The Electric Cooperatives of South Carolina, Inc.

Comments on Energy and Energy Policies

December 1, 2008

1. **What action do you anticipate from the U.S. Congress as to climate change legislation? What impact may this have on South Carolina?**

Impact of an Obama Presidency (federal, legislative or regulatory)

The electric cooperatives believe that action on climate change policy is likely within the next 18 months; however, full scale implementation of any policy decision could take several years to achieve. The reason is that the issue is enormously complex and the potential risk of making a mistake with serious economic ramifications is very real.

Sen. Obama's presidential victory opens the door to a major change in perspective on energy and climate change issues in the next Administration. Dan Kammen, an energy advisor to the Obama campaign, said that cap-and-trade legislation will be a top priority for the Obama Administration. Mr. Kammen also stated that President-elect Obama will review all Bush Administration environmental regulations and policies, including a possible re-visitation of the decision to deny California's request for a waiver to implement its vehicle GHG standards. In addition, President-elect Obama's environmental advisors have made clear that, while the President-elect prefers a Congressionally-enacted cap-and-trade program, he will start the process of EPA rulemaking if Congress does not take action within 18 months.

President-elect Obama favors implementation of an economy-wide cap-and-trade system to reduce greenhouse gas emissions 80% below 1990 levels by 2050. Obama's energy plan would require 100% of pollution credits to be auctioned to ensure that all industries pay for every ton of emissions they release. While a full auction approach is not optimal, the Obama plan would invest in clean energy technology development and deployment, invest in energy efficiency improvements to help families reduce energy prices and assist lower income Americans in transitioning to higher energy costs.

Cost Estimates for Previous Climate Change Proposals (Congress)

During the 110th Congress, there were numerous bills introduced that aimed to curb greenhouse gas emissions. One of the most publicized was the Lieberman-Warner Climate Change legislation (S.2191), which would use a cap-and-trade program to set limits on the amount of CO_2 a company can emit. Under a cap-and-trade program, emitters are allocated tradable allowances. If those allocations are insufficient to cover emissions, the emitter must purchase allowances from someone else, assuming the allowances are available. The price of the allowances will be determined by supply and demand. The Cooperatives have estimated that the cost of allowances alone could add $150 to $565 a year to each South Carolina electric cooperative member's electricity costs.

Dr. Anne E. Smith of CRA, International, has also made estimates of how the Lieberman-Warner bill would affect electricity costs. According to Dr. Smith's estimations, the annual redistribution of wealth caused by the Lieberman-Warner legislation would be between $150 and $500 billion. This amount is on par with our total U.S. Defense Department spending, or half of our total Social Security payout a year.

Furthermore, according to CRA and Dr. Smith, under an ideal scenario of technological progression, natural gas prices, and available cap offsets, the increased costs per ton of carbon under the Lieberman-

Warner plan could be $35[1] *by 2015 and $150 by 2050. Under a less-than-ideal scenario, increased costs per ton of carbon could be as high as $50 in 2015 and $350 in 2050. These increased costs of emitting carbon would translate into a 35% increase of wholesale electricity prices nationwide by 2015 and an 85% increase by 2050 under the ideal scenario. Under the less-than-ideal scenario, wholesale electricity prices could be 70% higher by 2015 and 125% higher by 2050. These increases in electricity costs will mean that household spending power in the United States will be reduced between $1000 in 2020 to almost $3000 in 2050. The Electric Power Research Institute (EPRI) estimates that under the ideal scenario of technological development, electricity costs could increase by 45% by 2050; under the less-than-ideal scenario, electricity could cost 260% more than what it costs today by 2050. These results will be more drastic in the Southeastern United States, where a greater percentage of electricity is generated by coal.*

Impact of Changes in Congressional Membership and Leadership

Before the election, many believed that the Lieberman-Warner bill would be the starting template for activity in the Senate. However, Senator Barbara Boxer (D-CA) announced in mid-November that she plans to introduce a "greatly streamlined" climate change bill shortly after the 111th Congress convenes in January 2009. Sen. Boxer offered few specifics but said that the bill will follow the greenhouse gas emission reduction goals laid out by President-elect Obama during his campaign. In addition to Senator Boxer's plans, Senator Joseph Lieberman (I-CT) said that he and Senator John McCain (R-AZ) would begin work on a new Lieberman-McCain bill.

In the House, Henry Waxman (D-Calif.) defeated John Dingell (D-Mich.) who had either chaired or been the ranking member of the Energy and Commerce Committee since 1981. The change in committee leadership could have significant implications for the movement of climate legislation in the next Congress as Rep. Waxman has been a proponent of aggressive greenhouse gas emissions reduction targets, Waxman supports more aggressive emissions reductions targets than does Dingell, and he supports states' abilities to reduce emissions even further than Federal law would provide.

Bottom Line Impact on South Carolina

Less moderation in the climate change dialogue could be an ominous sign for the people served by our state's electric cooperatives. As noted in the Office of Regulatory Staff's report, "South Carolina Energy Policy Inquiry Aggregate Responses," the average remaining depreciable book life of a coal plant in our state is 27 years. The electric cooperatives receive their power from the S.C. Public Authority (Santee Cooper). For Santee Cooper's 11 coal-fired plants — including one that went online only a year ago — the average remaining depreciable book life is 38.7 years. An inflexible and overly aggressive timeline on greenhouse gas emissions will hit co-op members particularly hard.

The reality is that the actions taken to limit greenhouse gas emissions will almost certainly increase the cost of power for South Carolina's electric cooperative consumers. These consumers are particularly vulnerable to policies which mandate unachievable caps on emissions.

[1] All amounts in 2007 dollars (i.e., not taking future inflation into account.)

