also been reported that U.S. utilities spent an estimated $2.8 billion on demand-side efficiency measures in 1993, providing avoided power generation ("negawatts") at an average cost of 2.1¢/kWh—half the cost of power from the cheapest new power plants.[70]

This chapter provides details of the technical opportunities for energy efficiency in the industrial, commercial, and residential sectors.

INDUSTRIAL ENERGY EFFICIENCY

Many opportunities exist for improving energy efficiency of industrial processes. Replacement of existing components with more-efficient ones, adding efficiency-boosting controls to existing components, rethinking processes to eliminate steps, and improving maintenance and monitoring practices can all save energy, often with payback times of a few years or less. And efficiency improvements generally lead to productivity increases, resulting in energy savings with no capital outlay or drastically reduced payback times, and increased return on investment for the business.[71]

Combined Heat and Power

Aging fossil-fuel-based electrical generating plants in the United States are fairly inefficient, converting only about a third of the energy in the fuel to electricity and throwing the rest away as waste heat. For industrial processes where both electricity and heat (often in the form of steam) are required, capturing the waste heat for use increases overall system efficiencies dramatically. This combined heat and power (CHP), or cogeneration, while used in this country for many years, often still relies on outmoded technology. Upgrading existing CHP facilities to use more-efficient energy conversion and waste heat recovery technologies can improve system efficiencies even further, often to 90% of the useable energy or more.

Steam Distribution System Upgrades

Steam is crucial for many industrial processes, on-site power generation, and often building heat. Steam production uses the majority of fossil fuel burned directly by industry, and accounts for over $20 billion per year in U.S. manufacturing costs and over one-third of U.S. industrial carbon dioxide (CO_2) emissions.[72] Much of this steam is produced in aging, inefficient boilers or wasted through leaks.

Key ways to improve steam energy efficiency are by insulating steam lines, fixing steam leaks, and fixing malfunctioning steam traps, which when work properly allow condensate to drain off without steam loss. One DuPont manufacturing plant reduced total steam use by 12% and saved more than $1.5 million a year using these methods.[73] Steam heat can be shut off to unoccupied building areas, and a move to smaller decentralized gas-fired steam boilers can improve efficiency over centralized coal-fired boilers with extensive distribution networks by reducing line losses, allowing zoned steam control, and using cleaner and more-efficient burners. Similarly to steam, simple measures such as eliminating leaks and reducing air pressure can cut compressed air energy use by 30–60% while increasing airflow and improving productivity.

Improved Energy Recovery
Improved monitoring of wastewater temperatures cut the steam required for treatment processes. Heat recovery systems can recover heat from effluent liquids for use in various processes, improving total energy efficiency. Where cooling is required, high-temperature waste heat can also run absorption chillers (combined heat, power, and cooling, or CHPC).

Waste Recycling
Every product that comes out of a manufacturing plant holds what is termed "embodied energy," the energy used to extract the raw materials from the earth, to transport the materials to the factory, to refine the materials to usable form, and to purify, temper, and shape the materials for final use. For every scrap of industrial waste that is landfilled, this energy is lost, and even more energy is used to transport the waste to the landfill.

Overall manufacturing efficiencies can be improved, sometimes greatly, by recycling scrap materials at the manufacturing plant, as well as by introducing new methods of manufacture that reduce the formation of scrap in the first place. The aluminum industry provides probably the most well known example of reduced energy use through materials recycling. Vast amounts of electricity are required for smelting aluminum. Recycling of aluminum cans saves 95% of the energy needed to make aluminum from bauxite ore—the energy saved from recycling just one aluminum can will operate a computer for three hours.[74]

Motor and Drive System Improvements
Industrial motor systems represent the largest single end use of electricity in the United States—23% of electricity consumption. A 1998 study by Xenergy, Inc., found that business can

typically reduce energy use by 11–18% by using current energy-efficient drive motor technology, with simple payback times of three years or less.[75] A U.S. Department of Energy (DOE) study found that many motor system retrofits could reduce energy use by over 30% with 1.5-year payback times. Eliminating oversized motors, right-sizing motors so they run at or close to full load, and redesigning processes so no motors run at part load are all essential to reducing motor energy inefficiencies.

Many motors can be designed or retrofit with controls to vary their speed depending on load requirements. So-called variable-speed drives are particularly important for use with fans, as fan energy increases as the cube of the fan speed. As an example, a hospital in Australia installed variable-speed drives on its air handling units, which resulted in a 71% reduction in fan power requirements and a payback period of three months. In this case an investment of $120,00 (Australian dollars) yielded energy savings of $450,000 (Australian) per year. [76]

Process Control and Management
Microprocessors in combination with variable speed motor and drive controllers allow drives to maintain more accurate and uniform flow rates, improving product quality and productivity while decreasing energy use. While retrofit of individual motors and other components saves energy, the largest gains are to be made by rethinking and redesigning processes entirely. The elimination of one motor or a step from a process can save great amounts of energy, often with little capital cost and short payback times.

Energy Audits
Energy audits are an excellent low-cost method for identifying energy-related problems and opportunities for reducing energy usage and cost. (See Box 4.1.) Audits and energy assessments can specifically target the following:

■ Compressed air, dryers/heat recovery (such as humidity adjustments, more-efficient motors and drives);

■ Electric motors and drives (low-cost maintenance and capital replacement);

■ Boiler systems (burner tuning, oxygen trimming, economizer stacking, improved blowdown control, blowdown heat recovery);

■ Building envelopes (structural changes, energy system improvements, building simulation software for automation control);

■ Hood efficiency (efficiency in capturing emissions to minimize worker exposure, costs of operating hood fans, efficiency in concentrating fumes for further treatment);

■ Lighting systems (more-efficient lighting, lighting controls);

■ Steam systems (eliminating losses incurred before steam from the boiler delivers its energy to the desired end point); and

■ Utility analysis (energy balance and profile, load analysis).

They can also provide comprehensive assessments that include evaluation of facility waste streams for cost-saving opportunities.

Preventative Maintenance
Proper maintenance of equipment and systems is essential to maintain design energy efficiencies. Energy audits often turn up many simple, easily correctable flaws that are silently wasting energy. Identifying, correcting, and avoiding these flaws as part of a maintenance routine can save a company significant energy, money, and downtime, all at little or no capital cost. Preventative maintenance and monitoring of systems helps to keep all systems and components running at top efficiency.

Industry-Specific Opportunities
Steel, Cement, and Aluminum Industries. Energy use can be reduced through increased use of waste materials and recycling. In the steel industry, scrap preheating for electric arc furnaces, new casting technologies to reduce material and energy losses, and advanced smelting reduction technologies can all save energy. According to the DOE Clean Energy Future study, development of near net shape casting technologies may save up to 4 MBtu/ton steel and reduce production costs $20–40/ton. By 2020 smelt reduction may replace blast furnaces, reducing energy use by 20–30% in iron making as well as reducing emissions from coke ovens and ore agglomeration.[77]

Food, Paper, and Chemical Industries. Improvements in the generation, distribution, and use of steam offer great opportunity. In the pulp and paper industry, reduced bleaching and increased wastepaper recycling can lower energy use, while black liquor gasification can provide additional on-site energy. In the cement industry, modern pre-heater pre-calciner kilns can replace old wet-process clinker plants. According to the Clean Energy Future study, continued energy efficiency R&D may produce an efficient black li-

quor gasifier integrated with a combined cycle, making a kraft pulp mill a net electricity exporter and resulting in primary energy savings of up to 5 MBtu/ton air-dried pulp. If new drying processes such as condebelt and impulse drying are successfully developed, energy savings of up to 1.4 MBtu/ton paper may be realized in paper machines. [78]

COMMERCIAL ENERGY EFFICIENCY
Almost every component in a building can be improved to reduce energy use, from the building shell itself to mechanical systems to the office equipment that occupies it. The key to maximizing energy efficiency, whether considering new construction or retrofit applications, is to treat the building as a complete system in order to take advantage of synergies between different components. (See Box 4.2.)

Box 4.1 Energy Audit and Motor Systems Upgrade, Georgia

Georgia Tech's Industrial Assessment Center (IAC) provides energy, waste, and productivity assessments at no charge to small and mid-sized manufacturers. A team of Georgia Tech engineering faculty and students performs the assessment to help manufacturers maximize productivity as well as save energy. On average, recommendations from an assessment result in savings of more than 10% of annual utility costs.[79]

When the new owners of Blue Ridge Carpets in Ellijay wanted to improve and expand their operation, they turned to Georgia Tech for help. Field engineers provided a layout of the facility, materials requirement planning assistance and software demonstrations, and an IAC energy audit. Potential energy savings from the energy audit topped $121,000 annually, or 39% of the annual energy costs.

Energy specialists from Georgia Tech also assisted Blue Circle Aggregates, a Lithonia-based quarry operation. Implementing recommended motor system upgrades has cut the firm's annual energy consumption and peak demand by 6.2% and 16%, respectively, and resulted in a cost saving of $21,000 a year.

For more information, contact the Business and Industry Services office at Georgia Institute of Technology, Atlanta, GA 30322-0640, (888) 272-2104, fax (404) 894-1192, e-mail: <energy@edi.gatech.edu>, or visit the Web site at <www.industry.gatech.edu/energy>.

As an example, reducing a building's cooling load through use of solar control Glazings, daylighting, and efficient lighting allows the use of smaller, less costly heating, ventilation, and air conditioning (HVAC) systems. When these changes are used systematically, building energy use can be reduced 35–50% or more, with a three- to five-year simple payback, if not less.[80]

Because the top energy users in commercial buildings are lighting, space cooling, office equipment, water heating, and refrigeration, the largest gains will be found in these areas.

Lighting

Lighting efficiency upgrades can drastically reduce energy use while improving the quality and distribution of light, thus increasing worker productivity. The key is to take the end-user into account, to put the light where it needs to be and in the right amount.

Efficient upgrades include replacing incandescent light bulbs with compact fluorescents, replacing conventional T-12 fluorescent fixtures that have magnetic ballasts with efficient T-8 fixtures that have electronic ballasts, and installing lighting sensors and controls to turn off lights in unoccupied rooms and automatically dim lights to adjust to available sunlight levels.

Finally, the number of fixtures can often be reduced, as many offices are overlit. DOE instituted these changes in one of its large office buildings and reduced lighting electricity use by 60% while saving $400,000 per year in electricity costs.[81]

Space Cooling, Heating, and Ventilation

Space cooling, heating, air conditioning, and ventilation account for a significant portion of building energy requirements. Once efficient lighting, daylighting, and glazing reduces the cooling load, the HVAC system can be sized correctly to meet building needs. Yet oversized HVAC systems that waste energy are common.

An efficient office building not only reduces load, but load fluctuations allow for better matching of HVAC systems to actual loads, thereby reducing also energy use. Ventilation system fan motors can be downsized with more-efficient motors and retrofit with variable speed drives and microprocessor-based sensors and with process controls to further reduce energy use. Central chillers and water heaters can use the newest, most efficient technologies. Finally, air handling ducts need to be sealed against leaks to realize

the full efficiency gains from the other parts of the system. Upgrades such as these that improve comfort and air quality while reducing HVAC energy consumption 40% are now commonplace.[82]

Office Equipment

Office equipment—computers, fax machines, copy machines, telecommunications devices, and the like—are coming under increasing scrutiny for their energy use. Using the most efficient office machines not only saves electricity directly, it also reduces the amount of heat generated within the building, thereby reducing cooling energy requirements.

Also of concern is an effect called "phantom load" or "leaking electricity," which is electricity dissipated as heat when office machines and electronic devices are in standby mode. Standards are currently being promulgated to reduce these inefficiencies.

Finally, simple efforts such as turning off office machines when not in use, using power standby modes, and setting these modes correctly can all help reduce office energy use.

Daylighting

Because office buildings are generally used in the day, free lighting is available from the sun. Use of this light in building design is known as daylighting, and it relies on strategically placed windows, skylights, light shelves, and light pipes, as well as sophisticated computer radiance simulations to optimize daylighting while taking into account shadows and sun angles throughout the year. Because daylighting directly reduces the amount of lighting energy used, and thus heat generated by lights, it cuts air conditioning loads and energy use.

Just as important, daylighting can provide non-energy benefits to many businesses. For example, a department store in California found that replacing a quarter of its roof with a translucent tensile fabric to increase daylighting saw sales go up by 15% regardless of the merchandise. An insurance company saw productivity increase 16% due to daylighting, plus a 40% cut in energy consumption.[83]

Windows

The choice of windows can have a significant effect on building energy use. In heating-dominated climates, highly insulating windows that use low-emissivity coatings, inert gas fills such as argon, and insulating glazing spacers and frames can allow both the light and the heat from the sun to enter the building while insulating the interior from low

temperatures outside and reducing heating energy demands. Glazings can even be chosen to minimize energy use in climates that experience both high and low temperature extremes. Many advanced technologies currently under development, such as electrochromic, photochromic, and thermochromic glazings, will let users switch settings manually or automatically to adapt to given ambient conditions.

Building Shell

The building shell—the floor, walls, roof, and openings for windows and doors—should be insulated both to reduce temperature fluctuations for occupant comfort and to lower cooling and/or heating requirements. Adding insulation to walls, ceilings, and floors beyond building code requirements can result in significant energy savings when combined with other measures. Openings for windows, doors, and skylights should be of energy-efficient design, otherwise other building shell efficiency measures will be defeated. Unless a building is designed to be naturally ventilated, air leaks should be sealed to help reduce HVAC loads. Finally, low albedo roof materials can be used to reflect heat from the sun during the day, further reducing cooling loads.[84]

Exit Signs

While not commonly considered, exit signs burn 24 hours a day, 365 days a year. With the advent of low-cost, reliable, commercially available light-emitting diodes (LEDs),

retrofitting building exit signs has the potential to save a considerable amount of energy nationwide. The most efficient LED exit sign available today requires 96% less electricity than a 40-watt incandescent-lighted system. There are more than 100 million incandescent exit signs in use throughout the United States, consuming some 30–35 billion kWh of electricity annually. Converting these signs would save over 30 billion kWh of electricity per year—the output of five large nuclear plants. While initial costs are higher for LEDs, they have almost no maintenance costs and are cost-effective on a life-cycle basis.[85]

Solar Water Heating and Ground Source Heat Pumps

While using solar energy to heat water and the thermal mass of Earth to heat and cool buildings are technically uses of renewable energy, they are often categorized under the heading of energy efficiency because they avoid electricity use that would have otherwise occurred. Both of these are firmly established technologies that offer significant energy savings and reasonable payback times in many climates.

Geothermal ground source heat pumps (GSHP) can reduce air conditioning peak loads, winter heating loads, and water heating loads. They are 50–70% more efficient at heating and 20–40% more efficient at cooling than traditional electric heating and cooling systems, and can reduce electricity use by 25–60%.[86] According to DOE, GSHPs

---

Box 4.2 Perimeter Center Place, Georgia

Equity Office Properties Trust's 11-story office building at Perimeter Center Place in Atlanta, Georgia, was one of the first commercial buildings in the United States to receive the federal Energy Star label for its efficiency.[87] Energy efficiency was a top priority when the building was constructed in 1986, and efficiency improvements have continued through the years. Equity's goal was to meet the needs of its customers while managing energy consumption, without sacrificing tenant comfort. [88]

Equity achieved its energy efficiency by implementing efficient lighting, HVAC, and energy management system technologies and by strengthening preventative maintenance protocols. For energy-efficient lighting, Equity retrofit all conventional fluorescent light fixtures to more efficient T-8 fixtures with electronic ballasts. They also replaced 90- and 100-watt incandescent bulbs with 15- and 18-watt compact fluorescent bulbs during their tenant improvement projects.

Equity upgraded the building's Energy Management System to control the base building mechanical systems more efficiently. Mechanical cooling systems were equipped to efficiently control the staging of the water side economizer and to minimize mechanical cooling, and the Building Automation System samples outside and indoor air temperatures to calculate the optimal start and stop time of each air handling unit. The owners installed variable frequency drives on all air handlers, and use two-speed motors to run cooling towers with less cycling and lower energy consumption. A computerized Preventative Maintenance Program allows Equity to meet proper maintenance frequency levels for maximum efficiency of the equipment. Equity also works to educate customers on practical energy efficiency, such as turning off lights as they exit their suites and closing window blinds to reduce solar load.

For more information, contact the federal Energy Star Buildings Program at <www.energystar.gov >.

provide water heating free in summer, use about half the water heating energy in winter, have a payback time 2–10 years, and reduce emissions up to 72% compared with an electric resistance heating and standard air conditioning systems.[89]

In Florida, an installed residential solar water heating system (SWH) can cost anywhere from $1,500 to $3,500, depending on the size of the family served, the size of the solar system, type of financing, type of roof, building code requirements, and professional versus do-it-yourself installation. According to the Florida Solar Energy Center, SWHs can save state residents 50–85% of the hot water portion of the monthly utility bill, or $200–300 a year for a family of four.[90]

RESIDENTIAL ENERGY EFFICIENCY

As in commercial buildings, almost everything in a residential building that uses electricity can be made more energy-efficient. The synergy between lighting, heating, cooling, and building shells is again found—the greatest energy efficiency is achieved when a residence is designed or retrofit with due regard to the whole house as a system. (See Box 4.3.) Top energy uses and opportunities for energy savings in residences include space heating and cooling, water heating, lighting, and refrigeration. Additional energy savings can be achieved through efficient clothes washers and dryers, dishwashers, televisions, ceiling fans, pool pumps, home electronics, and other electronic devices.