Individuals and Families below Poverty Line

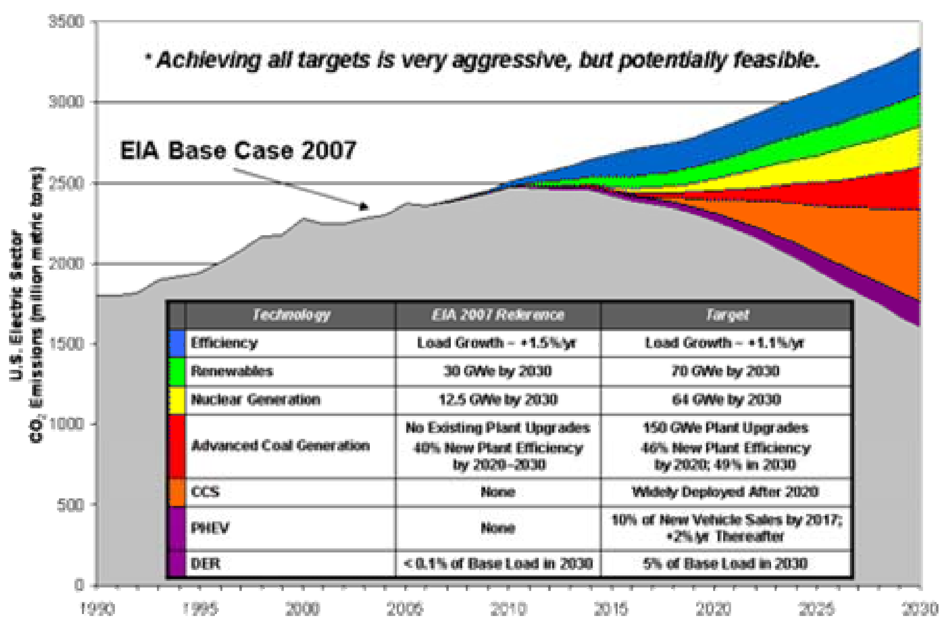
State	Median Household Income 2004		Median Family Income 2004		Individuals Below Poverty Level 2004		Families Below Poverty Level 2004	
	Dollars	Rank	Percent	Rank	Percent	Rank	Percent	Rank
South Carolina	39,837	37	47,680	38	15.7	9	12.5	9
United States	44,684	X	53,692	X	13.1	X	10.1	X

Source: U.S. Census Bureau, 2007 Statistical Abstract of the United States; Tables 687, 688 and 690.

South Carolinians are poorer than the average American. In 2005, 15.7% of individuals and 12.5% of families in South Carolina were below the poverty line, as opposed to 13.1% of individuals and 10.1% of families nationally. These differences may seem small, but South Carolina's poverty rate for individuals is 19.8% higher than the national rate; the family poverty rate in South Carolina is 23.8% higher than the national rate. The U.S. Department of Energy estimates that low-income families might spend up to 14% of their annual income on energy costs, as opposed to only 3.5% for other households, meaning that energy expenditures represent four times the burden on lower-income families than on families of higher income brackets. With so many citizens below poverty, and with electricity representing such a significant portion of low-income families' budget, increased electricity costs could put some South Carolinians in the position of having to choose between food, medicine, and paying the electric bill.

For the short term, energy efficiency is our greatest hope.
Will it be universally available to all South Carolinians?

Another important issue to be aware of is the presumption that South Carolinians will be just as able to take advantage of the cost reductions offered by increased energy efficiency as the rest of the country. In 2007, the Electric Power Research Institute performed a study in which they estimated how various technologies will help to reduce CO_2 emissions. From that study, EPRI created a "prism" graph, which is shown below. The blue band of the prism represents efficiency. The graph shows that increased energy efficiency will be one of the most significant avenues of CO_2 emission reductions. In fact, it is that portion of the prism that promises the greatest reduction in CO_2 emission in the early years (pre-2025).



A key component of the energy efficiency sliver of the EPRI prism is increased energy efficiency in residential homes. And indeed, conventional wisdom will hold that the best way for Americans to combat higher electricity rates will be to upgrade the efficiency of their homes. However, for a variety of reasons, South Carolinians are disadvantaged in terms of being able to upgrade their home energy efficiency. First, these upgrades are often very expensive, requiring the buyer to pay a heavy initial cost for long-term savings. According to Consumer Reports, a washer with the highest efficiency rating can cost as much as $1,900, with a Consumer Reports rating of 81. The cheapest washer on the market costs only $350, but has the second-worst energy efficiency rating and an overall Consumer Reports rating of only 38. Just as more of South Carolina's population falls below the poverty line than does the population nationally, so too does South Carolina's population have less disposable personal income.

Disposable Income

State	2001	2002	2003	2004	2005	2006 [1/]	Rank 2006
South Carolina	$22,065	$22,802	$23,449	$24,554	$25,493	$26,517	47
United States	$26,228	$27,148	$28,028	$29,513	$30,612	$32,111	x

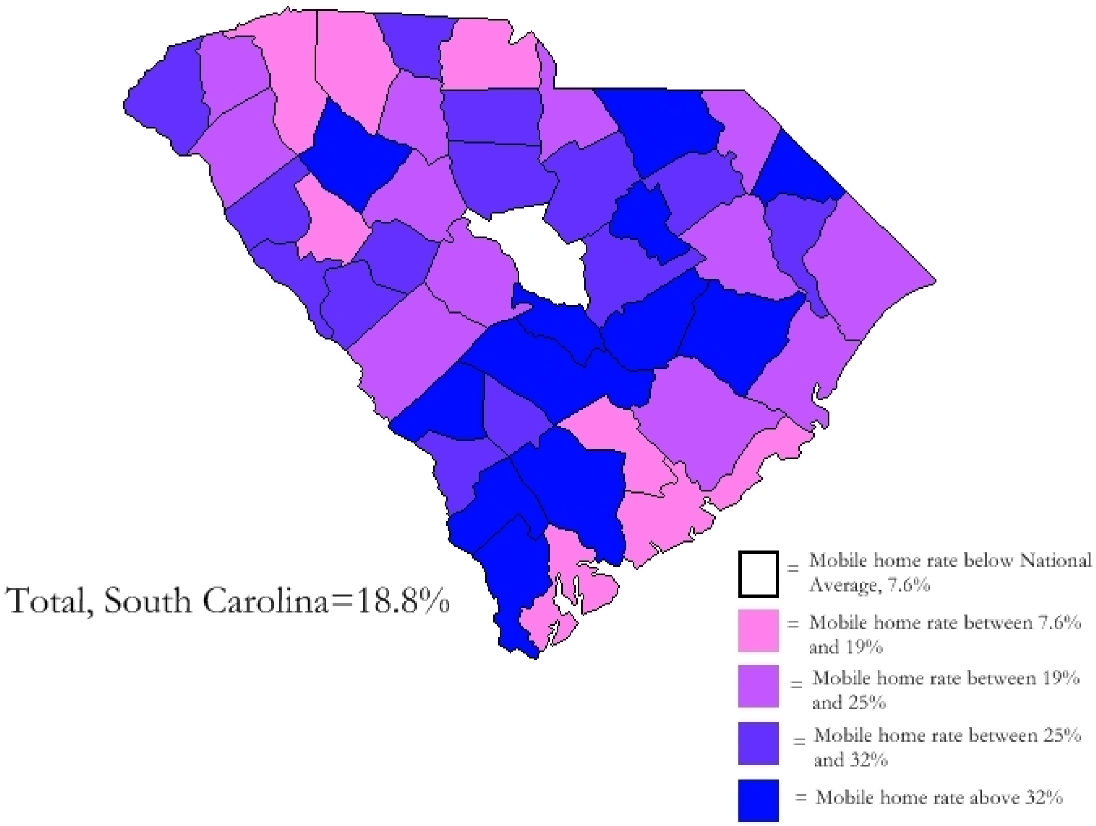
Source: U.S. Department of Commerce, Bureau of Economic Analysis; Regional Economic Information System.

Disposable personal income is a person's income minus taxes. Any energy efficiency upgrades made to a person's home would have to be paid for with disposable personal income. In 2006, the average South Carolinian's disposable personal income was $26,517, the 5th lowest average in the United States. The nationwide average disposable personal income in 2006 was $32,111, which is 21.1% higher than that of South Carolina. Clearly, South Carolinians simply have less money to spend on either increased electricity rates or on purchasing energy efficiency upgrades.

Mobile home use

Another stumbling block in South Carolina's attempts to become more energy efficient will be housing stock. Mobile homes make up a much larger percentage of the houses in South Carolina than they do anywhere else in the country. In South Carolina, 18.8% of houses are mobile homes, compared to 7.1% nationally— meaning that South Carolina's mobile home rate is 168% times higher than the country's. Every county in the State except Richland County has a higher mobile home rate than the rest of the country. The challenge presented by such a high mobile home rate is that mobile homes are notoriously difficult to upgrade with energy efficiencies. The biggest problem in mobile homes is insufficient insulation, but there are other problems as well. With the state of South Carolina's housing stock, even if South Carolinians want to upgrade their home's efficiency to reduce their electricity bill, as much as 18.8% of the state's population will be severely constrained in their efforts by the fact that they live in a mobile home.

Mobile Homes as Percentage of all Home, by County (2000)



State of South Carolina Must Design South Carolina-Specific Solutions

For all of the above reasons, the effect of increased electricity costs to the people of South Carolina could be potentially disastrous. While we cannot know for certain how higher electricity rates will affect South Carolina, we do know that our state has a set of demographic conditions that will translate into electricity rate increases being a far greater burden on the people of South Carolina than on the average American.

The Cooperatives support the development of responsible policies to address climate change, but encourage lawmakers to recognize the potential significant economic impacts which may result from such legislation unless it is economy-wide, timed to allow economically reasonable transition away from existing generation, allows for differences in regional growth rates, focuses on technology investment and is flexible enough to deal with the uncertainties inherent in such a dramatic shift in how our nation is powered.

2. **Does South Carolina have governmental resources available to study, plan, or act upon current or future policies? Are these resources sufficient? Are these resources appropriately empowered to act? Is there any overlapping of roles?**

In the face of the challenges ahead,
authority and responsibility must be clearly assigned.
Full accountability should leave no room for finger pointing.

The need for a coordinated and comprehensive approach to energy policy in South Carolina is of critical importance for our state to enhance the quality of life of her citizens amid an array of economic and environmental uncertainties. With federal regulation of carbon emissions forthcoming and the potential for federal money to be directed back to the states for investment in technologies to mitigate costs, having a coordinated plan in place beforehand must a top priority for our state.

The primary difficulty with constructing a comprehensive energy policy is that there are numerous necessary entities performing fundamentally different functions. Some of these functions are well-defined in theory and in practice, but others lack theoretical and practical clarity. The result is a situation in which no single entity owns the problem and a piecemeal approach to the solution naturally results. Achieving passage of a comprehensive energy policy for South Carolina will require the dedication of a single entity with a unique combination of subject matter expertise, legal authority and political legitimacy. The Electric Cooperatives of South Carolina, Inc. believes that the State Regulation of Public Utilities Review Committee possesses the factors necessary for the successful development and implementation of a comprehensive energy plan.

The subject matter is complex. Every fuel type — including
conservation — must be rigorously assessed as to its reliability,
affordability and level of environmental responsibility.

One of the most difficult aspects of constructing an energy policy is the complexity of the subject matter. Not only is there a wealth of information to consider, but frequently there is disagreement among comparable data depending upon its source and the methodology used to obtain it. Information as simple as the mix of fuels used in electricity generation can be misleading when applied to policy matters. For example, the U.S. Department of Energy represents South Carolina's electricity generation mix to consist of 51% nuclear while industry leaders will represent it to be closer to 30%. The source of the disparity is how the generation is allocated: if it is allocated at the production level, the number is over 50%, if it is allocated at the consumer level, the number is closer to 30%. The ability to discern such scenarios and their implications to South Carolina's citizens are critical. The PURC members and its staff have accumulated unique expertise on energy issues by virtue of the committee's oversight responsibilities and have demonstrated their ability to make such determinations.
The PURC also has the legal authority to take the lead on an energy policy. It is already empowered by its enabling statute to "make reports and recommendations to the General Assembly" on matters related

to energy. No legislation would be required nor further resources appropriated for the committee to undertake this effort.

Ultimately, the General Assembly sets the policy direction for the state's administrative and regulatory agencies and, accordingly, an effective approach to a comprehensive energy policy must originate from within its membership. The composition of the PURC adds multiple layers of legitimacy to any policy recommendation that it might generate. First, by virtue of its composition alone, its recommendations carry the tacit support of the committees of jurisdiction in each of the respective chambers of the General Assembly. Second, the committee is both bipartisan and bicameral which would aid significantly in the successful implementation of its recommendations. Finally, the committee is composed of members of the General Assembly as well as members of the general public. The PURC is uniquely situated to ensure that the necessary political action is taken once the policy is designed.

3. How do we use electricity in South Carolina? How is our use different from other states', with respect to amount of use and type of use? What factors drive this usage? What can we do to better use our energy resources? What demographic or other factors prohibit or inhibit our ability to be more energy efficient?

As to total per-capita energy consumption, South Carolina falls close to the national average. Of energy consumed by South Carolinians, a much greater percentage is from electricity.

A recent study published on www.energy.sc.gov suggests that South Carolina's electric energy use per capita ranks third nationally when compared with all other states and the District of Columbia. That high personal consumption results, in part, from very low per capita use of other traditional sources of energy such as natural gas (44th in the nation) and home heating oil. Low use of non-electric energies in our state is based on the mild winter heating season in South Carolina (44th in annual Heating Degree Days, HDD). In such mild winters, heat pumps are very efficient. In colder climates, heat pumps are ineffective and inefficient, forcing consumers to direct-use energies like gas and oil. States with significantly higher HDD needs, such as New York, have the infrastructure to support natural gas and heating oil-based home heating.