Space Heating and Cooling

Heating and cooling systems account for over 40% of the average home's energy bill. Sizing these systems correctly (up to one-third of all residential air conditioning systems are oversized, wasting energy), purchasing the most efficient Energy Star–approved products, and using programmable thermostats to match heating and cooling to actual end-user needs can all increase residential energy efficiency.[91]

Water Heating

Hot water systems account for over 14% of the average home's energy bill. High-efficiency water heaters, solar water heating systems, and ground source heat pumps are all more efficient than conventional water heating systems. Proper maintenance, water heater jacket insulation, and hot-water saving features such as low-flow shower heads and faucet aerators can all reduce energy use.[92] Residential solar water heating can save up to $500 per year in electricity and fuel bills, with payback times of four to eight years and 80% lower life-cycle costs.[93]

Insulation and Air Leaks

Because heating and cooling are such a large part of residential load, insulating walls, ceilings, and roofs can go a long way toward eliminating energy-wasting heat gain or loss driven by interior-exterior temperature differentials. While most modern homes and many older homes have insulation, adding insulation beyond what is required by building codes will reduce energy use further, often with very reasonable payback times.

Closely related to the insulating value of the building envelope is the extent to which air unintentionally leaks in or out. Air carries heat into or out of a house through cracks and holes at joints in the house framing; where pipes, ducts, and vents run through walls; and around windows and doors. The average U.S. home has five square feet of leaks, equivalent to leaving a window open all the time.[94] Sealing up these leaks, as well as sealing leaks in air handling ductwork, can improve residential energy efficiency by 10% or more.[95]

Windows

Just as in commercial buildings, choosing energy-efficient windows with glazing properties appropriate for the climate zone and purchasing thermally efficient window frames can improve residential energy efficiency. In general, inefficient windows can account for 15–25% of a home's utility bill.[96] Low-emissivity (Low-E) coatings, inert gas fills, and insulating glazing spacers increase the insulating value of the glazing unit. Wood, foam-filled vinyl, and thermally broken aluminum frames are much more energy-efficient than standard aluminum frames, hollow vinyl frames, or non-thermally broken metal-clad frames.

In cooling-dominated climates, spectrally selective glazings can be chosen to admit light but reject heat. In heating-dominated climates, highly insulating windows save energy. Windows must be of high quality and installed properly in order to minimize air leakage.

Daylighting and other passive solar designs can also improve a home's overall energy efficiency through lower electricity use for lighting.

Lighting

Lighting accounts for 5–10% of residential energy use.[97] Purchase of compact fluorescent bulbs, lighting timers, and motion sensors can reduce this energy use. Compact fluorescents use roughly one-quarter of the electricity that an incandescent bulb will use to give off the same amount of light. Generally bulbs that are used three hours a day or

more are good candidates for replacement with compact fluorescents. [98] Again, high-efficacy light fixtures will further increase the amount of available light for a given amount of energy.

Refrigerators

Energy demands of refrigerators have dropped dramatically over the years, so purchase of a new, highly efficient refrigerator will not only save energy but be economical even if the current refrigerator has not reached the end of its life. [99] For example, an 18-cubic-foot refrigerator produced before 1990 is likely rating to use above 1,200 kWh per year, while the same-size modern highly efficient refrigerator is likely rated to use less than 485 kWh per year. [100] Using the current price of electricity, a homeowner can fairly easily calculate if it makes economic sense to buy a new refrigerator immediately rather than to wait for the old one to die a long and energy-wasting death.

Clothes Washers and Dryers

About 85% of the energy used by clothes washers is for heating the hot water used to wash the clothes. [101] Reducing the amount of hot water used saves energy. Energy use of clothes dryers is affected by how much moisture remains in the clothes from the washer, so the effectiveness of the washer spin cycles affects dryer energy use. Modern Energy Star–rated highly efficient clothes washers and dryers will save residences energy, money, and water.

Consumer Electronics

Home electronics equipment is responsible for the fastest energy growth in homes in recent years. [102] For example, color televisions use up to 6% of residential energy, and leaking electricity accounts for approximately 5% of U.S. residential electrical load. [103] Purchasing new, energy-efficient consumer electronic products can help reduce these residential energy uses. Leaking electricity is likely to increase as a new generation of consumer electronics penetrates the market. However, currently available technologies using redesigned appliance circuits can reduce leaking electricity by over 75% with little increase in first cost, and probably with life-cycle savings. [104]

Low-Albedo Roofs and Shading

Roofs covered with materials with high solar reflectance (low albedo) values absorb less of the sun's energy, staying cooler and reducing daytime air conditioning requirements. Low-albedo roofs typically provide the greatest benefit where cooling energy costs exceed heating costs. [105] Planting of shade trees next to residences can also reduce solar gain and thereby reduce cooling energy requirements.

RENEWABLE ENERGY OPTIONS

Integrating renewable energy such as wind, biomass, and solar in the energy mix in the South is an essential strategy to reduce emissions and diversify risk. Under the Clean

---

Box 4.3 EarthCraft Houses, Georgia

EarthCraft House is a green building program of the Greater Atlanta Home Builders Association and Southface Energy Institute, in partnership with local government and the housing industry. [106] The goal is reduce the energy and environmental impact of housing. In its first 18 months, more than 700 homes have been committed to the program. The objective is to reach 10% of the new housing market within five years.

On average, EarthCraft homes reduce energy waste 30% over typical construction. The energy savings per house prevents over 3.5 tons of atmospheric pollutants. At least 80 builders have enrolled in the EarthCraft program, and offer houses at all price points and throughout the greater Atlanta area. Most energy features in the EarthCraft program offer a positive cash flow to the buyer since the annual energy savings exceed the additional mortgage cost.

An independent party inspects the energy and environmental features for each home. The Georgia Environmental Facility Authority and Georgia Pollution Prevention Assistance Division provide support for training and technical assistance. The Georgia Department of Community Affairs provides a pilot mortgage assistance program for affordable EarthCraft homes.

EarthCraft remodeling and multifamily programs are being developed, as well as expanding the program statewide. In addition, interest in green commercial buildings is expanding, including formation of a chapter of the U.S. Green Building Council.

For more information, contact Jim Hackler, EarthCraft Director, Southface Energy Institute, 241 Pine St., Atlanta, GA 30308, (404) 872-3549 ext 119, fax (404) 872-5009, e-mail: <earthcraft@earthcrafthouse.com>, or visit the Web site at <www.earthcrafthouse.com>.

Power Plan, renewables represent 4% of total generation in 2010 and 10% in 2020, contributing to reductions of 30% drop in sulfur dioxide emissions, 49% drop in nitrogen oxide emissions, and 32% drop in carbon dioxide emission in 2020 compared to Business As Usual. With volatile natural gas prices, renewables also represent an important method to reduce the exposure of customers to fluctuating power prices, since renewables are fuel-free or, in the case of biomass, dependent on fuel sources unrelated to the fossil fuel sector.

WIND ENERGY

In the Southeast, the Great Smokey Mountains and the Appalachians of North Carolina feature the best wind resources. These sites offer class 4, 5, and 6 wind speed areas. With today's wind technology, most utility-scale wind plants are being installed in class 4, 5, and 6 areas.[107] The next best areas in the region are the coastal region of South Carolina and the Appalachian Mountain and Cumberland Plateau of Tennessee. (See Box 4.4.) Modeling also includes off-shore wind resources in Florida and Georgia, as well as Class 3 winds in all states in 2011–20 due to wind technology improvements.

As shown by the state-by-state modeling results, North Carolina is expected to produce the majority of wind energy generation in the six-state region. At 70% of all wind generation in 2010, and 60% in 2020, North Carolina could potentially produce 4.5 times more wind energy than any other state in the South in 2010, and four times more in 2020.

Wind System Costs

Over the past 20 years, the cost of wind energy has dropped dramatically and reliability has increased. Capital costs in this study continue to drop—on-shore wind energy drops from $1,100 per kilowatt in 2000 to $660 per kilowatt in 2020 (see Table 4.1), and off-shore wind costs drop from $1,800 per kilowatt in 2000 to $1,310 per kilowatt in 2020. Off-shore wind capital costs in Europe, which has significant experience in this field, may be lower than capital costs used in this study. For example, the Middelgrunden off-shore wind farm, 3 kilometers outside the Port of Copenhagen, had a capital cost of $1.2 million euro per megawatt ($1.1 million/MW), including grid connection, and an electricity cost of $0.053 euro/kWh (4.8¢/kWh).[108]

The long-run cost of wind energy from large machines today is 3–6¢ per kilowatt-hour, down from more than 30¢/kWh in the early 1980s. The cost of wind energy includes the annualized capital cost and ongoing operating costs.

The range of costs reflects the windiness of the site, the size of the plant, the availability of tax credits, and other factors. The lower end of this range compares favorably with wind's leading fossil fuel competitor, natural gas-fired combined-cycle plants. At the same time, the efficiency and reliability of wind equipment has soared. Today, individual wind turbines are typically available for operation 98% of the time. Many wind turbines in the United States produce 30% of their technical potential, a capacity factor (that is, the portion of capacity that is actually used to generate power) that is lower than fossil fuel plants but steadily improving.[109]

Table 4.1 Current and Projected On-shore Wind Energy Costs and Performance in the South[110]

Year	2000	2010	2020
Capital ($/kW)	1,100	810	660
O&M (¢/kWh)	0.8	0.5	0.4
Capacity Factor			
Class 3	24.5 percent	27.4 percent	29.6 percent
Class 4	28.9 percent	32.4 percent	35.0 percent
Class 5	33.0 percent	37.0 percent	39.9 percent

Wind Technology

Utility-scale wind power plants consist of one or more individual wind turbines.[111] The power produced by the turbines—carefully controlled by power electronics—is collected and the voltage is boosted at a transformer to the correct level to be sent over power lines to customers. An above-ground transmission line may be required to bring the power from the site to the grid. Alternatively, wind turbines located near users (for example, a "wind cluster" located next to a town) may merely require a distribution line to send power to its local customers.

Although in the early years of the wind industry companies experimented with many different designs, most of today's new wind turbines are of the horizontal-axis type, with two or three blades facing upwind on a tubular tower. While their basic design has not changed much in the past decade, wind turbines have become larger. Larger wind turbines require slightly more land than smaller turbines, but their greater power production can reduce power costs. In 1981, a typical new wind turbine produced a maximum of 25 kilowatts (kW), had a rotor 10 meters (32 feet) in

diameter, and cost $2,600 per kilowatt. Today's turbines typically generate 750 kW to 1 MW, have rotors spanning 50 meters or more, and cost around $800 per kilowatt.

Despite the larger size, today's wind turbines are far less noisy and more attractive than their predecessors. Wind plants range enormously in size, from a single turbine for a small community to hundreds of turbines producing enough power to supply thousands of homes. The largest collection of wind turbines in the world is on California's Altamont Pass, with more than 6,000 turbines.

Although there are economic advantages to building large wind plants with many turbines, smaller facilities have a different kind of appeal. There is increasing interest in this development path, more common in Europe, which features individual or small clusters of large machines owned by landowners, farmers' cooperatives, or similar groups and connected to the low-voltage distribution system for power sales to the local utility.

The focus of this study is on large wind turbines and power plants because they offset the most fossil fuel use, but "small" wind turbines—those less than 10 kW in size and as small as a couple of kilowatts—also have an important part to play. These turbines typically supply power to individual customers, much like a solar panel. The United States is a leading manufacturer and exporter of these systems, which are aimed primarily at two markets: remote or off-grid power, such as villages in developing countries, and grid-connected residential or farm applications.

Small wind turbines designed for residential and commercial applications may be able to find a growing market niche in the Southeast. Although their costs per kilowatt-hour tend to be higher than the larger models, small turbines have the virtue of operating near or at the end of the distribution grid where they displace higher-cost energy and capacity. They also function in lower-speed winds. The installed cost for a typical 10 kW turbine on a 30-meter tower is approximately $3,300/kW, including all parts, shipping, and installation. This cost may decrease in the future as the industry's production grows.

Electric System Stability and High Wind Penetration
Electrical system operators face the challenge of instantaneously or nearly instantaneously matching a constantly fluctuating demand for electricity with supply from a large array of power plants with unique operating characteristics.[112] Electrical system dispatch is complicated when the supply of electricity also fluctuates, as it is caused by the

varying output from wind turbines in response to wind speed increases or decreases. This volatility leads to concerns about the stability of the electrical system when wind or other intermittent resources provide a significant share of the electricity supply.

The renewable resources proposed in this report are not likely to create electrical system stability problems. The intermittent resources modeled—wind and photovoltaics (PV)—represent roughly 3.6% of generation in the region in 2020, which is well below amounts that have been successfully implemented in Europe.

The British Wind Energy Association estimates that the fluctuation caused by the introduction of wind to the system is not discernible above normal system fluctuations until electricity generated from wind turbines reaches approximately 20% of the total system supply. [113] Several regions in northern Europe are approaching this figure. According to the European Wind Energy Association, wind energy now accounts for 13% of domestic electricity demand in Denmark and the state of Schleswig-Holstein in Germany serves 18% of its demand with wind power. [114]

Some renewable electricity technologies are unavoidably intermittent and will need to be supplemented with less intermittent energy supplies. Currently, that means conventional electricity plants, but in the future the electricity supply could be regulated through the use of baseload biomass gasifiers, hydrogen fuel cells, hydrogen pipelines, and other storage technologies. In addition, increased energy efficiency helps to lower customer demand, thereby contributing to system stability.

Wind Market Trends
Worldwide installed wind generating capacity exceeded 17,000 MW by the end of 2000, enough to generate some 37 billion kWh of electricity each year. According to the American Wind Energy Association (AWEA), 3,900 MW of utility-scale wind energy were added worldwide in 1999, the largest addition ever in a single year. [115] This new wind energy development is concentrated in Germany, the United States, Spain, and Denmark.

In the United States, several of the world's largest single wind farms are being prepared for completion—four wind farms of 200 MW or more were due to be installed in Texas, California, and the Pacific Northwest by the end of 2001.[116] According to AWEA, leading states in installed and planned wind capacity today are California (1,659 MW),

Texas (1,109 MW), Iowa (501 MW), and Minnesota (437 MW).[117] Major manufacturers of large-scale wind technology include Bonus, Enercon, Enron, NEG Micron, and Vestas. With wind energy costs continuing to drop, and with production increasing by 25% or more per year, wind energy continues to be at the forefront of renewable energy development.

BIOMASS ENERGY

According to the state-by-state modeling results, the potential for biomass-based energy generation is spread fairly evenly throughout the South, with Alabama, Florida, Georgia, and North Carolina each having 15–25% of the biomass

generation share, and South Carolina and Tennessee each having 5–10%. Georgia leads the pack, with close to 25% of regional biomass generation in both 2010 and 2020. Averaging over the region, biomass co-firing is expected to account for roughly 60% of biomass energy generation, biomass combined heat and power (CHP) for roughly one-third of generation, and landfill methane for the remaining 5% of biomass energy generation.

Energy crops are expected the play the greatest role in the Clean Power Plan's biomass mix, representing over 80% of biomass supplied by 2020. Much of this would be used through co-firing with coal. The most promising for the

---

Box 4.4 Buffalo Mountain Wind Park, Tennessee

The Public Power Institute (PPI) of the Tennessee Valley Authority (TVA) has added 2 MW of wind power capacity to TVA's renewable energy sources with the dedication of a new wind-turbine park near Oak Ridge, Tennessee. The Buffalo Mountain Wind Park represents the first commercial use of wind power to generate electricity in the southeastern United States.[118]

The major driver for this project was TVA's Green Power Switch program, which gives customers the option to purchase renewable energy for a small premium on their bill. Several distribution utilities are participating in the program. TVA's objective is to provide 50% of their green power from solar and wind technology, and 50% from landfill methane.

Three 660-kilowatt Vestas wind turbines were erected on the two-acre site in the fall of 2000 at a cost of $3.4 million. TVA funded the project and California-based Enxco developed it. The generators will produce some 6 million kWh of electricity a year, enough to serve more than 400 typical households in the Tennessee Valley.

The site on Buffalo Mountain was chosen for several reasons: existing 161-volt and 69-volt TVA power distribution lines cross the site, the Clinton Utilities Board has distribution lines on two sides of the mountain, and the Tennessee Communication Company has a three-phase line within one mile of the site. Further, the site is an abandoned strip mine. Such sites in the Tennessee Valley—flattened, treeless areas at elevations above 3,300 feet—could be ideal locations for wind parks.

Photo Courtesy Southern Alliance for Clean Energy © 2000, Photographer: Stephen Smith

PPI is working with AWS Scientific Inc. and True Wind to evaluate other potential wind park sites. TVA recently issued a request for proposals to expand the Buffalo Mountain site to 25 or 50 megawatts. They had 18 responses, and conducted initial site walkthroughs in August 2001. The busbar cost (the cost of power at the point it leaves the power plant, not including the cost of transport) of wind power at the expanded site is expected to be in the range of 5–7¢ per kilowatt-hour.[119]

For further information, contact Public Power Institute, Reservation Rd., Box PPI 1A, Muscle Shoals, AL 35662-1010, (877) 365-6074 (toll-free) or (256) 386-2601, e-mail: <info@publicpowerinstitute.org>, or visit the Web site at <www.publicpowerinstitute.org>.

Southeast appears to be switchgrass, a perennial that is deep-rooted, very persistent, and less susceptible to drought than other options. Switchgrass is already used as a cover crop for erodible land not in active cultivation. Fast-growing hybrid poplar trees are another viable option for the region.