Additionally, South Carolina has a long summer that places it seventh nationally in the number of Cooling Degree Days, CDDs. States that enjoy year-round mild weather, such as California (45th in HDD; 24th in CDD), have much more flexibility in energy efficiency and conservation since energy use is a matter of choice and convenience rather than avoiding discomfort.

South Carolina falls closer to the national average in total energy consumption per capita (18th) and well below average for commercial use (40th), but well above average for industrial energy consumption (14th). The higher-than-average industrial use is explained by the availability of cheap labor in our state, the moderate climate and close proximity to shipping ports as well as relatively low electric rates that are necessary for big, heavy users of electric energy.

South Carolina is a relatively poor state that ranks 46th nationally in income per capita, with workers typically earning 17 percent less than the national average income. The resulting lack of disposable income creates a barrier to costlier residential energy efficiency measures, regardless of how effective they might be in reducing electric use and power bills.

4. What types of renewable sources of energy are available in South Carolina? What is the expected cost to produce and transmit electricity from those resources?

Renewables:
Biomass in the short term. Offshore wind and, perhaps, solar as technology for energy storage matures.

Renewable sources of energy, including solar, hydroelectric and landfill methane gas, have for years generated a significant portion of the power used by South Carolina's electric cooperatives. In fact, co-ops — in partnership with the S.C. Public Authority (Santee Cooper)—were the first utilities in the state to offer business and residential consumers "Green Power:" electricity produced from 100 percent renewable energy sources. Renewable energy sources hold even more promise for our state as available technologies mature. However, despite frequent speculation and misinformation on the subject, our state's renewable energy sources come with practical challenges that limit their potential for meeting most or all of our state's energy needs. The limitations include reliability, availability, affordability and, in the case of both onshore and offshore wind, environmental impact.

These facts and others are detailed in the September 2007 study, "Analysis of Renewable Energy Potential in South Carolina" (GDS Associates, Inc. and La Capra Associates, Inc. for Central Electric Power Cooperative, Columbia, SC — copy attached*). The in-depth independent study was commissioned more than a year ago to determine viable options for power produced with renewable resources in South Carolina. The study provides an analysis of the availability and viability of renewable power including wind, solar, new hydro, wood biomass, landfill gas to energy, ocean (tidal, wave, current), geothermal and agricultural waste in our state.*

Two levels of potential were analyzed for each renewable energy source:

- *"Technical potential" – Possible potential without any limitations.*
- *"Practical potential" – The maximum potential that might reasonably be expected to be implemented based on currently available information and given assumed restrictions, without economic considerations.*

The study concludes broadly that renewable energy costs more — often much more — to generate and consume in our state than power generated from conventional sources. Our weather, topography and meager onshore winds contribute to the challenges. Unlike some other states particularly in the West, South Carolina lacks renewable resources to meet significant percentages of our electricity needs. Electric cooperatives are investing more than ever to make the most of renewables' potential for our members.

Landfill Methane Gas
Landfill gas is the state's lowest-cost renewable energy option for electric generation. The practical potential is about 70 MW (megawatts). **Cost:** *Levelized costs of less than $90 per MWh.*

There is tremendous potential for job creation in the growing and harvesting of biomass in rural South Carolina.

Biomass
The study finds that by far the largest percentage of renewables could come from burning wood and other biomass.

Biomass (wood waste, logging residue, commercial thinnings, corn and poultry litter) used in direct-fire generation can provide the next lowest-cost renewable energy option, contributing up to 490 MW (megawatt). Burning biomass with coal may be an option, but will be limited by compatibility issues. **Cost**: *Ranging from $90 to $135 per MWh (megawatt-hour), with incremental costs of $15 to $50 per MWh above coal-generation costs (for reference, energy from a newly-constructed coal-fired unit would cost about $50-75 per MWh).*

Hydroelectric
Small hydro (without impoundments/dams) may provide about 100 MWa (the average number of megawatt hours, not megawatts, over a specified period of time) of energy for the state, but costs may vary widely depending on site-specific issues and capacity factors. Permitting may also be an issue.

Wind
There are virtually no onshore wind sites that can be practically developed in South Carolina, but there may be some opportunities to develop offshore wind projects. Those projects must overcome permitting and performance barriers. **Cost**: *The levelized cost of electricity ranges from $120 to $155 per MWh.*

Solar Photovoltaic (PV)
Generally, solar PV deployment is not limited by resource availability but rather by costs and technological barriers. Current technology in South Carolina doesn't work, except passive thermal applications. **Cost**: *From $165 to $500 or more per MWh.*

Renewables: The Bottom Line
While the potential exists to do more with renewable energy sources in S.C. as technology and affordability improve, the fact remains that these renewables, if fully deployed, could practically meet only 5–8 percent of South Carolina's electrical energy requirements.

The following chart, included in the 2007 study, summarizes the practical potential of generating power from renewable energy sources in South Carolina.

	Technical Potential (MW)	Practical Potential* (MW)	Practical Generation (GWh)
Wood Biomass	1,599	423	3,148
Agricultural By-Products	362	68	504
Landfill Gas to Energy	90	70	518
Hydroelectric (MWa)**	210	105	919
Onshore Wind	100	-	-
Total***	**2,361**	**up to 665**	**5,089**
Offshore Wind	N/E	N/E	N/E
Solar PV	N/E	N/E	N/E
Ocean (Tidal, Wave, Current)	N/E	N/E	N/E

* Practical potential is the maximum potential that might reasonably be expected to be implemented.

** Hydroelectric potential is measured in average MW based on annual mean flow rates or estimated annual production.

*** Total may not add up due to rounding.

N/E: Off-shore wind, solar and ocean power resource potential were not estimated because resources are abundant, but available technologies have not achieved maturity, or permitting issues introduce uncertainties for estimate.

The Case for New Nuclear

Though technically a non-renewable energy source, nuclear generation is a non-emittent power source, one that releases no greenhouse gases. Earlier responses to the Review Committee claimed the state's nuclear generation and/or capacity is at or near 50 percent, however the Office of Regulatory Staff's report, "South Carolina Energy Policy Inquiry Aggregate Responses," rightly recognizes that a significant portion of the electricity generated at South Carolina's nuclear facilities flows out of state. For electric cooperatives, 80 percent of electricity is generated from coal, making Santee Cooper's partnership with SCE&G in new nuclear facilities important, not only to addressing climate change concerns in our state, but also to meeting a critical need for more electricity. Recognizing ongoing concerns about safety, the cooperatives recommend building nuclear incrementally, allowing time for technology to develop, risks to be mitigated and the economy to recover. Additionally, because of the substantial demand for and cost of concrete, steel and other construction materials (as noted in Question 7) — and because significant water resources are required for nuclear generation — new nuclear should be built on a coordinated basis in South Carolina.

5. What types of non-native renewable resources are available to South Carolina? What is the expected cost to transmit electricity from those resources to South Carolina?

Congressional or regulatory action to establish Renewable Portfolio Standards (RPS) that not grounded in what is practically possible will be one of several methods by which wealth is transferred out of South Carolina.

Because of very similar topologies of South Carolina and its neighbors, the Cooperatives expect that the density of renewables is roughly the same as in South Carolina. Because of this, the Cooperatives have not commissioned a study of non-native renewables. Given current technologies, even local renewables are still at a 15 percent to more than 100 percent premium above traditional electric generation. Wheeling (transmitting electricity across several different systems over long distances) this already expensive electric energy produced from non-native renewable resources will only make the economies worse. A larger concern is that renewable portfolio standards in neighboring states may pull some of the most economical native renewable energy out of South Carolina.

Availability and price of renewables outside of the region is made unattractive due to the losses and unreliability of long distance wheeling. Electricity that enters a system at 100 percent comes out of that system at 97 percent. That reduced electricity comes out of the next system at having lost another three percent. At each system, the losses are compounded. Cost is another challenge in this scenario. Wheeling across as few as 10 transmission systems can add more than 50 percent to the cost of the electric energy and greatly increases exposure to forced curtailments.

6. What programs that promote energy efficiency exist in our state? Are these programs affordable to all South Carolinians? Should they be affordable to all South Carolinians? Are energy efficiency measures a cost-effective alternative to the construction and operation of generation facilities? How should energy efficiency incentives be designed?

South Carolina's electric cooperatives offer numerous programs promoting energy efficiency and energy conservation for both residential and commercial consumers. While the menu of programs offered may differ from cooperative to cooperative, they all are designed to help member-owners be more energy efficient, use electricity more wisely and save money.

- **Residential Energy Efficiency Reduced Rate**
  Cooperatives offer reduced rates as incentives for all members who choose to invest in greater residential energy efficiency.

- **Loans for Energy Efficient Construction/Home Improvement**
  Working in partnership with Santee Cooper and Touchstone Energy, cooperatives offer low interest loans to members as incentives to improve the energy efficiency of their homes and businesses, either in new construction or by upgrading existing facilities By installing more efficient heating and air conditioning equipment, members can lower their energy consumption and qualify for a lower billing rate.

- **Compact Fluorescent Bulbs (CFLs)**
  Through the "Do the Light Switch" campaign, South Carolina's cooperatives have committed to investing millions in energy efficiency by giving member-owners CFLs and promoting the bulbs' cost- and energy-saving qualities. CFLs use 75 percent less energy than standard incandescent

bulbs. In 2008, each of South Carolina's 20 local cooperatives sent 2 free bulbs to members' homes, a total of 1.2 million CFLs. Phase 2 of the giveaway campaign launches in 2009.

- **Water Heater Control Programs**
  In an effort to cut down on the amount of electricity used by residential water heaters during peak hours, cooperatives offer residential water heater controls that automatically turn water heaters off during peak hours and back on during off-peak hours. Members still have hot water when they need it, but use less energy when demand is highest and it is most expensive.

- **Energy Audits**
  Cooperatives provide energy audits for members who request them for their homes or businesses. These audits help members identify issues with insulation, ductwork, weatherization and other inefficiencies that may be resulting in wasted energy and much higher bills. If any such issues are found, the audits include recommendations on how to address them, including references to any related cooperative programs that may help.

- **Daily Use Charts**
  These charts, often distributed with monthly bills or available on local cooperative Web sites, give cooperative members an opportunity to track on a monthly basis how much electricity their homes or businesses use. Members can see more clearly how weather effects use and how simple adjustments can result in lower monthly bills and greater energy efficiency for their homes.

- **Ground Source Heat Pump Rebates**
  Ground source heat pumps use geothermal energy from just below the earth's surface, where the temperature is more stable year-round, to heat and cool water. Because the amount of electricity required for this process can vary a great deal based on temperature fluctuation, the more stable and constant the temperature means the less electricity is necessary. The more constant underground temperature allows ground source systems to use minimal amounts of electricity and is the reason they are considered the most energy efficient heat pump on the market.

- **Lighting and Appliance Calculators**
  Cooperatives offer these devices to help members recognize the real benefits of replacing older, less efficient lighting fixtures and appliances with more modern versions. By using the calculators, members can see more clearly that, despite the higher initial cost of more efficient replacements, the long-term savings are well worth it.

- **Children's Website on Energy Efficiency**
  Cooperatives believe that the more educated the population is on issues like energy efficiency and conservation the more active it will be in taking part, no matter the age. Often, the most effective lessons are the ones taught at an early age and repeated. That idea led the cooperatives to design an energy efficiency Web site specifically for children: www.TouchstoneEnergyKids.com.

- **Energy Tips Brochure**
  A consumer-friendly collection of 101 low-cost and no-cost do-it-yourself home energy efficiency tips published by the Touchstone Energy Cooperatives and made available to South Carolina co-op members through their local electric cooperatives.

While many of these programs are free or available at very little cost to consumers, the reality for many of our cooperative member-owners is that some key programs simply are not affordable to them. Twenty-two percent of the South Carolinians served by electric cooperatives live in manufactured housing, where inefficient resistant heating is the norm and the cost of retrofitting energy efficient heat pumps, even with rebates and other incentives, typically is prohibitive.

Existing federal tax incentives and a limited number of state tax incentives benefit those citizens who can afford to invest in energy efficiency. While those tax breaks are beneficial, they reach only a small percentage of the population. Expanding the incentives could offer low-income families opportunities to make their homes more energy efficient with heat pumps and other costly but impactful upgrades, saving them thousands of dollars on future power bills and reducing consumption statewide. Additionally, more guaranteed low-interest loans would bridge the gap for many families who need to weatherize their older homes or upgrade their current appliances to more energy efficient models.

There also must be an increased focus on businesses in South Carolina, specifically those involved in manufacturing and construction. These industries could contribute greatly to our state's push for energy efficiency if presented with financial incentives to encourage the construction of more efficient homes and buildings. Providing greater tax breaks for companies who build in the most energy efficient way, for example, would be an investment in a cleaner and more efficient South Carolina.