Wood wastes include primary mill residues, yard trimmings, and construction wastes. Mill and logging residues are already widely used for energy and other needs in the pulp and paper sector. Competing uses for these residues—for example, chip board, bedding, and packing materials—bring more revenue than residue use for energy. The cost of this resource can therefore be high, since biomass energy producers must compete with other industries interested in the fuel. The main opportunity for the pulp and paper sector is increased efficiency of energy conversion of current waste streams through modern combined heat and power applications.[120] It is unlikely that the availability of urban wood wastes, such as tree trimmings, pallets, and construction waste, will increase substantially in the next two decades, even as population and construction increases, due to efforts to reduce waste production at the source and increased recycling. However, as landfills are filled and tipping fees increase, power generation may become an increasingly economic end-use for urban wood waste.[121]

Crop residues (stalks and leaves) are usually left in the field after harvesting. For the South, modeling focuses on corn stover and wheat straw, though rice is also a possible resource. In order to prevent excessive erosion, it is better to not remove all such residues, but a portion can be collected and converted to energy. Farmers often produce residues of straws from cereal grains such as rice, as well as corn cobs and stalks, in quantities that far exceed levels necessary for erosion control. Furthermore, residues contain few nutrients and, consequently, are of little value as fertilizer.

Landfill gas, the result of decomposition of organic waste materials in the absence of oxygen, is composed primarily of methane, a potential fuel as well as a potent greenhouse gas. The most prevalent use for landfill gas is as a fuel for power generation, with the electricity sold to a utility or a nearby power customer. The global warming potential of methane is greatly reduced when it is burned under controlled conditions to create power rather than flaring it or letting it escape into the atmosphere. In 1996, the costs of landfill-generated electricity ranged from 3.5–7.9¢ per kilowatt-hour, depending on the size of landfill, financing available, distance from the grid or local application, and other factors.[122]

Biomass Technology
Because biomass can be stored for use, it can be used to supply baseload power in both on-grid and off-grid applications. Primary applications of biomass for power generation include co-firing with coal, use in CHP industrial applications, and use in dedicated biomass power plants.

Co-Firing Biomass With Coal. A relatively low-cost, near-term option for converting biomass to energy is to co-fire it with coal in existing power plants.[123] Co-firing means mixing the biomass with the coal to reduce the amount of coal used. (See Box 4.5.) Co-firing has been practiced, tested, or evaluated for a variety of boiler technologies, including pulverized coal boilers of both wall-fired and tangentially fired designs, coal-fired cyclone boilers, fluidized-bed boilers, and spreader stokers. Demonstrations and trials have shown that biomass can effectively substitute for 15% or more of coal use, though ranges of 5–10% are more common.

Preparation of biomass for co-firing involves well-known and commercial technologies. After tuning the boiler's combustion output, there is little loss in total efficiency. Test results indicate that a 0.5% decrease in the boiler's overall thermal efficiency with 10% biomass co-firing is likely. Since biomass generally has much less sulfur than coal, there are reductions in sulfur dioxide emissions and, to a lesser degree, nitrogen oxide emissions.

The cost of converting a coal plant to co-firing varies widely, depending on the size of the plant, the type of boiler, the available space for storing biomass, and the fuel drying and processing facilities required. For cyclone-type boilers, the cost may be as low as $50/kW of biomass capacity. Conversion costs tend to be higher for the far more common pulverized coal boilers. DOE estimates a median cost of $180–200/kW of biomass capacity.

The potential for co-firing in the Southeast is large because of its many coal-fired power plants. It is important, however, to consider how much biomass might be available—and at what price—within a feasible trucking distance of the plants. It is likely that the co-firing fraction will be higher at some plants than others, and that some plants will not be converted to co-firing at all. The most favorable locations for co-firing will generally be where the coal price is relatively high and biomass price relatively low. In addition, plants with relatively high capacity factors will be able to recover the capital investment in co-firing more quickly than plants that run less often.

Combined Heat And Power. The most efficient use of biomass fuel is in combined heat and power applications. New

CHP plants can convert biomass to usable forms of energy with almost 90% efficiency. Because the pulp and paper industry produces large quantities of biomass waste each year, it has traditionally been the industrial sector with the highest rate of biomass fuel utilization. Most of these plants burn some combination of fossil fuels (generally coal in older CHP plants and gas in the newer ones) and biomass. As mentioned earlier, competing economic uses for pulp and paper residues make it unlikely that additional quantities of these residues would be available for new CHP. In the Southeast, therefore, replacement of existing CHP systems with modern, more-efficient systems holds the greatest promise for additional electric output for on-site usage and/or exports to the grid. Capital and operating costs of new CHP are expected to hold steady from 2000 to 2020 at $860/kW and 3.7¢/kWh, respectively.

Gains in new biomass-based CHP capacity outside the pulp and paper industry are expected to be modest by comparison. Recent advances in biomass combustion technologies, however, have made biomass-fueled CHP systems cost-effective for many other industries as well. New R&D into wood gasification technologies and fast-growing energy crops will likely further increase biomass generation effi-ciency and fuel supply, and cause the rate of growth of new biomass-based CHP systems to continue to increase.

Biomass energy projects have the added economic advantage of creating far more local jobs (particularly in slow-growth rural areas) than other types of energy projects, because biomass fuels are generally produced by local suppliers within a 50-mile radius of the site, while the average distance between production and consumption of fossil fuels is generally much greater. Another advantage of biomass over gas for CHP is that when the full fuel cycle is considered, closed-loop biomass energy systems (in which the rate of annual biomass fuel production meets or exceeds consumption) produce no net greenhouse gases.

As noted, the Southeast has the technical potential to fuel significantly more biomass-based CHP and reap these economic benefits. But while increased employment in rural areas, a slower rate of climate change, greater energy self-sufficiency, and so on would undoubtedly yield benefits to the region's economies, such factors are often difficult to quantify (and are not directly accrued by the CHP developer).

Box 4.5 Biomass Co-Firing at Gadsden Station, Alabama

Southern Company has conducted pilot-scale tests for co-firing switchgrass energy crops with coal, and recently completed full-scale testing with switchgrass at Alabama Power's 60 MW pulverized-coal fueled station in Gadsden, Alabama. The co-firing system uses switchgrass as a supplement to coal, and consists of a fuel-handling and pneumatic direct-injection system that introduces switchgrass into the boiler separately from the coal. The switchgrass provides up to 10% of the total heat input.[124]

Southern Company's motivating factors for investigating biomass co-firing include developing a relatively low-cost renewable energy technology to lower economic risks, preparing to meet possible future requirements for renewable energy portfolio standards, reducing carbon dioxide emissions from existing coal plants in the near term, and taking advantage of farm-grown biomass that could be produced in large quantities in the South.

Three hundred acres of "Alamo" switchgrass have been planted on Alabama farmland to feed the Gadsden project. Switchgrass is a rugged native grass that has high growth rates and can be harvested with existing farm equipment. It requires little fertilization and herbicide input, can be harvested twice a year, and can grow to 8–10 feet prior to harvest. Switchgrass can be grown on marginal agricultural lands as an additional cash crop to boost farmer income.

Based on results to date, Southern Company expects that switchgrass co-firing will be shown to be one of the lowest-cost renewable energy options in the South. It would take approximately 1,700 acres of switchgrass to supply 10% of the heat to Plant Gadsden's 60 MW Unit 1 boiler.[125] Results from the full-scale test were to become available in late 2001.

For more information, contact Doug Boylan, Southern Company, Generation and Energy Marketing, 270 Peachtree St. N.W., Atlanta, GA 30303, (205) 257-6917, or visit the biomass Web site at <www.southerncompany.com/planetpower/research/renewable.asp>.

The result is that except for the pulp and paper industries, biomass is often overlooked as a fuel for CHP. Despite significant advances in the efficiency of new biomass-based CHP systems, expanding the use of biomass for CHP applications to other industries is hampered by the fact that supply infrastructures to guarantee access to sufficient low-cost biomass fuel do not exist in most areas, but economies of scale adequate to lower costs are unlikely to develop without guarantees of sufficient demand.

Dedicated Biomass Plants. Today's dedicated biomass-fueled power plants use mature, direct-combustion boiler/steam turbine technology. They tend to be small (average size of 20 MW) and inefficient (average biomass-to-electricity efficiency of 20%), both of which contribute to a relatively high cost of delivered electricity: 8–12¢/kWh. That explains why most biomass plants use waste feedstocks, which are free or may even earn money for the plant owner by providing a waste-disposal service.

The next generation of stand-alone biomass power plants will be both less expensive and more efficient. One of the most promising near-term technological options is gasification combined-cycle systems, the biomass equivalent of the natural gas combined-cycle. Gasification involves the conversion of biomass in an atmosphere of steam or air to produce a medium- or low-energy-content gas. This biogas powers a combined-cycle power generation plant (which has both a gas turbine topping cycle and a steam turbine bottoming cycle, making use of both high- and low-temperature heat generated in combustion).

Biomass gasification combined-cycle systems are not yet commercially available, although one small plant is operating in Sweden. DOE projects that the first generation of such systems would have efficiencies of nearly 40%, and in co-generation applications they could exceed 80%. The cost of the first commercial systems in this country is projected to be in the $1,800–2,000/kW range. With learning, the cost may drop rapidly to reach $1,400/kW by 2010. Even this capital cost is still high for utility-scale power generation, indicating biomass gasification combined-cycle systems will enter the market more slowly than co-firing or CHP, and will probably require a continuing subsidy.

Animal Waste Digestion. Biogas from animal waste is produced through anaerobic digestion, which promotes the bacterial decomposition of the volatile solids in animal wastes. Anaerobic digesters are sealed with covers that trap the biogas produced in the digester. The biogas is then pulled from the digester by providing a slight vacuum on a pipe with a gas pup or blower. Biogas, which contains 60-

80 percent methane and has a heating value of approximately 600-800 Btu per cubic foot, is then used to produce energy through a variety of energy conversion technologies, including combined-cycle gas turbines, simple gas turbines, microturbines and fuel cells.

The total installed-megawatt potential for non-landfill biogas in the U.S. is close to 3,000 MW, with the vast majority coming from animal waste digester projects. Daily biogas production at installed farm-based anaerobic digesters in the United States varies from 24,000 to 75,000 cubic feet, or an energy equivalent of 13 to 42 million British thermal units (Btu). [126] According to the EPA AgStar program there are five digester systems located in the South—three generate electricity, one recovers heat for hot water and another flares the gas—preventing 500 metric tons of methane from entering the atmosphere each year.[127]

Environmental Implications of Biomass
The use of biomass for energy can raise significant environmental issues. For example, taking too much agricultural residue off the land can increase erosion and reduce soil quality. Cultivating energy crops on a large scale requires land, as well as energy and other inputs. The combustion of biomass, of course, produces air pollutants such as nitrogen oxides that must be controlled. There are additional questions concerning how large-scale biomass production might displace or compete with food production, encourage unsustainable forest use, or (in co-firing) provide an incentive to keep dirty and inefficient coal plants in operation.

On balance, however, the environmental benefits of biomass use outweigh these risks when sensitive practices are used. It is important to first consider the activities displaced by biomass production and use, starting with coal mining and the pollution generated by coal plants. A major advantage of biomass—if sustainably produced, as proposed in this study—is that it does not contribute to global warming, since the CO_2 that is emitted into the atmosphere during combustion is absorbed as plants are grown to replace the biomass consumed.

Right now, agricultural residues are often burned in the open to make way for new plantings, producing far more pollution than would be generated if the residues were collected and consumed in a controlled power plant. Moreover, the removal of residues from the field does not lead to erosion if a sufficient amount is left in place, as our study assumes in its price and supply projections.

Last, the leading energy crop, switchgrass, has far fewer impacts on land and wildlife than food crops. Unlike food crops, energy crops are not replanted every year, so their roots systems remain in place to hold the soil. In fact, switchgrass is commonly used as a cover crop on erodible or fragile soils enrolled in the Conservation Reserve Program of the U.S. Department of Agriculture. In the right locations, energy crops can even act as chemical buffers to absorb agricultural runoff before it enters river systems.

Still, it is clear that biomass use must be carefully monitored and regulated to avoid unwanted impacts. For example, co-fired or dedicated biomass power plants should be required to meet the same air pollution regulations as others. Potentially contaminated feedstocks (such as municipal wastes) should not be used in biomass power plants.

Biomass Markets

The United States is currently the largest biopower generator, with over half of the world's installed capacity. There are about 7,800 MW of biomass power capacity installed at more than 350 locations in the country, representing 1% of total U.S. electricity generation capacity. The U.S. biomass power industry is primarily located in the Northeast, Southeast, and West Coast regions, representing a $15-billion investment and 66,000 jobs. Forest biomass is mostly concentrated in the Southeast, Northeast, Pacific Northwest, and Upper Great Lakes regions. Herbaceous or grassy biomass is most plentiful in the Midwest states, while cropland is mostly concentrated in the upper Midwest, the Lower Great Lakes region, and in the Mississippi delta.

Recent studies indicate that more than 39 million tons of wood residues are available at low cost in the United States just by recovering clean discarded wood from municipalities, construction activities, and manufacturers. Using new, more efficient biopower technologies such as co-firing or gasification, these supplies are enough to double the amount of electricity generated from biomass each year in the United States. Research on biomass power continues, with biomass co-firing projects ongoing in Alabama, Indiana, Iowa, Kentucky, New York, North Dakota, Pennsylvania, Texas, and West Virginia, and with biomass gasification projects under way in California, Colorado, and Vermont.[129]

SOLAR PHOTOVOLTAIC ENERGY

While the amount of sunlight available for generating power varies across the South and from season to season, the highest value of grid-connected solar electricity as modeled in this study comes from its ability to match summer peak loads. In many parts of the region, peak electricity demand is driven by air conditioning on hot summer days, precisely the time when solar radiation is highest. It has been shown that PVs can deliver firm, dependable power even during extreme peak conditions leading to outage situations, such as the recent power crisis in California.[130]

Since peak loads are expensive for power companies to meet, solar PV systems are sometimes attractive even in areas with below-average amounts of sunlight. This concept is expressed as the effective load-carrying capability (ELCC), which is the probability that PV can contribute to a utility's capacity to meet its load. A region with comparatively low solar resources may still have a high ELCC if the utility load and solar resource are well matched. The degree of this match is related to the ratio of summer-to-winter peak loads—as summer loads exceed winter loads, the effective load carrying capacity of PV increases (see Figure 4.1). [131] In the Southeast, the ELCC for PV systems ranges from 50% to 70% of capacity.

PV Technology

PV cells—the most basic component of a PV system—come in many shapes and forms, from flat, thin films made of amorphous (non-crystalline) silicon to pure crystals of silicon or other materials on which direct sunlight is concentrated in intense beams.[132] By and large, the crystalline cells achieve good efficiencies of conversion of light into electricity but are expensive to manufacture. Thin films are less efficient but cheaper to make. As yet, no single technology has proved decisively superior. On the contrary, each has found a niche, reflecting wide variations in the quality of the resource and the needs of customers.

Individual PV cells are assembled into modules that produce direct current power. Depending on the application, PV modules are either fixed flat plates, tracking flat plates, or concentrating. The fixed flat-plate modules face in one direction all the time (see Box 4.6), whereas tracking flat plates and concentrating modules are turned to face the sun. The concentrating systems in particular must be finely controlled to maintain an orientation so sunlight is focused precisely on the comparatively small cells. Again, there is a trade-off between efficiency and cost: more efficient designs tend to cost more.

PV modules are combined with other components, such as power conditioners and inverters, tracking motors, and mounting structures, to form a complete PV system. The components to be included depend on the application:

■ Off-grid systems are intended to supply power to the customer only. They can include a battery to increase power availability when solar insolation is not available. Batteries also allow the customer to draw power when needed, for example during power outages. Such systems, typically designed for residential use or small business customers, offer both backup and full-time power benefits.

■ Grid-connected systems use the transmission system as a whole for backup. At night and on cloudy days, the consumer draws power from the grid, but when there is plenty of sunlight the consumer draws power from the PV system and may, in fact, become a net power producer. Some products also include batteries that offer backup power as well.

Perhaps the main challenge behind a grid-connected system is dealing with the local utility. Connecting a PV or any distributed energy technology to the grid is not always easy. (See Box 4.7.) The challenging interconnection rules imposed by some utility companies date back to the days when there was concern in power engineering circles that grid-connected PV systems might adversely affect the quality of power. Experience has demonstrated conclusively, however, that well-designed PV systems can be safely and reliably connected with the utility grid.

PV System Costs
The cost of PV installation mainly depends on the installation's size and the degree to which it uses standard, off-the-shelf components.[133]

■ For small, one-of-a-kind grid-connected PV systems (1–3 kW residential), the complete cost ranges between $9,000/ kW and $11,000/kW. The addition of emergency battery storage may add $1,000/kW.[134]

■ For mid-size grid-connected building-integrated PV installations where the roof or walls may be used as structure, the current cost ranges from $6,000/kW to $8,000/kW. For bulk orders of small standardized systems, the cost could be as low as $5,000/kW to $6,000/kW, based on experience with a program conducted by the Sacramento Municipal Utility District.

■ The costs of large grid-connected PV systems are not well known, since most of the current ones are one-of-a-kind prototypes designed with little emphasis on cost efficiency. A reasonable estimate, based on

Figure 4.1. PV's Effective Load Carrying Capacity Increases As Summertime Demand Rises Above Wintertime Demand
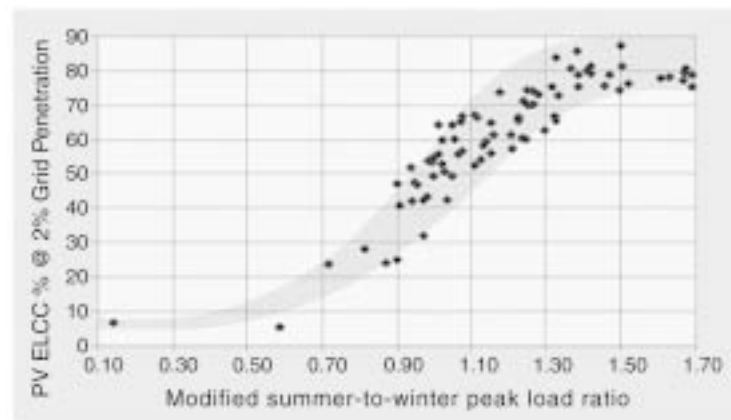
Figure 4.1 Source: Richard Perez, Robert Seals, and Christy Herig. "Photovoltaics Can Add Capacity to the Utility Grid," DOE/GO-10096-262 (Washington, DC: DOE, September 1996).

discussions with system manufacturers, indicates that the cost of such systems might range from $5,000/kW to $6,000/kW.