While energy efficiency alone cannot replace the base-load electricity generation required to meet South Carolina's growing energy needs, it should be viewed as an important part of the overall solution to clean reliable electricity for electric cooperative members and all South Carolinians.

7. The heavy use of concrete and steel to construct coal and nuclear generating facilities in China, India and other developing nations and the importation of fuel need of fuel needed to create energy from those facilities has increased the price of these raw materials and commodities beyond most projections. Is this level of growth sustainable? Will prices continue to be driven by this global demand? How will South Carolina be affected by this global demand?

The increasing cost of raw materials does and will have an effect on the price of energy, especially capital costs for new construction. Making matters worse, refining of steel and concrete manufacturing are, themselves, both heavy users of energy which further increases the cost of these materials as energy increases. If taken to extreme, this may shift resource planning decisions away from base-load units like coal-fired steam and nuclear to combustion turbines. Unfortunately, many renewable resources also are heavy users of steel so the price of renewables will likely increase as well.

If these trends continue, they will increase the attractiveness of energy efficiency and energy conservation programs and will likely foment interest in distributed energy storage through battery or hydrogen technologies.

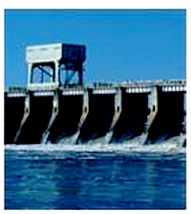
8. How has the current economic situation affected the projections for energy use?

The sluggish economy has lowered the expected economic growth which, in turn, lowers projected energy forecasts by reducing the anticipated number of new homes and businesses. Although, electric energy use has historically been rather inelastic, the combination of higher energy prices and a slow economy have also lowered energy use in existing homes through conservation efforts, projects and educational programs sponsored and funded by South Carolina's Cooperatives.

The net expected result of this slow economy is, in a best case scenario, 18 months of little to no growth followed by normal growth once the economy begins to recover. No pent-up growth is expected as the economy recovers, but rather a quiet transition to normal expected growth for the region.








Analysis of Renewable Energy Potential in South Carolina

Renewable Resource Potential – Final Report

Prepared for: Central Electric Power Cooperative Inc.

September 12, 2007

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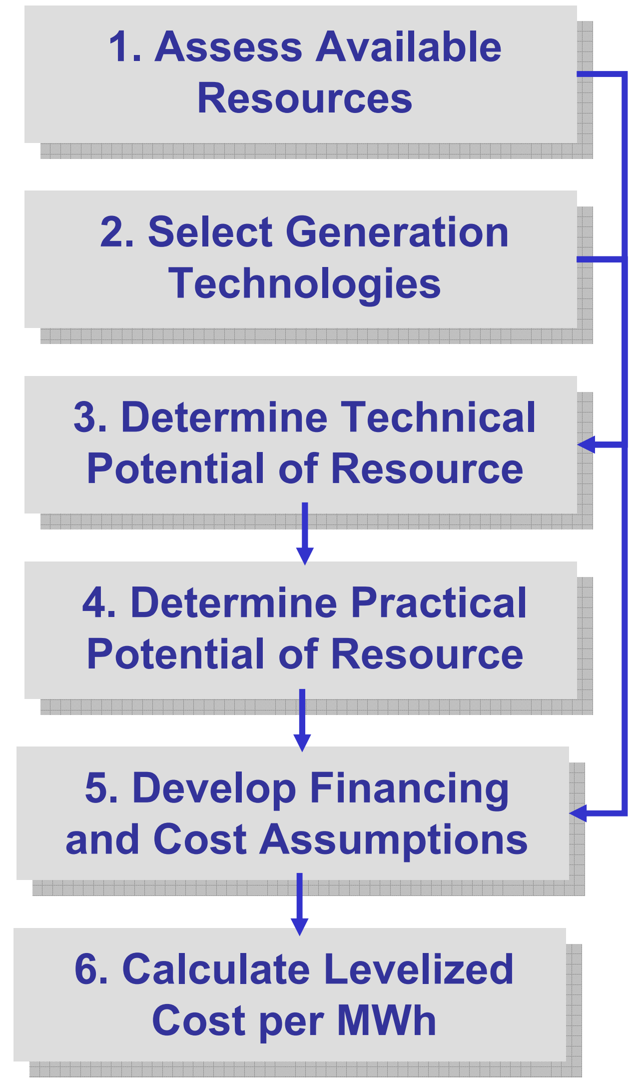
Table of Contents

Overview

This analysis seeks to quantify the renewable energy resource potential that can be used for electric generation within the state of South Carolina and to calculate the associated costs.

Approach

1. **Assess the total renewable resources or fuels (biomass, wind, landfill gas, etc…) available in the state.**
2. **Select generation technologies that can utilize the resources in the near-term.**
   - These technologies must be commercially available or the technologies themselves are mature, though they may be lacking mass deployment.
3. **Translate the resources into electric energy (and nameplate capacity) Technical Potential.**
   - Use performance characteristics of select technologies to estimate technical potential.
4. **Determine Practical Potential from Technical Potential.**
   - Criteria used for practical potential is different for each resource, but attempts to quantify the maximum potential that could reasonably be expected to be implemented.
5. **Develop financing assumptions, range of costs and operating characteristics for such technologies.**
6. **Calculate levelized costs ($/MWh) for electricity produced from selected renewable technologies given resource availability.**



Approach

Define Potential

Two levels of potential were estimated:

Technical Potential

- Total renewable resources, located within the state, with the potential for electric energy conversion.
- Resource estimates are based on the utilization of commercial or mature technologies.
- The potential of offshore wind, solar and ocean power resources was <u>not</u> estimated because various factors currently limit their development, even though the resources themselves may be abundant.