A report recently released by the U.S. PV industry in conjunction with DOE provides a view of the future of the industry based on market and cost projections. All major PV manufacturers (Siemens, Astropower, and BP Solar) participated in the preparation of this report, along with universities (Purdue and MIT), Idaho Power, and Trace Engineering. The Industry Road-Map report establishes a goal of $3,000/kW (including capitalized operations and maintenance costs) in 2010, and $1,500/kW in 2020.

PV Market Trends
While PVs account for a very small share of worldwide energy production, the market sector is growing quickly and prices are dropping rapidly. The global market for PV grew at about 25% a year from 1993 to 2000, and PV module prices have declined by 18% for each doubling of cumulative production. In 2000, over 280 MW of PV were produced, and another 350 MW are expected to be produced in 2001. As of 1999, the five largest PV companies globally are BP Solar, Kyocera, Sharp, Siemens, and Solarex.

Approximately 60% of all PV currently goes to off-grid applications (split 40% industrial and 60% rural), and the other 40% goes to grid-tied and large-scale power applications. As grid-tied applications become more popular, this balance is expected to shift to about 50/50.

Box 4.6 PV for Jacksonville High Schools, Florida

Photo Courtesy Florida Solar Energy Center © 2001, Photographer: Steven Spencer

As part of its environmental commitment, a Florida municipal utility, JEA, has committed to increasing its renewable energy capacity to 7.5% of all generation by 2014. This is currently the largest commitment to renewable energy in the state. Up to 2 MW of PV will be installed by 2007 to meet this goal. As part of meeting this objective, JEA recently completed installation of 22 PV systems on area high schools.[135]

Each of the 22 PV systems will have a capacity of 4 kW, for a total installed capacity of 88 kW, and will generate enough electricity to offset lighting and air conditioning loads for roughly one classroom at each school. The photovoltaic school installations are part of the Solar Education Project, a $900,000 program managed by JEA, which provides solar education for students while allowing JEA to test solar energy sources for future use in homes and businesses.

In November 1999, the first of the school-based solar energy projects was installed at Terry Parker High School in Jacksonville. The 4 kW system cost $6.27 per peak watt, with the balance of system components and installation labor costing an additional $2.57 per peak watt each. The total installed cost for this first site was $46,595, or $11.42 per peak watt.

In addition to the high school sites, two 4 kW photovoltaic systems will be installed on JEA facilities in downtown Jacksonville and at their water treatment facility to heighten public exposure to solar energy. These projects are the first of many planned investments in renewable energy for JEA.

For more information, contact Larry E. Wagner of JEA, 21 W. Church St., Jacksonville, FL 32202, (904) 665-6292, or visit the Web site at <www.jea.com/community/greenworks/index.asp>.

The U.S. share of the global PV market ranged from 30 to 45% during 1992–99, and continued advances in photovoltaic R&D have helped lower PV manufacturing costs.[136] U.S. PV exports have increased from 55% of U.S. production in 1988 to 70% in 1998. [137] Many of these exports go to Germany and Japan, where high electricity prices and significant subsidies and incentives are driving the global market in PVs. Japan alone is expected to exceed 50% of worldwide PV demand in 2001. [138] The U.S. share of the global PV market ranged from 30-45% during the period from 1992-99, and continued advancements in photovoltaic R&D have helped lower PV manufacturing costs by 30% and have helped stimulate a seven-fold increase in U.S. PV manufacturing capacity since 1992. [139]

LONG-TERM OPTIONS: A HYDROGEN ECONOMY

Experts believe hydrogen may one day become an important part of the energy system. Hydrogen is an inert gas that can be extracted from hydrogen-bearing compounds, such as water and hydrocarbons. Once extracted, it can be converted to electricity or used directly as a fuel to power transportation and other applications using a range of technologies, including fuel cells, gas turbines, and internal combustion engines. When burned or otherwise used to create energy, pure hydrogen produces no polluting emissions. However, most hydrogen today is produced from natural gas (a hydrocarbon) using steam reforming, a process that releases more carbon dioxide into the atmosphere than combustion of the natural gas feedstock alone.

Hydrogen can be extracted from water using electrolysis. If the energy for this extraction process were itself derived from a renewable energy source such as wind, solar, or hydro power, hydrogen and water would form a clean and renewable energy loop. Hydrogen can also be renewably produced from biomass using a process similar to that for extraction from natural gas. Research is currently being conducted on novel methods for hydrogen production, including a photobiological process using specially modified algae to form hydrogen directly with very little net carbon production.

**Box 4.7 Examples of Utility Requirements Often Imposed on
Grid-Connected Distributed Energy Resources**

■ Inconsistent interconnection requirements across states and utilities. (New Institute of Electrical and Electronic Engineers standards have been developed to created national consistency. National Electric Code standards also exist to address requirements for fire safety.)

■ Extraneous equipment requirements due to fears of "islanding," whereby a PV continues to feed power into the grid when the main generator is off-line. Utility workers repairing downed lines can die from electrocution as a result. (PV inverters that meet UL safety standards are incapable of islanding.)

■ Liability insurance requirements in case of islanding.

■ Fees imposed by the utility for engineering reviews, inspection, and equipment testing.

■ Standby charges to cover reserve utility generation in case the PV system goes down.

Although solar and wind systems may be the ultimate hydrogen sources, fossil fuels may be the only affordable hydrogen sources in the near-term. Fossil fuels enjoy an already established transmission and distribution network, and can be used very efficiently in fuel cells configured for combined heat and power applications. According to the Argonne National Laboratory, building a dedicated hydrogen infrastructure would be an expensive proposition. They have estimated that the cost for building production facilities and pipelines sufficient to meet U.S. energy needs could be as high as $300 billion, with distribution costing another $175 billion, coming to roughly $3 per gallon of gasoline equivalent. Operating and maintenance costs, the cost of the feedstock itself (such as natural gas), and the cost of transporting and storing the hydrogen would be additional. However, perhaps distributed hydrogen production using renewable energy, as well as additional R&D on hydrogen production, transport, storage, and use, can bring these costs down.[140]

CHAPTER 5. SUMMARY AND STATE RESULTS

CONTENTS

IN SUMMARY

Powering the South offers citizens, businesses, politicians, environmentalists, and others a path towards a vastly cleaner energy future. If it is successful, the Report will lead these disparate groups into actions to secure this healthier future. Before looking at the state-by-state summaries, we review how the Report reaches these conclusions.

The Report blends technical estimates of the potential for efficiency and renewables on a state-by-state basis. These two clean energy options are then used to replace existing generation, particularly the dirtiest coal generating plants. The results for the region are dramatic. In 2020 all the major pollution indices are down, down not only from the 2020 business as usual forecasts, but down from the year 2000 baseline.

The Report first estimated the technical potential of energy efficiency. If adopted as recommended, electricity usage will decline significantly from the projected growth rates. By 2020, under the clean energy plan electricity demand will be 236 million MWh less than the business as usual projection. These savings allow 112 new 300 MW power plants not to be built. Part of the savings from the energy efficiency measures is used to bring on-line renewable production that can increase the environmental gains of the clean energy plan.

The types of changes represented by the clean energy plan do not come automatically. They require new policies to be adopted, policies that will influence how the electric system operates, plans, and most importantly how environmental values are incorporated into the system. The Report offers six policy recommendations related to efficiency, seven to renewable development, and four specifically to

pollution control. This is an ambitious agenda but one that has been tried and found to work in other states and regions.

When interpreting state-by-state results, it is important to keep in mind that the results presented are estimates based on the regional results. The Report estimates growth, efficiency, renewable development and the cost impact on a total regional basis, assuming that each state picks up the policy recommendations laid out in the Report. The individual results seen in each state, from environmental indices to cost impacts, will depend upon the policy tools adopted by the state and by how individual citizens choose to use the incentives for efficiency and renewables presented to them. As they say: "Individual results may vary…" What will not vary is the regional potential presented in the Report. The South can have a vastly different power system, one that protects the environment and the health of citizens. The South can have this clean energy future with little or no impact on electric bills. Powering the South shows the way towards that future.

STATE RESULTS

ALABAMA

The Electricity Industry Under Business-as-Usual Conditions

As shown in Figure 5.1, Alabama currently relies heavily on fossil and nuclear power plants, with coal providing 64% of generation, oil providing 5% of generation, and nuclear providing 22%. Hydropower provides the remaining 9%. Electricity demand is expected to grow at roughly 2% per year from 2000 through 2020. Consequently, Alabama is expected to require 6,946 megawatts (MW) of new elec-

tricity capacity—equivalent to roughly 23 power plants of 300 MW each—over the next 20 years. This new electricity demand is expected to be met almost entirely with new natural gas power plants. (Note: There has recently been increased interest in building new coal plants to meet future load instead of new gas plants; if that happens, it would most likely result in slightly higher costs and increased air emissions than assumed here.)

The Clean Power Plan
Figure 5.2 presents a summary of the Clean Power Plan. The growth in electricity demand over the period is expected to be reduced dramatically as a result of the energy efficiency investments. New renewable biomass and solar resources are expected to reduce the need for new gas power plants. And generation from older, less efficient, highly polluting coal plants is expected to be reduced significantly.

The Clean Power Plan results in dramatic improvements in environmental quality by 2020, compared with business-as-usual practices. Sulfur dioxide (SO_2) emissions are expected to be reduced by roughly 37%, nitrogen oxide (NO_X) emissions are expected to be reduced by 66%, and carbon dioxide (CO_2) emissions are expected to be reduced by 38%. There will be comparable reductions in emissions of mercury and particulates.

The Clean Power Plan can be achieved with little or no additional costs to electricity customers on average. Regionally, the Clean Power Plan would increase overall electricity costs by 0.6% in 2010, and would reduce overall costs by 1.7% in 2020.

Energy Efficiency Opportunities
Alabama has the potential to reduce electricity consumption significantly through existing, cost-effective efficiency technologies and measures. Energy efficiency has the potential to:
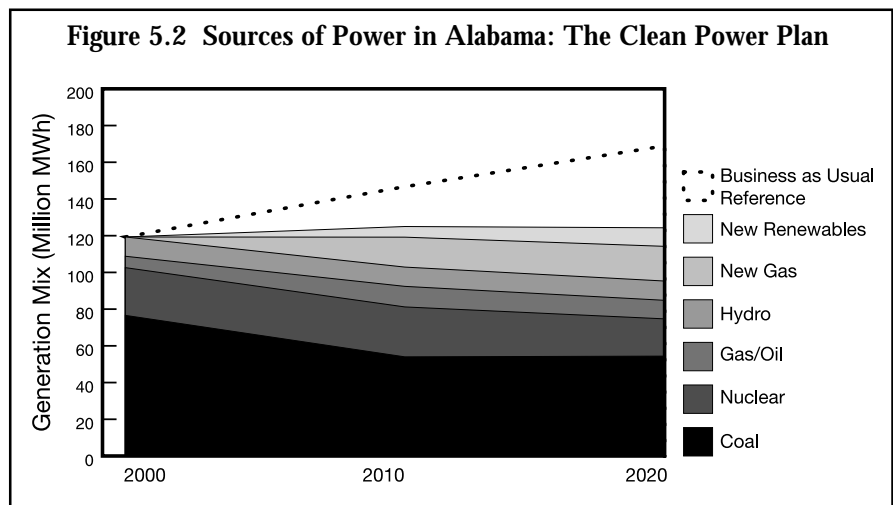
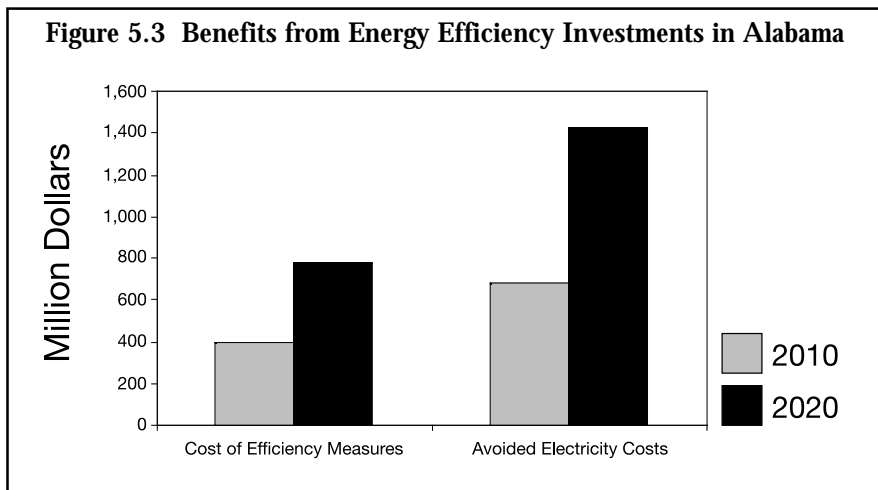■ Save 29 million MWh of electricity by 2020—roughly equivalent to the generation from 14 power plants.
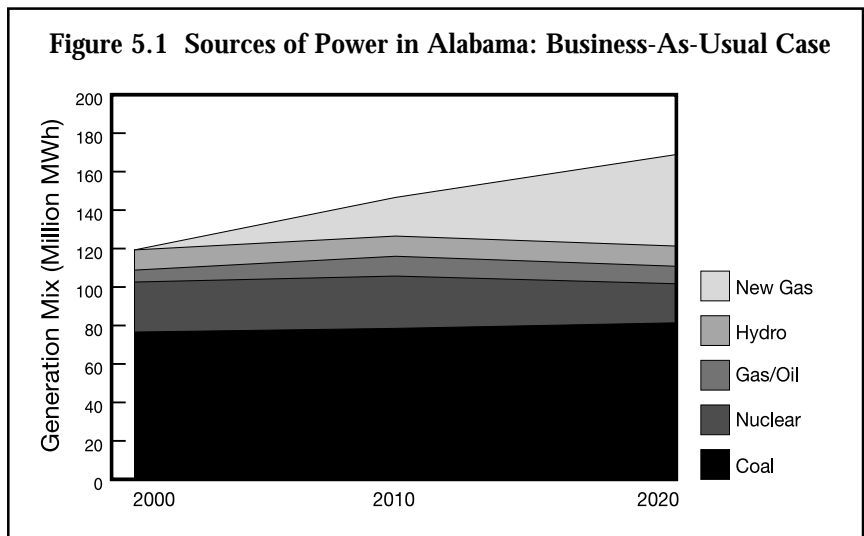
Figure 5.1 Sources of Power in Alabama: Business-As-Usual Case

■ Reduce electricity demand nearly 14% by 2010 and 23% by 2020.

■ Cost significantly less than generating, transmitting, and distributing electricity—with an average cost of 2.6¢/kWh.

■ Reduce net electricity costs by $651 million by 2020, as indicated in Figure 5.3.

Renewable Generation Opportunities
Table 5.1 presents the renewable resources installed in Alabama in the Clean Power Plan in 2010 and 2020. Biomass co-firing and biomass combined heat and power (CHP) present the greatest opportunity, representing roughly 5% and 3% of generation in 2020 respectively.

Figure 5.2 Sources of Power in Alabama: The Clean Power Plan

Figure 5.3 Benefits from Energy Efficiency Investments in Alabama

The Clean Power Plan

Figure 5.5 presents a summary of the Clean Power Plan. The growth in electricity demand over the period is expected to be reduced dramatically as a result of the energy efficiency investments. New renewable biomass, wind, and solar resources are expected to slightly reduce the need for new gas power plants. And generation from older, less efficient, highly polluting coal plants is expected to be reduced.

The Clean Power Plan results in improvements in environmental quality by 2020, compared with business-as-usual practices. SO_2 emissions are reduced by 2.2%, NO_X emissions are reduced by 31%, and CO_2 emissions are reduced by 22%. There will be comparable reductions in emissions of mercury and particulates.

The Clean Power Plan can be achieved with little or no additional costs to electricity customers on average. Regionally, the Clean Power Plan would increase overall electricity costs by 0.6% in 2010, and would reduce overall costs by 1.7% in 2020.

Energy Efficiency Opportunities

Florida has the potential to reduce electricity consumption significantly through existing, cost-effective efficiency technologies and measures. Energy efficiency has the potential to:

■ Save 63 million MWh of electricity by 2020—roughly equivalent to the generation from 30 power plants.
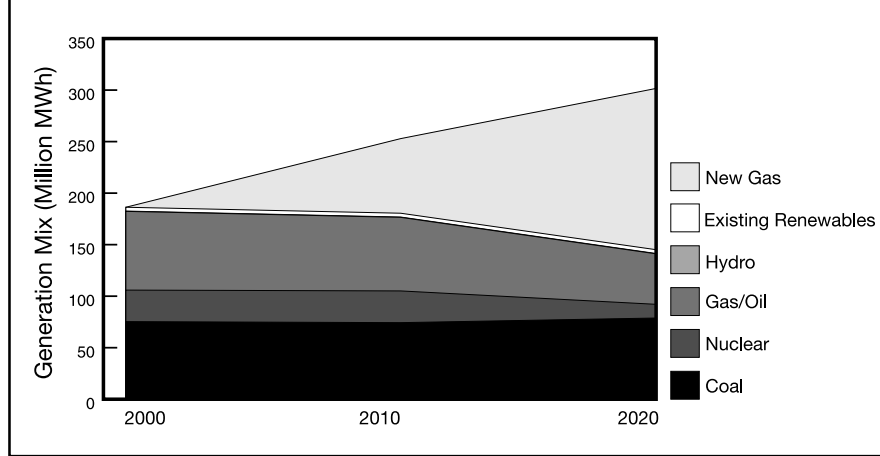
FLORIDA

The Electricity Industry Under Business-as-Usual Conditions

As shown in Figure 5.4, Florida currently relies heavily on fossil and nuclear power plants, with coal providing 40% of generation, oil providing 41% of generation, and nuclear providing 16%. Electricity demand is expected to grow at roughly 2% per year from 2000 through 2020. Consequently, Florida is expected to require 19,223 MW of new electricity capacity—equivalent to roughly 64 power plants of 300 MW each—over the next 20 years. This new electricity demand is expected to be met almost entirely with new natural gas power plants. (Note: There has recently been increased interest in building new coal plants to meet future load instead of new gas plants; if that happens, it would most likely result in slightly higher costs and increased air emissions than assumed here.)

Table 5.1 New Renewable Resources in the Clean Power Plan in Alabama

Generator Type	2010				2020			
	Installed Capacity (MW)	Capacity (% of all fuels)	Generation (1000 MWh)	Generation (% of all fuels)	Installed Capacity (MW)	Capacity (% of all fuels)	Generation (1000 MWh)	Generation (% of all fuels)
Biomass Co-Firing	612	2.6%	3,911	3.1%	908	3.9%	6,050	4.9%
Landfill Methane	16	0.1%	135	0.1%	33	0.1%	282	0.2%
BiomassCHP	329	1.4%	1,729	1.4%	693	2.9%	3,642	2.9%
PhotoVoltaic	5	0.0%	7	0.0%	60	0.3%	88	0.1%
Wind Turbines	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Total Renewables	**962**	**4.1%**	**5,782**	**4.6%**	**1,694**	**7.2%**	**10,062**	**8.1%**

Figure 5.4 Sources of Power in Florida: Business-as-Usual Case

Figure 5.5 Sources of Power in Florida: The Clean Power Plan

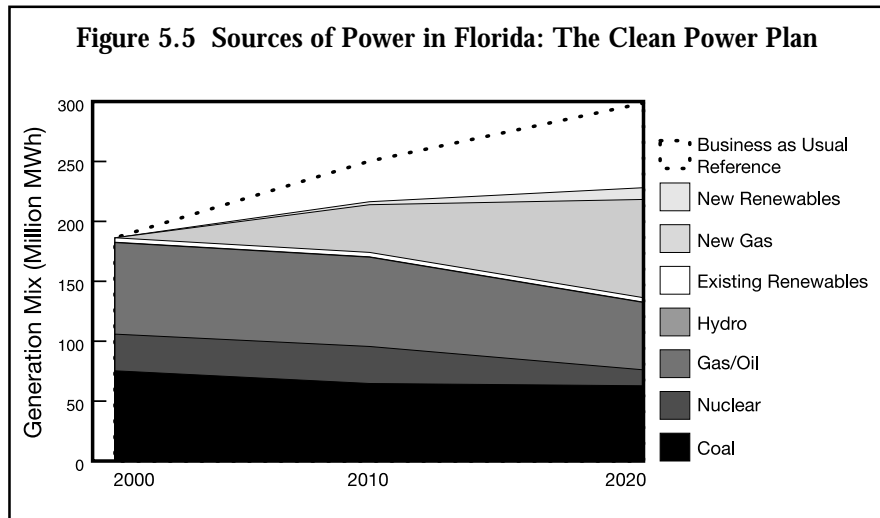**Figure 5.6 Benefits from Energy Efficiency Investments in Florida**

■ Reduce electricity demand nearly 13% by 2010 and 22% by 2020.

■ Cost significantly less than generating, transmitting, and distributing electricity—with an average cost of 2.6¢/kWh.

■ Reduce net electricity costs by $1,116 million by 2020, as indicated in Figure 5.6.

Renewable Generation Opportunities
Table 5.2 presents the renewable resources installed in Florida in the Clean Power Plan in 2010 and 2020. Biomass co-firing and biomass CHP present the greatest opportunity, representing roughly 3% and 1% of generation in 2020 respectively.
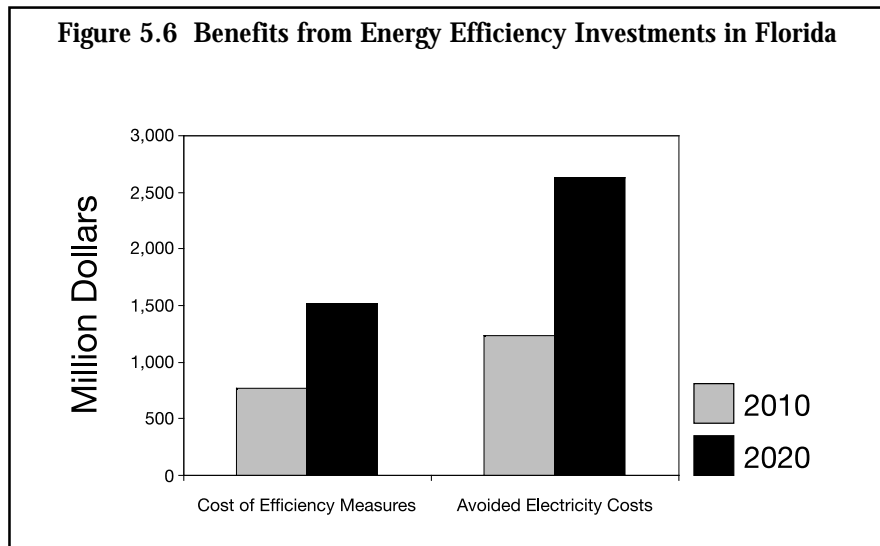
GEORGIA

The Electricity Industry Under Business-as-Usual Conditions
As shown in Figure 5.7, Georgia currently relies heavily on fossil and nuclear power plants, with coal providing 68% of generation, oil providing 4% of generation, and nuclear providing 24%. Hydropower provides the remaining 4% of generation. Electricity demand is expected to grow at roughly 2% per year from 2000 through 2020. Consequently, Georgia is expected to require 9,740 MW of new electricity capacity—equivalent to roughly 32 power plants of 300 MW each—over the next 20 years. This new electricity demand is expected to be met almost entirely with new natural gas power plants. (Note: There has recently been increased interest in building new coal plants to meet future load instead of new gas plants; if that happens, it would most likely result in slightly higher costs and increased air emissions than assumed here.)

The Clean Power Plan
Figure 5.8 presents a summary of the Clean Power Plan. The growth in electricity demand over the period is

Table 5.2 New Renewable Resources in the Clean Power Plan in Florida

Generator Type	2010				2020			
	Installed Capacity (MW)	Capacity (% of all fuels)	Generation (1000 MWh)	Generation (% of all fuels)	Installed Capacity (MW)	Capacity (% of all fuels)	Generation (1000 MWh)	Generation (% of all fuels)
Biomass Co-Firing	589	1.2%	3,571	1.6%	1,172	2.4%	7,287	3.2%
Landfill Methane	55	0.1%	465	0.2%	116	0.2%	976	0.4%
BiomassCHP	172	0.4%	904	0.4%	362	0.7%	1,903	0.8%
PhotoVoltaic	14	0.0%	26	0.0%	349	0.7%	637	0.3%
Wind Turbines	50	0.1%	177	0.1%	450	0.9%	1,721	0.7%
Total Renewables	**880**	**1.9%**	**5,143**	**2.3%**	**2,448**	**4.9%**	**12,522**	**5.4%**

Note: The wind turbine information is for off-shore turbines only. There are no on-shore turbines assumed for Florida in this study.
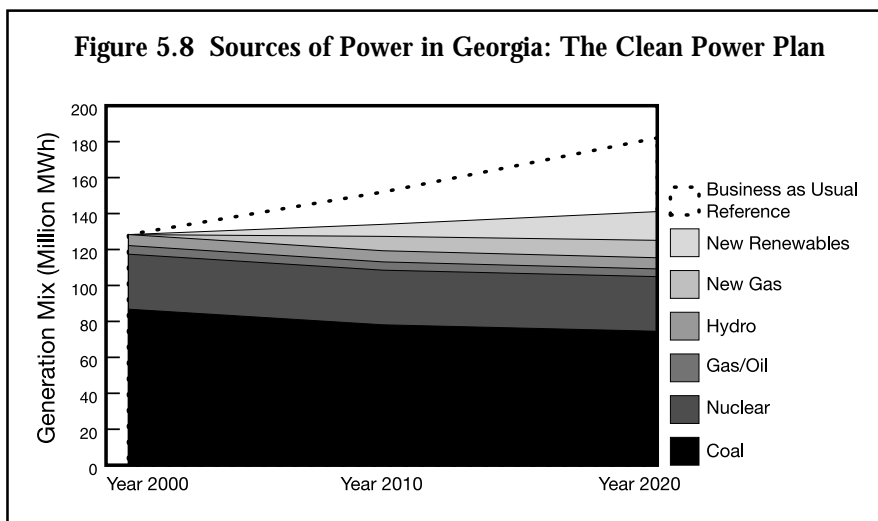

Figure 5.7 Sources of Power in Georgia: Business-As-Usual Case
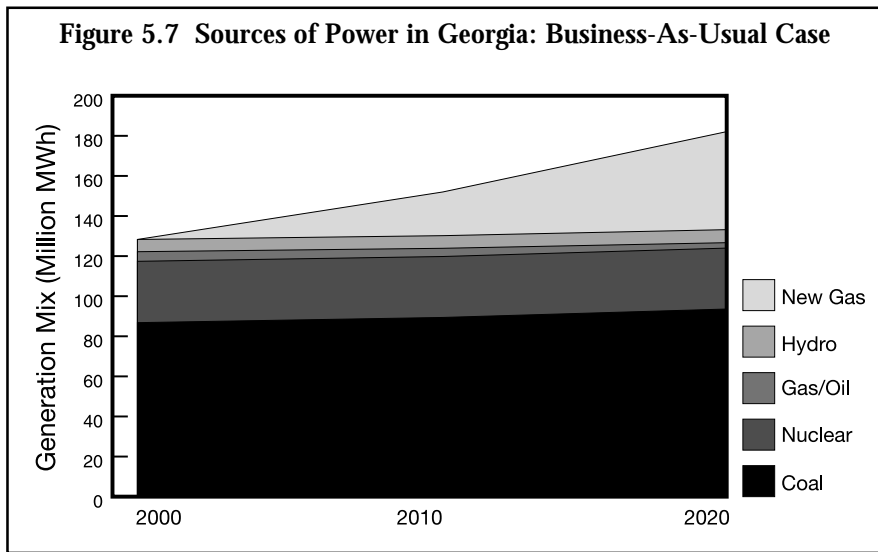
Figure 5.8 Sources of Power in Georgia: The Clean Power Plan

expected to be reduced dramatically as a result of the energy efficiency investments. New renewable biomass, wind, and solar resources are expected to reduce the need for new gas power plants. And generation from older, less efficient, highly polluting coal plants is expected to be reduced significantly.

The Clean Power Plan results in dramatic improvements in environmental quality by 2020, compared with business-as-usual practices. SO_2 emissions are reduced by 17%, NO_X emissions are reduced by 57%, and CO_2 emissions are reduced by 27%. There will be comparable reductions in emissions of mercury and particulates.
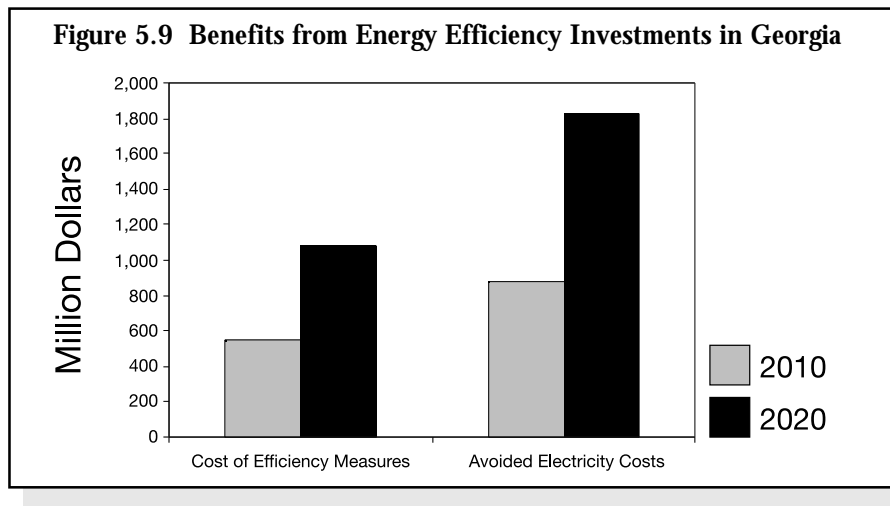
The Clean Power Plan can be achieved with little or no additional costs to electricity customers on average. Regionally, the Clean Power Plan would increase overall electricity costs by 0.6% in 2010, and would reduce overall costs by 1.7% in 2020.

Energy Efficiency Opportunities
Georgia has the potential to reduce electricity consumption significantly through existing, cost-effective efficiency technologies and measures. Energy efficiency has the potential to:

Figure 5.9 Benefits from Energy Efficiency Investments in Georgia

co-firing and biomass CHP present the greatest opportunity, representing roughly 6% and 3% of generation in 2020 respectively.

NORTH CAROLINA

The Electricity Industry Under Business-as-Usual Conditions
As shown in Figure 5.10, North Carolina currently relies heavily on fossil and nuclear power plants, with coal providing 62% of generation, oil providing 4% of generation, and nuclear providing 29%. Hydropower provides the remaining 5%. Electricity demand is expected to grow at roughly 2% per year from 2000 through 2020. Consequently, North Carolina is expected to require 9,947 MW of new electricity capacity—equivalent to roughly 33 power plants of 300 MW each—over the next 20 years. This new electricity demand is expected to be met almost entirely with new natural gas power plants. (Note: There has recently been increased interest in building new coal plants to meet future load instead of new gas plants; if that happens, it would most likely result in slightly higher costs and increased air emissions than assumed here.)
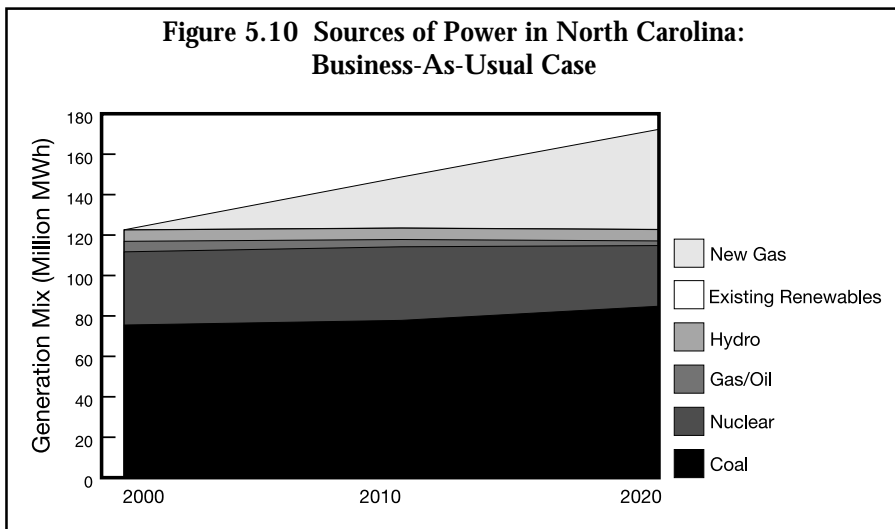
The Clean Power Plan
Figure 5.11 presents a summary of the Clean Power Plan. The growth in electricity demand over the period is expected to be reduced dramatically as a result of the energy efficiency investments. On-shore and off-shore wind, as

■ Save 41 million MWh of electricity by 2020—roughly equivalent to the generation from 20 power plants.

■ Reduce electricity demand nearly 14% by 2010 and 23% by 2020.

■ Cost significantly less than generating, transmitting, and distributing electricity—with an average cost of 2.6¢/kWh.

■ Reduce net electricity costs by $744 million by 2020, as indicated in Figure 5.9.