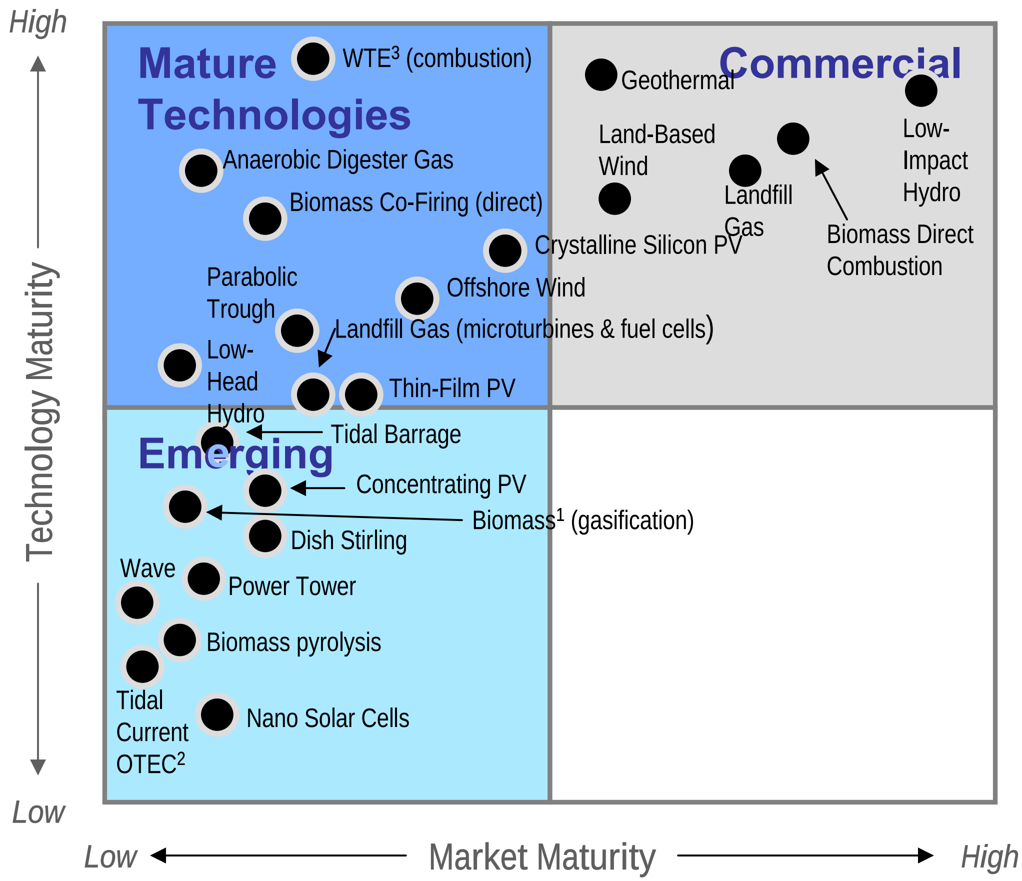
Practical Potential

- The maximum potential that might reasonably be expected to be implemented based on currently available information and given assumed restrictions.
- Practical does <u>not</u> necessarily mean economic, nor does it imply any resource can be developed in a cost-effective manner when compared to conventional generation.
- The ability to access and develop each resource is considered, along with cost, but the criteria used are different for each resource.
- Limitations due to transmission constraints or permitting/siting barriers were <u>not</u> taken into account.

Approach

Renewable Energy Technologies

Technologies to capture renewable resources for electricity generation are quite diverse. Some are based on mature technologies that have demonstrated good market penetration while others are still in nascent stages of development.



1. Biomass integrated gasification combined cycle
2. OTEC = ocean thermal energy conversion
3. WTE = waste to energy

Renewables

Renewable Technologies Reviewed

Mature Technologies

- **Anaerobic Digester Gas**
- **Biomass Co-Firing (direct)**
- **Crystalline Silicon PV**
- **Offshore Wind**
- Parabolic Trough
- Landfill Gas (microturbines & fuel cells)
- Thin-Film PV
- Low-Head and Ultra Low-Head Hydro

Commercial Technologies

- Geothermal
- **Land-Based Wind**
- **Landfill Gas**
- **Biomass Direct Combustion**
- **Low-Impact Hydro**

Emerging Technologies/ Resource

- Tidal Barrage
- Concentrating PV
- Biomass (Gasification)
- Dish Stirling
- Wave
- Power Tower
- Biomass (Pyrolysis)
- Tidal Current OTEC
- Nano Solar Cells

In developing estimates of potential for renewable resources in the next decade, the focus is on using "Commercial" technologies that have both technology and market maturity and some "Mature Technologies" that show promise for market expansion in the near-term.

"Emerging Technologies/Resources" are not included in the analysis for several reasons. The technologies are typically in development or pilot testing stages, so many issues may still need to be resolved. The costs for developing these technologies are higher than more mature technologies. Often times, the steps needed to advance emerging technologies and reduce costs require active support of government and utilities in the near term.

Technologies that are underlined were reviewed or used in the assessment.

Technical vs. Practical Potential

- **Technical potential of new in-state renewable resources total about 2,360 MW.**
  - Strong logging sector – wood fuel for renewable generation.
  - Modest hydro, agricultural waste, and landfill gas potential.
  - **The potential of offshore wind, solar and ocean power resources was not estimated** because various factors currently limit their development, even though the resources themselves may be abundant.

- **Practical potential of up to 665 MW within the next decade.**
  - **There are some off-shore wind resources that may be developed**, but the magnitude can not be estimated since there has not been a permitted project in the U.S. to date.
  - **The potential for hydro may increase by about 90 MW**, but these additional impoundments have not been verified as existing.
  - Limitations due to transmission constraints or permitting/siting barriers are not taken into account explicitly.

Summary of Practical Renewable Potential

	Technical Potential (MW)	Practical Potential* (MW)	Practical Generation (GWh)
Wood Biomass	1,599	423	3,148
Agricultural By-Products	362	68	504
Landfill Gas to Energy	90	70	518
Hydroelectric (MWa)**	210	105	919
Onshore Wind	100	-	-
Total* **	**2,361**	**up to 665**	**5,089**
Offshore Wind	N/E	N/E	N/E
Solar PV	N/E	N/E	N/E
Ocean (Tidal, Wave, Current)	N/E	N/E	N/E