Renewable Generation Opportunities
Table 5.3 presents the renewable resources installed in Georgia in the Clean Power Plan in 2010 and 2020. Biomass

Table 5.3 New Renewable Resources in the Clean Power Plan in Georgia

Generator Type	2010				2020			
	Installed Capacity (MW)	Capacity (% of all fuels)	Generation (1000 MWh)	Generation (% of all fuels)	Installed Capacity (MW)	Capacity (% of all fuels)	Generation (1000 MWh)	Generation (% of all fuels)
Biomass Co-Firing	561	1.9%	3,721	2.8%	1,216	4.0%	8,140	5.8%
Landfill Methane	28	0.1%	239	0.2%	59	0.2%	501	0.4%
BiomassCHP	423	1.5%	2,223	1.7%	891	2.9%	4,683	3.3%
PhotoVoltaic	5	0.0%	7	0.0%	60	0.2%	88	0.1%
Wind Turbines	173	0.6%	540	0.4%	814	2.7%	2,606	1.8%
Total Renewables	**1,191**	**4.1%**	**6,730**	**5.0%**	**3,040**	**10.0%**	**16,017**	**11.3%**

Note: The wind turbine information is for both on-shore and off-shore turbines. Off-shore turbines represented 39 MW of capacity in 2010 and 296 MW of capacity in 2020.
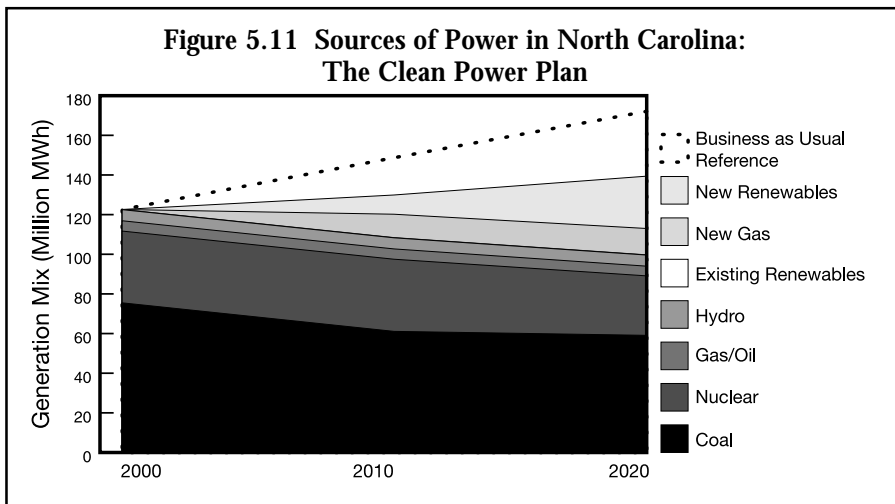
Figure 5.10 Sources of Power in North Carolina: Business-As-Usual Case

Figure 5.11 Sources of Power in North Carolina: The Clean Power Plan

Figure 5.12 Benefits from Energy Efficiency Investments in North Carolina

well as new biomass resources, are expected to reduce the need for new gas power plants. And generation from older, less efficient, highly polluting coal plants is expected to be reduced significantly.

The Clean Power Plan results in dramatic improvements in environmental quality by 2020, compared with business-as-usual practices. SO_2 emissions are reduced by 31%, NO_X emissions are reduced by 53%, and CO_2 emissions are reduced by 35%. There will be comparable reductions in emissions of mercury and particulates.

The Clean Power Plan can be achieved with little or no additional costs to electricity customers on average. Regionally, the Clean Power Plan would increase overall electricity costs by 0.6% in 2010, and would reduce overall costs by 1.7% in 2020.

Energy Efficiency Opportunities
North Carolina has the potential to reduce electricity consumption significantly through existing, cost-effective efficiency technologies and measures. Energy efficiency has the potential to:

■ Save 42 million MWh of electricity by 2020—roughly equivalent to the generation from 20 power plants.

■ Reduce electricity demand nearly 14% by 2010 and 23% by 2020.

■ Cost significantly less than generating, transmitting, and distributing electricity—with an average cost of 2.6¢/kWh.

■ Reduce net electricity costs by $731 million by 2020, as indicated in Figure 5.12.

Table 5.4 New Renewable Resources in the Clean Power Plan in North Carolina

Generator Type	2010				2020			
	Installed Capacity (MW)	Capacity (% of all fuels)	Generation (1000 MWh)	Generation (% of all fuels)	Installed Capacity (MW)	Capacity (% of all fuels)	Generation (1000 MWh)	Generation (% of all fuels)
Biomass Co-Firing	421	1.6%	2,668	2.1%	955	3.2%	6,202	4.4%
Landfill Methane	28	0.1%	237	0.2%	59	0.2%	495	0.4%
BiomassCHP	224	0.8%	1,177	0.9%	472	1.6%	2,481	1.8%
PhotoVoltaic	2	0.0%	3	0.0%	20	0.1%	29	0.0%
Wind Turbines	1,765	6.6%	5,732	4.4%	4,973	16.6%	17,341	12.4%
Total Renewables	**2,440**	**9.1%**	**9,817**	**7.6%**	**6,479**	**21.6%**	**26,548**	**19.0%**

Note: The wind turbine information is for both on-shore and off-shore turbines. Off-shore turbines represented 193 MW of capacity in 2010 and 1,213 MW of capacity in 2020.

Renewable Generation Opportunities
Table 5.4 presents the renewable resources installed in North Carolina in the Clean Power Plan in 2010 and 2020. On-shore and off-shore wind, as well as biomass co-firing, present the greatest opportunity, representing roughly 8%, 4%, and 4% of generation in 2020 respectively.

SOUTH CAROLINA

**The Electricity Industry Under Business-as-Usual Conditions**
As shown in Figure 5.13, South Carolina currently relies heavily on fossil and nuclear power plants, with coal providing 39% of generation, oil providing 2% of generation, and nuclear providing 54%. Hydropower provides the remaining 5%. Electricity demand is expected to grow at roughly 2% per year from 2000 through 2020. Consequently, South Carolina is expected to require 6,341 thousand MW of new electricity capacity—equivalent to roughly 21 power plants of 300 MW each—over the next 20 years. This new electricity demand is expected to be met almost entirely with new natural gas power plants. (Note: There has recently been increased interest in building new coal plants to meet future load instead of new gas plants; if that happens, it would most likely result in slightly higher costs and increased air emissions than assumed here.)

The Clean Power Plan
Figure 5.14 presents a summary of the Clean Power Plan. The growth in electricity demand over the period is expected to be reduced dramatically as a result of the energy efficiency investments. New renewable biomass, wind, and solar resources are expected to reduce the need for new gas power plants. And generation from older, less efficient, highly polluting coal plants is expected to be reduced significantly.

The Clean Power Plan results in dramatic improvements in environmental quality by 2020, compared with business-as-usual practices. SO_2 emissions are reduced by 30%, NO_X emissions are reduced by 62%, and CO_2 emissions are reduced by 35%. There will be comparable reductions in emissions of mercury and particulates.

Figure 5.13 Sources of Power in South Carolina: Business-As-Usual Case
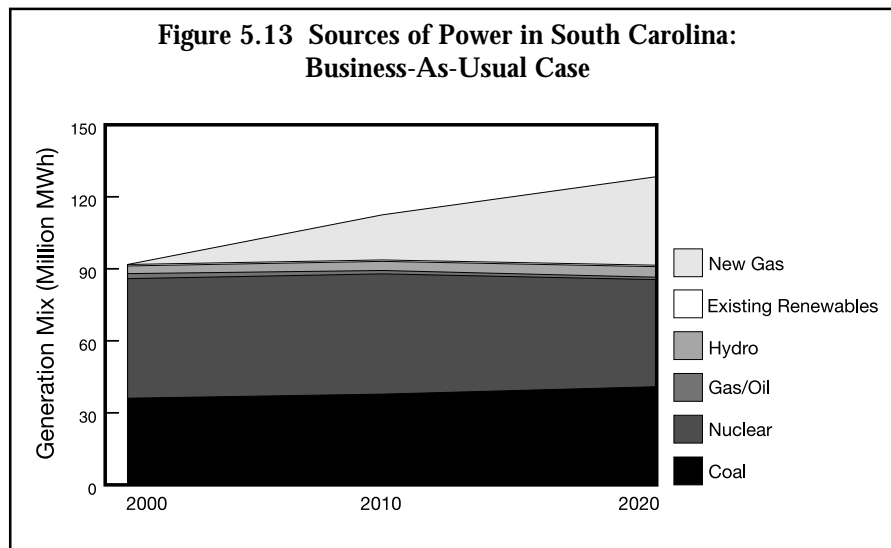
The Clean Power Plan can be achieved with little or no additional costs to electricity customers on average. Regionally, the Clean Power Plan would increase overall electricity costs by 0.6% in 2010, and would reduce overall costs by 1.7% in 2020.

Energy Efficiency Opportunities

South Carolina has the potential to reduce electricity consumption significantly through existing, cost-effective efficiency technologies and measures. Energy efficiency has the potential to:

■ Save 27 million MWh of electricity by 2020—roughly equivalent to the generation from 13 power plants.

■ Reduce electricity demand nearly 14% by 2010 and 23% by 2020.

■ Cost significantly less than generating, transmitting, and distributing electricity—with an average cost of 2.6¢/kWh.

■ Reduce net electricity costs by $375 million by 2020, as indicated in Figure 5.15.

Renewable Generation Opportunities

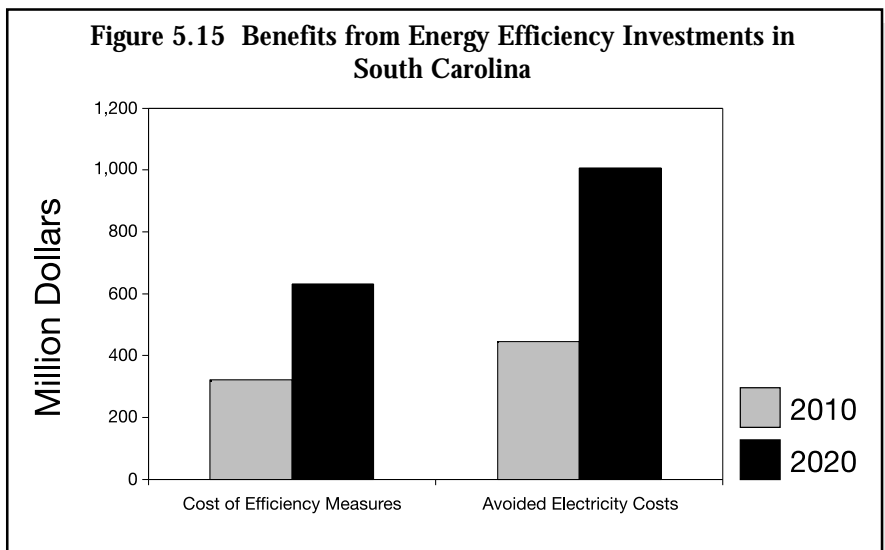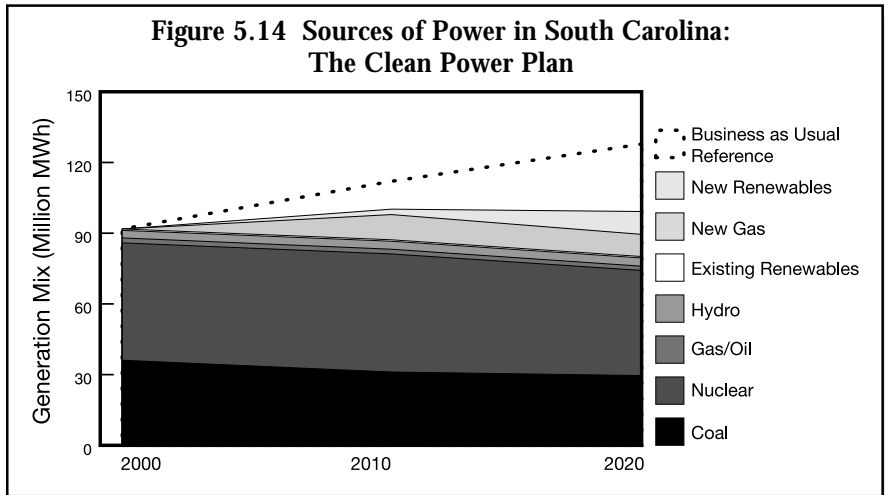Table 5.5 presents the renewable resources installed in South Carolina in the

Figure 5.14 Sources of Power in South Carolina: The Clean Power Plan

Figure 5.15 Benefits from Energy Efficiency Investments in South Carolina

Table 5.5 New Renewable Resources in the Clean Power Plan in South Carolina

| Generator Type	2010				2020			
	Installed Capacity (MW)	Capacity (% of all fuels)	Generation (1000 MWh)	Generation (% of all fuels)	Installed Capacity (MW)	Capacity (% of all fuels)	Generation (1000 MWh)	Generation (% of all fuels)
Biomass Co-Firing	227	1.1%	1,408	1.4%	522	2.4%	3,276	3.3%
Landfill Methane	14	0.1%	119	0.1%	30	0.1%	250	0.3%
BiomassCHP	201	1.0%	1,056	1.0%	424	2.0%	2,229	2.2%
PhotoVoltaic	2	0.0%	3	0.0%	40	0.2%	58	0.1%
Wind Turbines	88	0.4%	299	0.3%	1,165	5.4%	4,414	4.4%
Total Renewables	**532**	**2.6%**	**2,885**	**2.9%**	**2,181**	**10.2%**	**10,227**	**10.3%**

Note: The wind turbine information is for both on-shore and off-shore turbines. Off-shore turbines represented 46 MW of capacity in 2010 and 922 MW of capacity in 2020.

Clean Power Plan in 2010 and 2020. Biomass co-firing and off-shore wind present the greatest opportunity, each representing roughly 3% of generation in 2020.

TENNESSEE

The Electricity Industry Under Business-as-Usual Conditions

As shown in Figure 5.16, Tennessee currently relies heavily on fossil and nuclear power plants, with coal providing 64% of generation, oil providing 4% of generation, and nuclear providing 21%. Hydropower provides the remaining 11%. Electricity demand is expected to grow at roughly 2% per year from 2000 through 2020. Consequently, Tennessee is expected to require 8,053 thousand MW of new electricity capacity— equivalent to roughly 27 power plants of 300 MW each—over the next 20 years. This new electricity demand is expected to be met almost entirely with new natural gas power plants. (Note: There has recently been increased interest in building new coal plants to meet future load instead of new gas plants; if that happens, it would most likely result in slightly higher costs and increased air emissions than assumed here.)
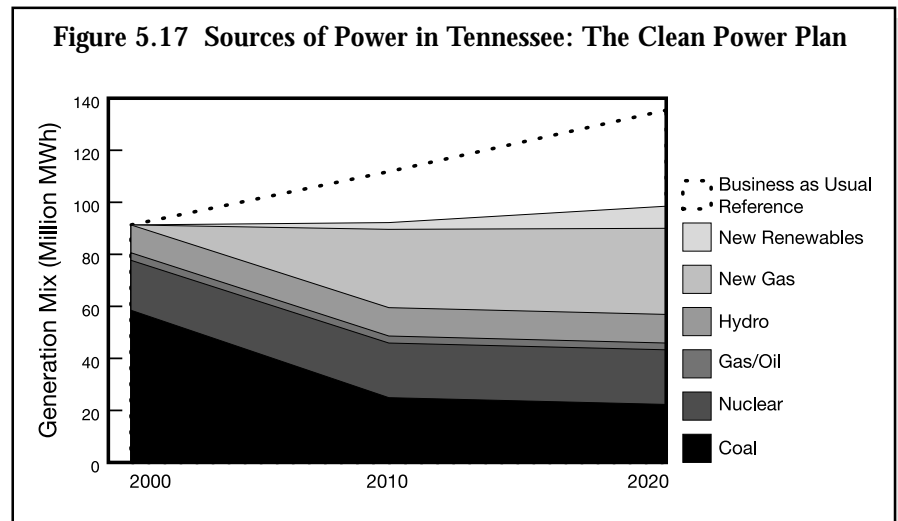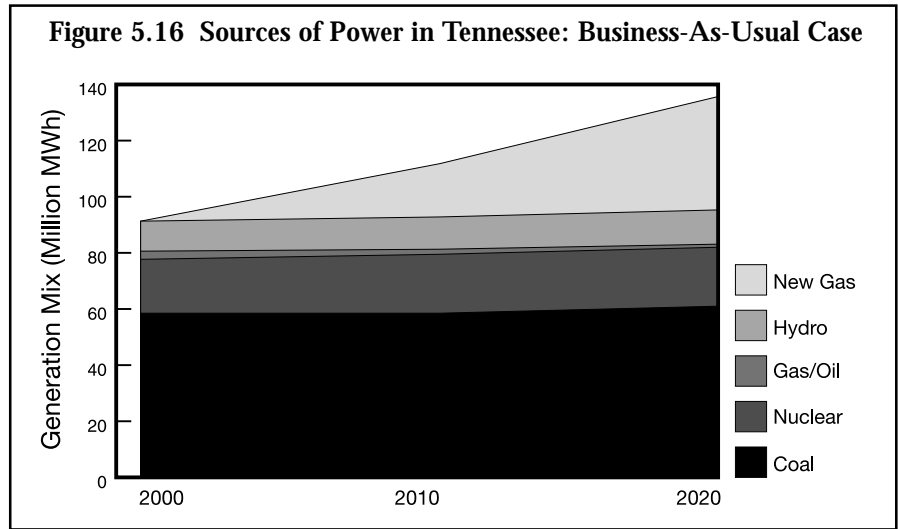
The Clean Power Plan

Figure 5.17 presents a summary of the Clean Power Plan. The growth in electricity demand over the period is expected to be reduced dramatically as a result of the energy efficiency investments. New renewable biomass, wind, and solar resources are expected to reduce the need for new gas power plants. And generation from older, less efficient, highly polluting coal plants is expected to be reduced significantly.

The Clean Power Plan results in dramatic improvements in environmental quality by 2020, compared with business-as-usual practices. SO$_2$ emissions
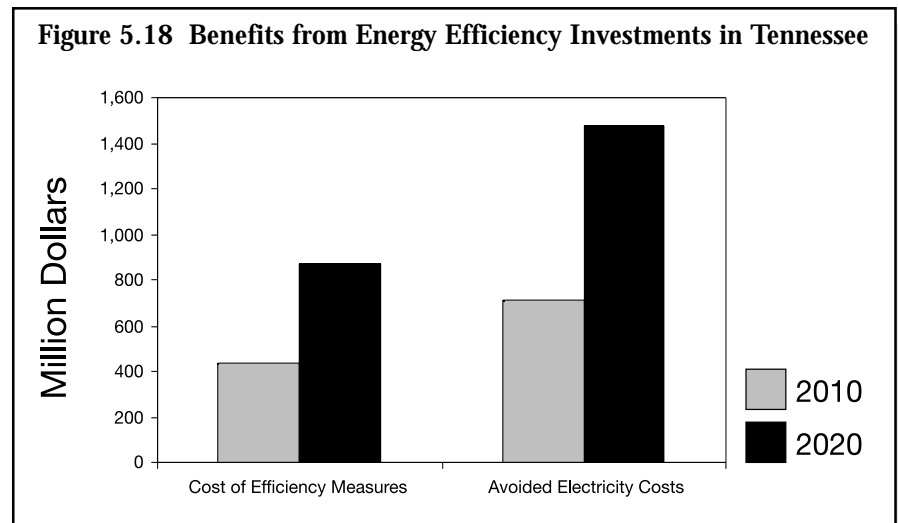

Figure 5.16 Sources of Power in Tennessee: Business-As-Usual Case

Figure 5.17 Sources of Power in Tennessee: The Clean Power Plan

Figure 5.18 Benefits from Energy Efficiency Investments in Tennessee

Table 5.6 New Renewable Resources in the Clean Power Plan in Tennessee

Generator Type	2010				2020			
	Installed Capacity (MW)	Capacity (% of all fuels)	Generation (1000 MWh)	Generation (% of all fuels)	Installed Capacity (MW)	Capacity (% of all fuels)	Generation (1000 MWh)	Generation (% of all fuels)
Biomass Co-Firing	0	0.0%	0	0.0%	332	1.3%	2,471	2.5%
Landfill Methane	20	0.1%	169	0.2%	42	0.2%	353	0.4%
BiomassCHP	217	0.9%	1,141	1.2%	458	1.8%	2,407	2.4%
PhotoVoltaic	2	0.0%	3	0.0%	20	0.1%	29	0.0%
Wind Turbines	413	1.7%	1,270	1.4%	1,088	4.3%	3,278	3.3%
Total Renewables	**652**	**2.7%**	**2,582**	**2.8%**	**1,940**	**7.7%**	**8,538**	**8.6%**

are reduced by 84%, NO_X emissions are reduced by 62%, and CO_2 emissions are reduced by 49%. There will be comparable reductions in emissions of mercury and particulates.

The Clean Power Plan can be achieved with little or no additional costs to electricity customers on average. Regionally, the Clean Power Plan would increase overall electricity costs by 0.6% in 2010, and would reduce overall costs by 1.7% in 2020.

Energy Efficiency Opportunities
Tennessee has the potential to reduce electricity consumption significantly through existing, cost-effective efficiency technologies and measures. Energy efficiency has the potential to:

■ Save 34 million MWh of electricity by 2020—roughly equivalent to the generation from 16 power plants.

■ Reduce electricity demand nearly 14% by 2010 and 23% by 2020.

■ Cost significantly less than generating, transmitting, and distributing electricity—with an average cost of 2.6¢/kWh.

■ Reduce net electricity costs by $600 million by 2020, as indicated in Figure 5.18.

Renewable Generation Opportunities
Table 5.6 presents the renewable resources installed in Tennessee in the Clean Power Plan in 2010 and 2020. On-shore wind and biomass co-firing present the greatest opportunity, representing roughly 3% and 2.5% of total generation in 2020 respectively.

CHAPTER 6. FOR FURTHER INFORMATION

ENVIRONMENTAL GROUPS

REGIONAL

Southeastern Regional Biomass Energy Program (SERBEP) <www.serbep.org>

Southern Alliance for Clean Energy (SACE). Contact: Stephen Smith, 865-637-6055, sasmith@tngreen.com <www.cleanenergy.org>

Southern Company's Earth Cents Web page <www.southerncompany.com/earthcents>

Southern States Energy Board (SSEB) <www.sseb.org>

State Energy Program Offices (SEP) <www.eren.doe.gov/aro/sep.html>

STATE

Alabama
Alabama Dept. of Economic and Community Affairs. Montgomery, AL (334) 242-5292

Alabama Environmental Council. Birmingham, AL (205) 323-4434 <www.aeconline.ws>

Alabama Solar Energy Center, University of Alabama, Huntsville, Phone: (800) 874-3327

Southern Research Institute <www.sri.org/renewable_energy.htm>

Florida
Florida Climate Alliance <www.floridaclimatealliance.net>

Florida Solar Energy Center <www.fsec.ucf.edu>

Florida Solar Energy Industries Association <www.flaseia.org>

Legal Environmental Assistance Foundation (LEAF). Contact: Deb Swim, 850-681-2591, dswim@leaf-environlaw.org

Georgia
Environmental Fund for Georgia <www.efg.org>

Georgia Environmental Facilities Authority <www.gefa.org>

Georgia Environmental Protection Department of Natural Resources <www.ganet.org/dnr/environ>

Georgians for Clean Energy. Contact: Rita Kilpatrick, Kilpatrick@cleanenergy.ws Phone: (404)-659-5675 <www.cleanenergy.ws>

Southface Energy Institute, Atlanta, GA, Contact: Dennis Creech, 404-872-3549 x110, dcreech@southface.org <www.southface.org>

North Carolina
Appalachian Voices. Contact: Harvard Ayers, 828-262-6381, Harvard@boone.net <www.appvoices.org>

Energy Division, North Carolina Department of Commerce, Raleigh, NC. Phone: (919) 733-2230, Toll-free in N.C. (800) 622-7131

North Carolina Advanced Energy Corporation, Raleigh, NC. Phone: (919) 857-9000 <www.advancedenergy.org>

North Carolina Solar Center, Raleigh, NC. (919) 515-3480, Toll-free in NC: (800) 33-NC SUN, Email: ncsun@ncsu.edu <www.ncsc.ncsu.edu/index.html

North Carolina Solar Energy Association, Raleigh, NC. Phone: 919-832-7601 <www.ncsolar.org>

South Carolina
South Carolina Energy Office <www.state.sc.us/energy/sust-renewablepage.htm>

Statewide Environmental Protection Organizations <www.sciway.net/org/environmental.html>

Tennessee
Energy Division, Department of Economics and Community Development <www.state.tn.us/ecd/energy_links.htm>

Foundation for Global Sustainability <www.korrnet.org/fgs>

Tennessee Green Online <www.tngreen.com>

NATIONAL ORGANIZATIONS

Alliance to Save Energy, Washington, DC. Phone: (202) 857-0666, E-mail: info@ase.org <www.ase.org>

American Bioenergy Association <www.biomass.org>

American Council for an Energy Efficient Economy, Washington, DC. Phone: (202) 429-8873, E-mail: info@aceee.org <www.aceee.org>

American Solar Energy Society, Boulder, CO. Phone: (303) 443-3130, E-mail: ases@ases.org <www.ases.org,>

American Wind Energy Association, Washington, DC. Phone: (202) 383-2500, E-mail: windmail@awea.org <www.awea.org>

Bioenergy Information Network (Oakridge National Laboratory) <http://bioenergy.ornl.gov>

Database of State Incentives for Renewable Energy (DSIRE) <www.dsireusa.org>

Department of Energy (DOE). Efficiency and Renewable Energy Network (EREN) <www.eren.doe.gov>

Energy Division at Oakridge National Laboratory (ORNL). <www.ornl.gov/divisions/energy/energy.html>

Energy Information Administration <www.eia.doe.gov>

EREN's Bioenergy Page <www.eren.doe.gov/RE/bioenergy.html>

Interstate Renewable Energy Council, Latham, New York. 518-458-6059 (phone & fax), Email: info@irecusa.org <www.irecusa.org>

National Bioenergy Industries Association <www.bioenergy.org>

National Renewable Energy Laboratory <www.nrel.gov>. For solar radiation data and wind data: <http://rredc.nrel.gov>

Office of Industrial Technology (OIT) <www.oit.doe.gov>

Renewable Energy Policy Project (REPP), Washington, DC. Email: info@crest.org <www.repp.org> and <www.crest.org>

Renewable Technology Characterizations <www.eren.doe.gov/power/techchar.html>

State Energy Alternatives <www.eren.doe.gov/state_energy>

Southeast Regional Office of the U.S. EPA <www.epa.gov/region4>

ENERGY EFFICIENCY AND RENEWABLE ENERGY FIRMS

California Energy Commission (CEC) Consumer Energy Center list of renewable energy equipment suppliers. <www.consumerenergycenter.org/renewable/buying/retailers.html>

Center for Resource Solutions page on purchasing green power <www.green-e.org>

Global Energy Marketplace (GEM) <www.crest.org/gem.html>

Internet marketplace for the wind power industry: <www.WindPowerOnline.com>

James & James online database of Renewable Energy Suppliers and Services <www.jxj.com>. To search database: <www.oma.ws/jxj_re_db/suppands_search.php>

Oikos searchable database of companies manufacturing energy efficient products <www.oikos.com>

RealGoods catalogue <www.realgoods.com>

ENDNOTES

CHAPTER 1 ENDNOTES

1   Beth Schapiro & Associates, *Survey of 1600 Voters in Florida, Georgia, Tennessee and Virginia* (Atlanta: November 1998).

2   U.S. Environmental Protection Agency (EPA). Emissions & Generation Resource Integrated Database 2000 (E-GRID2000PC Version 2.0). September 2001. <http://www.epa.gov/airmarkets/egrid/>

3   Ibid.

4   American Lung Association, *State-by-State Lung Disease Trend Report 2001*, at <www.lungusa.org/data/s2s/table_1.html>, accessed 19 September 2001.

5   Clear the Air. *Tennessee's Dirty Power Plants* (Washington, DC: July 2000) <http://cta.policy.net/relatives/17240.pdf> and *North Carolina's Dirty Power Plants* (Washington, DC: June 2000) <http://cta.policy.net/relatives/17240.pdf>, accessed 19 September 2001.

6   EPA, *Air Quality Index*, at <www.air.dnr.state.ga.us/psg/stats00.php>, accessed 19 September 2001.

7   Georgia state data cited in Campaign for a Prosperous Georgia, *Southern Fried Air* (Atlanta, GA: September 1998).

8   EPA, *National Air Quality Trends and Emissions Report 1999*, at <www.epa.gov/oar/aqtrnd99>, accessed 24 September 2001.

9   Based on analysis of data obtained from EPA, *National Air Toxics Assessment*, at <www.epa.gov/ttn/atw/nata/tablemis.html>, accessed 24 September 2001.

10 National Academy of Sciences, "EPA's Methylmercury Guideline Is Scientifically Justifiable For Protecting Most Americans, But Some May Be at Risk," press release (Washington, DC: July 11, 2001).

11 U.S. Global Change Research Program, *Climate Change Impacts on the United States: The Potential Consequences of Climate Variability and Change* (Washington, DC: 2000).

12 EPA, at <www.epa.gov/globalwarming/impacts/stateimp/southcarolina/index.html>, accessed 19 September 2001.

13 Natural Resources Defense Council and Florida Climate Alliance, *Feeling the Heat in Florida* (Washington, DC: October 2001).

14 EPA, at <www.epa.gov/globalwarming/impacts/stateimp/alabama/index.html>, accessed 19 September 2001.

15 Op. cit. U.S. Global Change Research Program.

16 The poor may be at greater risk because they are less able to afford air conditioning or to engage in other strategies that can reduce heat stress, e.g., leaving the city during peak heat or visiting air-conditioned environments.

17 Jonathan A. Patz et al., "Potential Consequences of Climate Variability and Change for Human Health in the United States," in U.S. Global Change Research Program, op. cit.

18 Janice Longstreth, "Public Health Consequences of Global Climate Change in the United States—Some Regions May Suffer Disproportionately," *Environmental Health Perspectives*, Supplement 1, February 1999.

19 EPA, *Deposition of Pollutants to the Great Waters: Third Report to Congress* (Washington, DC: June 2000).

20 EPA, *Visibility in Our National Parks and Wildernesses*, at <www.epa.gov/air/vis/grsm_t.html>, accessed 24 September 2001.

21 Ibid.

22 Op. cit. EPA. *National Air Quality Trends and Emissions Report 1999*, especially Chapter 6.

23 U.S. Office of Surface Mining, at <www.osmre.gov/mtindex.htm>, as cited in Adam Serchuk, *The Environmental Imperative for Renewable Energy: An Update* (Washington, DC: Renewable Energy Policy Project, April 2000).

24 U.S. Office of Surface Mining, at <www.osmre.gov/coalprodindex.htm#A>, accessed 24 September 2001.

25 Wayne Solely, Robert Pierce, and Howard Perlman, *Estimated Use of Water in the United States in 1995*, U.S. Geological Survey Circular 1200, at <water.usgs.gov/watuse/pdf1995.html>, accessed 17 February 2000, as cited in Adam Serchuk, *The Environmental Imperative for Renewable Energy: An Update* (Washington, DC: Renewable Energy Policy Project, April 2000).

26 Marshall Goldberg. *Federal Energy Subsidies: Not All Technologies Are Created Equal.* Renewable Energy Policy Project, Research Report No. 11 (Washington, DC: July 2001)

27 Mark Holt, Congressional Research Service, "Civilian Nuclear Waste Disposal," Issue Brief for Congress 92059 (Washington, DC: 8 November 1999), as cited in Adam Serchuk, *The Environmental Imperative for Renewable Energy: An Update* (Washington, DC: Renewable Energy Policy Project, April 2000).

28 Erin Moriarty. *PSC Backs Southern On Nuclear Waste.* (Atlanta Business Chronicle: February 16, 2001) Accessed December 3 at <http://atlanta.bcentral.com/atlanta/stories/2001/02/19/story2.html>

29 U.S. Department of Energy (DOE). *Yucca Mountain Science and Engineering Report: Technical Information Supporting Site Recommendation Consideration.* (Washington DC: May 2001) Report No. DOE/RW-0539.

30 Auke Piersma, *Petition to Federal Trade Commission to Declare Nuclear Energy Institute Advertisements False and Misleading* (2 June 1999), p. 9, at <www.citizen.org/cmep/restructuring/ftc.pdf>, accessed 8 March 2000, as cited in Adam Serchuk, *The Environmental Imperative for Renewable Energy: An Update* (Washington, DC: Renewable Energy Policy Project, April 2000).

31 Safe Energy Communication Council, *Myth Buster #8: "Low-Level" Radioactive Waste* (Washington, DC: summer 1992), as cited in Adam Serchuk, *The Environmental Imperative for Renewable Energy: An Update* (Washington, DC: Renewable Energy Policy Project, April 2000).

CHAPTER 2 ENDNOTES

32 Exports and imports between states within the six-state region were not modeled in this study due to data availability limitations. Due to this, generation shares by fuel type from information reporting sources such as the U.S. DOE Energy Information Administration (EIA), which are based on power consumed by state rather than power physically generated by state, may in some cases differ from the generation shares presented in this report.

33 A plant's "capacity factor" is a measure of the portion of the time that it generates electricity. It is determined primarily by its availability, its variable costs, and the electricity load on the system. Plants with low variable costs—baseload plants—will operate at capacity factors of roughly 60–85%. Those with moderate variable costs—cycling plants—tend to operate at capacity factors of roughly 35–60%. And plants with high variable costs—peaking plants—tend to operate at capacity factors below 35%.

34 The efficiency of a power plant is a measure of the amount of electricity that can be generated with a given amount of fuel input.

35 The state-by-state electricity generation presented in Figure 2.2 and elsewhere in this report is based on the geographic location of the power plants; it does not account for the imports and exports across state boundaries. This and other modeling approaches are explained in more detail at the end of this chapter.

36 U.S. Department of Energy (DOE), Energy Information Administration (EIA), *Annual Energy Outlook 2001* (Washington, DC: December 2000).

37 A megawatt (MW) is equal to 1 million Watts. One megawatt running for one hour produces roughly enough power to meet one average American home's power needs for a month.

38 There are currently 26,283 MW of nuclear capacity in the region. Between 2010 and 2020, roughly 18% of this (4,812 MW) is expected to retire. The nuclear retirements are based on op. cit. DOE *Annual Energy Outlook 2001*, as described in more detail at the end of this chapter.

39 SO2 emissions are likely to increase by 5% under Business as Usual from 2000 to 2020.

40 The costs of the Clean Power Plan include the annualized costs associated with the retirement of the old, inefficient coal plants in response to a carbon dioxide reduction policy. This cost is estimated to be roughly $564 million per year. Without this, the Clean Power Plan is projected to result in net benefits of $271 million in 2010 and net benefits of $1,446 in 2020. Adding the coal retirement cost to the Clean Power Plan results in net costs in 2010 but net benefits in 2020.

41 Interlaboratory Working Group on Energy Efficient and Clean Energy Technologies, *Scenarios for a Clean Energy Future* (Oak Ridge, TN, and Berkeley, CA: November 2000); Interlaboratory Working Group (Five Labs), *Scenarios of US Carbon Reductions: Potential Impacts of Energy Technologies by 2010 and Beyond*, prepared for the Office of Energy Efficiency and Renewable Energy, DOE (Washington, DC: September 1997).

42 Alliance to Save Energy, American Council for an Energy-Efficient Economy, Natural Resources Defense Council, Tellus Institute, and Union of Concerned Scientists, *Energy Innovations: a Prosperous Path to a Clean Environment* (Washington, DC: 1997); World Wildlife Fund and Energy Foundation, *America's Global Warming Solutions*, prepared by Tellus Institute and Marshall Goldberg (Washington, DC: August 1999).

43 DOE, *Wind Energy Resource Atlas of the United States* (Washington, DC: 1987).

44 The windy land area estimates were derived from wind resource maps developed by TrueWind Solutions, LLC, a New York-based wind energy consulting firm. The maps, which were developed for private clients, are not publicly available.

45 Ocean wind speed estimates are obtained from microwave imagers (TMI or SSM/I) that measure the reflectances of waves. Monthly and daily wind data can be downloaded from <www.ssmi.com>.

46 Antares Group, *Biomass Residue Supply Curves for the United States*, Update, prepared for DOE's Biomass Power Program and the National Renewable Energy Laboratory (Landover MD: June 1999).

47 The premium paid to farmers, $10–15/dry ton, is based on the experience of several companies that purchase corn stover or wheat straw for bedding, insulating materials, particle board, paper, and chemicals. The transportation cost of $5–10/dry ton covers hauling crop residues a distance of up to 50 miles.

48 R. Perez, H. Wenger, and C. Herig, "Valuation of Demand-Side Commercial PV Systems in the United States," Proceedings of the 1998 Annual Conference—American Solar Energy Society, Albuquerque, NM, 14–17 June 1998; Electric Power Research Institute, *Electricity Technology Roadmap: 1999 Summary and Synthesis*, CI-112677-VI (Palo Alto, CA: July 1999); DOE, EIA, *Annual Energy Outlook 2000* (Washington, DC: December 1999).

CHAPTER 3 ENDNOTES

49 Efficiency investments in the Clean Power Plan total $2.9 billion. Electricity generation under the plan is 801 million MWh. Assuming 9% line loss, this translates into 729 million MWh; $2.9 billion divided by 729 million MWh equals 0.4¢ per kilowatt-hour, or the investment in energy efficiency in 2010 when fully allocated to total electricity consumption.

50 Mark Bolinger, Ryan Wiser, Lew Milford, Michael Stoddard, and Kevin Porter, *Clean Energy Funds: An Overview of State Support for Renewable Energy* (Berkeley, CA: Lawrence Berkeley Laboratory, April 2001).

51 See, for example, Joe Romm, *Cool Companies: How the Best Businesses Boost Profits and Productivity by Cutting Greenhouse Gas Emissions* (Washington, DC: Island Press, 1999), and Amory Lovins, Paul Hawken, and Hunter Lovins, *Natural Capitalism* (Snowmass, CO: Rocky Mountain Institute, 2000).

52 Jennifer Thorne, Toru Kubo, and Steven Nadel, *Opportunity Knocks: Capturing Pollution Reductions and Consumer Savings from Updated Appliance Efficiency Standards*, Appliance Standards Awareness Project (March 2000), available at <www.standardsasap.org>.

53 Steven Nadel and Miriam Pye, *Appliance and Equipment Safety Standards: Impacts by State* (Washington, DC: American Council for an Energy-Efficient Economy, 1996).

54 Virinder Singh, *Clean Government: Options for Governments to Buy Renewable Energy* (Washington, DC: REPP, April 1999).

55 U.S. Department of Energy, Energy Information Administration, *1997 Residential Energy Consumption Survey*, at <ftp://ftp.eia.doe.gov/pub/consumption/residential/ce_tables/enduse_expend.pdf>, accessed 26 September 2000.

56 Nancy Rader and Scott Hempling, *The Renewable Portfolio Standard: A Practical Guide* (Washington, DC, National Association of Regulatory Utility Commissioners, February 2001), pp. 88–89.

57 Ibid., Appendix A.

58 Bolinger et al., op. cit.; California Energy Commission (CEC), *Annual Project Activity Report to the Legislature: Renewable Energy Program*, P500-00-004 (Sacramento, CA: March 2000); CEC, *Annual Project Activity Report to the Legislature: Renewable Energy Program*, P500-00-021 (Sacramento, CA: December 2000).

59 Alec Jenkins, Richard Chapman, and Hugh Reilly, *Tax Barriers to Four Renewable Electric Generation Technologies* (Sacramento, CA: CEC, undated).

60 Brent Alderfer, Monika Eldridge, and Thomas Starrs, *Making Connections: Case Studies of Interconnection Barriers and Their Impact on Distributed Power Projects*, NREL/SR-200-28053 (Golden, CO: National Renewable Energy Laboratory, May 2000).

61 National Database of State Incentives for Renewable Energy, at <www.dcs.ncsu.edu/solar/dsire/regulatory.html>, accessed 7 August 2001.

62 Tennessee Valley Authority, at <www.tva.gov/greenpowerswitch/newsletter/updates.htm>, accessed 13 August 2001.

63 Based on analysis by authors of data from U.S. Environmental Protection Agency's 2000 E-Grid database.

64 Elizabeth Thompson, *Poisoned Power* (Washington, DC: Clean Air Network, September 1997).

65 Analysis by authors based on data from ibid.

66 Virinder Singh, *Blending Wind and Solar into the Diesel Generator Market* (Washington, DC: REPP, winter 2000–01).

67 Joseph Iannucci, *Air Pollution Emission Impacts Associated with Economic Market Potential of Distributed Generation in California*, prepared for the California Air Resources Board and the California Environmental Protection Agency, June 2000).

68 Duncan Mansfield, "TVA to Install Scrubbers at 5 of Its Power Plants," *Knoxville News*, 5 October 2001.

CHAPTER 4 ENDNOTES

69 Safe Energy Communication Council, "Bush Plan to Revive Nuclear Power is the Most Costly Option to Fight Climate Change & Air Pollution: Energy Efficiency and Renewable Energy Most Cost-Effective Strategy," press release (Washington DC: 16 May 2001).

70 International Rivers Network, "The Coming Energy Revolution," in *World Rivers Review* (Berkeley, CA: 1996).

71 Joe Romm, *Cool Companies: How the Best Businesses Boost Profits and Productivity by Cutting Greenhouse Gas Emissions* (Washington DC: Island Press, 1999).

72 Ibid.

73 Ibid.

74 Consumer's Choice Council, *Energy Savings from Recycling* (Environmental Media Services: 8 May 2001).

75 Interlaboratory Working Group on Energy Efficient and Clean Energy Technologies, *Scenarios for a Clean Energy Future* (Oak Ridge, TN, and Berkeley, CA: November 2000).

76 Op. cit. Romm.

77 Op. cit. Interlaboratory Working Group.

78 Ibid.

79 Information in this box adopted from the Business and Industry Services office at Georgia Institute of Technology, at <www.industry.gatech.edu/energy>, accessed 20 September 2001.

80 Op. cit. Romm.

81 Ibid.

82 Ibid.

83 Donald Aitken, *Putting It Together: Whole Buildings and a Whole Buildings Policy* (Washington, DC: REPP, September 1998).

84 Solar reflectance, or albedo, is the fraction of incoming direct and diffuse solar radiation reflected by a surface. Materials with high solar reflectance values absorb less of the sun's energy and therefore stay cooler, reducing daytime air conditioning requirements. For more information, see <www.eren.doe.gov/femp/procurement/roof.html>.

85 "Revolutionary New Exit Signs," *Environmental Building News*, May/June 1994, and FacilityManagement.com, "Winning With LED Exit Sign Technology," at <www.facilitymanagement.com/articles/artexit.html>, accessed 27 September 2001.

86 *Financing Your Geothermal Heat Pump* (on-line resource), at <www.igshpa.okstate.edu/Technology/MoreInfo/FactSheet/FinanceFactSheet.htm>; U.S. Department of Energy (DOE), *Geothermal Heat Pumps*, DOE/GO-10098-652 (Washington, DC: September 1998).

87 Energy Star performance is rated on a 1 to 100 scale, where a score of 75 or higher signifies the building is among the nation's top 25% in terms of energy performance, and may qualify it to display the Energy Star logo if indoor environmental criteria are also met. For more information on the Energy Star program of the U.S. Environmental Protection Agency (EPA), see <www.energystar.gov>.

88 Information in this box adapted from <www.pplinc.com/service/energy/energystar.htm> and from <www.energystar.gov>, accessed 21 September 2001.

89 Op. cit. DOE/GO-10098-652

90 David Block and John Harrison, Florida Solar Energy Center, *Solar Water Heating: A Question and Answer Primer* (rev. May 1997), at <www.fsec.ucf.edu/Solar/Apps/SDHW/En5.htm>, accessed 12 October 2001.

91 Op. cit. Romm; EnergyGuide.com, "Bigger is Not Better When It Comes to Air-Conditioned Comfort," at <www.energyguide.com/info/article1.asp>, accessed 27 September 2001.

92 Op. cit. Romm.

93 Solar Energy Industries Association, *Solar Thermal Fact Sheet*, at <www.seia.org>.

94 Ibid.

95 Op. Cit. EnergyGuide.com.

96 Op. cit. Romm.

97 Ibid.

98 The EnergyGuide.com Web site has a calculator to determine the economics of light bulb replacements, as well as an extensive list of lighting information links; see <www.homeenergy.org/consumerinfo/lighting>.

99 The average service life of refrigerators is about 17 years; James Cavallo, "Refrigerators—Eight Year Olds Burn a Lot of Energy," *Home Energy Magazine*, at <www.homeenergy.org/consumerinfo/refrigeration/index.php>, accessed 27 September 2001.

100 Ibid. The HomeEnergy.org Web site also walks a consumer through the economic analysis of whether or not to buy an energy-efficient refrigerator to replace an aging inefficient one.

101 DOE, "About Clothes Washer Efficiency, " at <www.eren.doe.gov/buildings/ consumer_information/clotheswashers/ >, accessed 27 September 2001.

102 Op. cit. Romm.

103 Op. cit. Interlaboratory Working Group on Energy Efficient and Clean Energy Technologies; Alan Meier and Wolfgang Huber, "Results from the Investigations on Leaking Electricity in the USA," 1997 EU Conference on Home Appliances, LBNL Report No. 40909 (Berkeley, CA: Lawrence Berkeley National Laboratory, November 1997). Leaking electricity falls into three major categories: video, audio, and communication. TV sets, VCRs, compact audio equipment, cable boxes, rack audio, microwave ovens, battery chargers, answering machines, clock radios, and cordless phones account for about 70% of leaked electricity. For more information, see <http://standby.lbl.gov> and <http://EETD.LBL.gov/EA/Reports/40909/>.

104 Op. cit. Meier and Huber, LBNL Report No. 40909.

105 DOE, Federal Energy Management Program, "How to Buy 'Cool' Roof Products," at <www.eren.doe.gov/femp/procurement/pdfs/roof.pdf>, accessed 27 September 2001).

106 Information in this box derived from personal communication with Dennis Creech of Southface Institute, 14 September 2001, and from <www.earthcrafthouse.com>. Mr. Creech can be reached at 404-872-3549.

107 Projected improvements should make class 3 areas attractive in the future. Smaller wind turbines for residential and farm applications are designed to run in lower wind speeds.

108 P. Vølund, SEAS Denmark. "World's Largest Wind Farm Built in Denmark," *CADDET Renewable Energy Newsletter*, March 2001, at <www.caddet-re.org/assets/101art5.pdf>, accessed 15 October 2001.

109 The discussion of wind system costs is adopted with permission from *Repowering the Midwest: The Clean Energy Development Plan for the Heartland*, prepared for the Environmental Law and Policy Center by Synapse Energy Economics in collaboration with Brower and Company, Environmental Law and Policy Center, Renewable Energy Policy Project, and Tellus Institute (Chicago, IL: 2001).

110 Ibid. Assumes an average new wind plant size of 50 megawatts (MW) in 2000 and 100 MW in 2010 and 2020. The capacity factor increases reflect projected improvements in technology and increases in tower height from 60 to 80 meters in 2010 and 100 meters in 2020. The capacity factors include expected electrical, mechanical, and wake losses. Capital costs do not include transmission interconnection.

111 The discussion of wind system costs is adopted with permission from Op. Cit. *Repowering the Midwest.*

112 The discussion of wind penetration is adopted with permission from Op. Cit. *Repowering the Midwest.*

113 British Wind Energy Association <www.britishwindenergy.co.uk>

114 European Wind Energy Association <www.ewea.org>

115 American Wind Energy Association (AWEA), "Wind Energy OUTLOOK 2000," a Web-based presentation, at <www.awea.org/outlook2000/index.html>, and from AWEA, "2000 Global Wind Energy Market Report" at <www.awea.org/faq/global2000.html>, both accessed 25 September 2001.

116 Ibid.

117 AWEA, "Wind Energy's Costs Hit New Low, Position Wind as Clean Solution to Energy Crisis, Trade Group Says," press release (Washington DC: 6 March 2001).

118 Information in this box adopted from Public Power Institute, Tennessee Valley Authority (TVA), at <www.publicpowerinstitute.org/windpower.html>, and from TVA's Green Power Switch Program at <www.tva.gov/greenpowerswitch>, both accessed 18 September 2001.

119 Personal communication with Rick Carson, TVA, 18 September 2001; Carson can be reached at 423-751-7461, or at <wrcarson@tva.gov>.

120 The discussion of biomass resources is in part adopted with permission from Op. cit. *Repowering the Midwest.*

121 For detailed information on urban wood waste, see DOE's "Urban Wood Waste Resources Assessment," NREL/SR-570-25918 (November 1998), at <www.eren.doe.gov/biopower/bplib/library/urbanwaste.pdf>.

122 EPA, *State Resources and Options: a Handbook for Facilitating Landfill Gas-to-Energy Projects* (Washington DC: 1996), Table 3.1. These costs are currently being revised by EPA, and significant changes are expected; personal conversation with Shelley Cohen of EPA, Landfill Methane Outreach Program (LMOP), 2 April 2001.

123 Discussion of biomass co-firing, combined heat and power, and direct firing are adapted with permission from Op. cit. *Repowering the Midwest.*

124 Information in this box derived from the following sources: D. Boylan, V. Bush, and D. Bransby, "Switchgrass Cofiring: Pilot Scale and Field Evaluation," *Biomass and Bioenergy*, Elsevier Science, Vol. 19, Issue 6 (2000), pp.411–17; D. Boylan, S. Wilson, B. Zemo, and V. Bush, "Evaluation of Switchgrass Co-Firing for Utility Boiler Applications," 2001 International Joint Power Generation Conference, New Orleans, LA, 4–7 June 2001, JPGC2001/FACT-19050, at <asme.pinetec.com/ijpgc2001/data/html/fact/19050.html>; *Greenhouse Gas Technology Verification Center Newsletter*, Issue 5 (December 2000) at <www.epa.gov/etv/12/gh_nletter_205.pdf>.

125 Based on data obtained from the 1995 Utility Data Institute Coal Plant Database.

126 McNeil Technologies, Inc. *Assessment of Biogas-to-Energy Generation Opportunities at Commercial Swine Operations in Colorado.* (Golden, CO.: November 1, 2000). Viewed November 27, 2001 at <www.westbioenergy.org/swine/four.html>.

127 U.S. EPA AgSTAR program. Viewed November 27, 2001 at <www.epa.gov/agstar>.

128 A full version of the principles can be found at <www.crest.org/bioenergy>.

129 DOE, "Biomass Power-at-a-Glance," EREN State Technology Factsheets, at <www.eren.doe.gov/state_energy/technologies.cfm>, and DOE, "Biopower Projects," at <www.eren.doe.gov/biopower/projects/ia_pr_text.htm>, both accessed 25 September 2001.

130 Richard Perez, Steven Letendre, and Christy Herig, "PV and Grid Reliability: Availability of PV Power During Capacity Shortfalls" (NREL: 2000), at <lunch.asrc.cestm.albany.edu/~perez/ases2001-outages/paper-outage.pdf>, accessed March 2001.

131 Richard Perez, Robert Seals, and Christy Herig. "Photovoltaics Can Add Capacity to the Utility Grid," DOE/GO-10096-262 (Washington, DC: DOE, September 1996).

132 Generic description of PV cells and modules adopted with permission from Op. cit. *Repowering the Midwest.*

135 Personal communication with Jennifer Szaro, Florida Solar Energy Center, 19 September 2001; Ms. Szaro can be reached at 321-638-1427.

134 All costs reported here refer to the power output PVUSA test conditions (PTC) rating, which is defined as the AC output at 25 degree Celsius ambient temperature. Caution should be used in comparing PV systems costs from other sources, as the cost per kilowatt at standard test conditions (STC), which refers to DC at 20 degrees Celsius, will appear lower.

133 The discussion of PV system costs is in part adopted with permission from Op. cit. *Repowering the Midwest.*

136 M. Symko-Davies, R.L. Mitchell, C.E. Witt, H.P. Thomas, R. King, and D. Ruby, *Decade of PV Industry R&D Advances in Silicon Module Manufacturing*, NREL/CP-520-28928 (Washington, DC: DOE, January 2001).

137 Bill Rever, "Grid-Tied Markets for Photovoltaics—A New Source Emerges," *Renewable Energy World*, July-August 2001.

138 *PV News*, vol. 20, no. 3 (2001).

139 Peter Holihan, "Technology, Manufacturing, and Market Trends in the U.S. and International Photovoltaics Industry," in *Renewable Energy 2000: Issues and Trends* (Washington, DC: DOE, Energy Information Administration, February 2001).

140 Op. cit. *Repowering the Midwest*; Anders Hove, RAND Science and Technology Policy Institute, "Water World," in Noreen Clancy and David Rejeski, eds., *Our Future—Our Environment* (Arlington, VA: 2001), at <www.rand.org/scitech/stpi/ourfuture/GameChangers/hydrogenfuel.html>, accessed 12 October 2001.

The Renewable Energy Policy Project (REPP) supports the advancement of renewable energy technology through policy research. We seek to define growth strategies for renewables that respond to competitive energy markets and environmental needs. Since its inception in 1995, REPP has investigated the relationship among policy, markets and public demand in accelerating the deployment of renewable energy technologies, which include biomass, hydropower, geothermal, photovoltaic, solar thermal, wind and renewable hydrogen. The organization offers a platform from which experts in the field can examine issues of medium- to long-term importance to policy makers, green energy entrepreneurs, and environmental advocates.

REPP receives generous support from the U.S. Department of Energy, the Energy Foundation, the Joyce Mertz-Gilmore Foundation, and the U.S Environmental Protection Agency, the National Renewable Energy Laboratory (NREL), the Bancker-Williams Foundation, the Oak Foundation, the Surdna Foundation, and the Turner Foundation.

To order REPP publications, contact REPP at (202) 293-2898.

Get Involved with Powering the South
@
www.poweringthesouth.org

REPP publications are available free of charge on the Internet at
www.repp.org