**Practical Potential is the maximum potential that might reasonably be expected to be implemented*

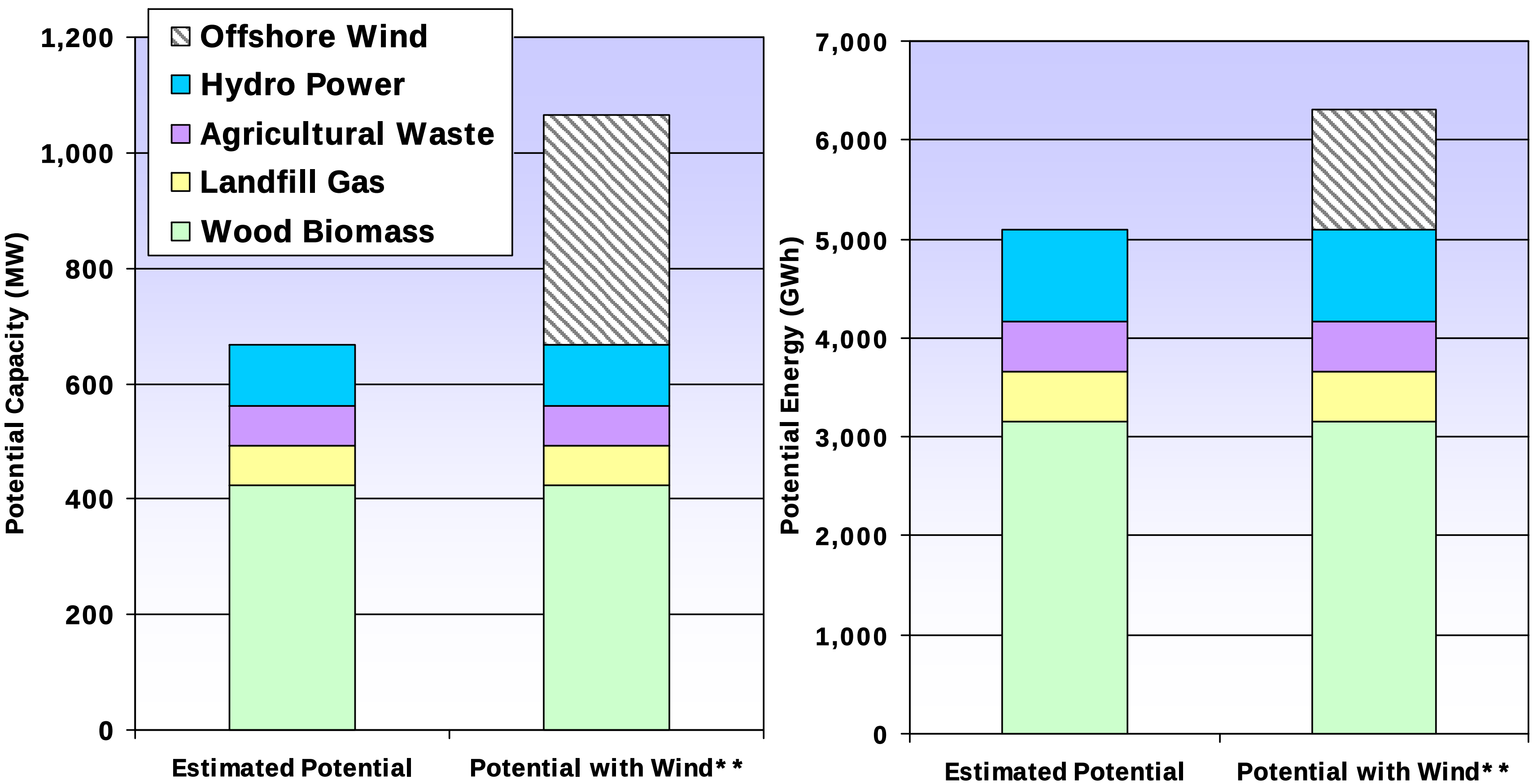
***Hydroelectric potential is measured in average MW based on annual mean flow rates or estimated annual production.*

****Total may not add up due to rounding.*

N/E: Off-shore Wind, Solar and Ocean power resource potential were not estimated because resources are abundant but available technologies have not achieved maturity or permitting issues introduce uncertainties for estimate.

Practical Renewable Potential*

The biggest contributor to renewable energy production would derive from **biomass** (landfill gas, wood, agricultural by-products). The next would be **hydro**. **Offshore wind** may become a large contributor if projects can be permitted.



**Practical Potential is the maximum potential that might reasonably be expected to be implemented*
***This example demonstrates the contribution from 400 MW of offshore wind if projects can be permitted.*

Renewables

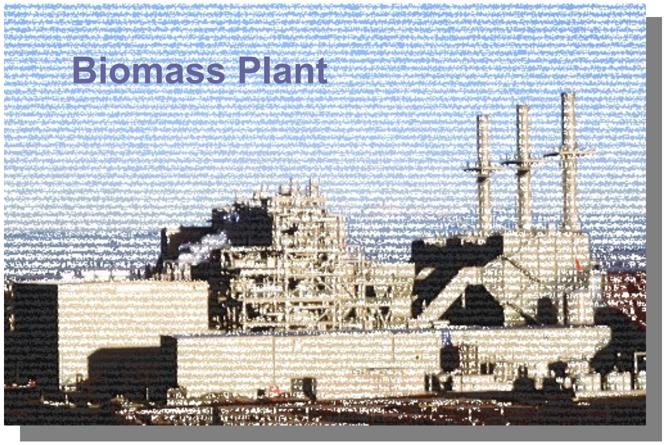
Wood Biomass

Description

Use of wood in direct-fired boilers for electricity generation is a well-established technology. Combined heat and power projects (CHP) also consume significant wood by-products, often co-located with industrial facilities.

National Installed Capacity: 5890 MW*

SC Installed Capacity: 360 MW*



Mature Technologies

- **Stoker Grate (direct-fire):** Most common direct-fire technology for biomass, recent improvements in efficiency and emissions controls.
- **Fluidized Bed:** Uses bed of inert material that is fluidized by high-pressure combustion air, reduces NOx emissions, capable of dealing with low-quality, high moisture content material.
- **Co-firing in Coal Plants:** While the technology is mature, co-firing is highly dependent on coal units' characteristics.

Emerging Developments

- **Biomass Gasification:** Syngas product can be used in combined-cycle or simple cycle generation.
- **Biomass Pyrolysis:** Multiple fuel products (liquids) that can also be used in combined cycle or combustion turbines.

** Estimates based on compilation of data from sources including Energy Information Agency, National Renewable Energy Laboratory, Environmental Protection Agency, and other web-based sources.*

Summary of Wood Biomass Potential

It is assumed that direct-fire biomass facilities would use a mix of Wood biomass, urban wood waste and agricultural by-products (discussed in next section) to generate electricity. The determination of practical potential includes fuels that would have a cost of less than $65 per dry ton or about $4.00 per MMBtu.

Wood Biomass Options	Technical Potential				Practical Potential*	
	Green Tons per Year	Dry Tons per Year[2]	Annual Heat Value[3] (MMBtu)	Technical Potential (MW)[4]	Practical Potential (MW)	Potential Energy (GWh)
Logging Residue	4,411,500	2,205,750	37,497,750	360	180	1,339
Pre-commercial Thinnings	8,555,796	4,277,898	72,724,266	698	-	-
Commercial Thinnings	5,336,000	2,668,000	45,356,000	435	217	1,617
Southern Scrub Oak[1]	48,792	24,396	414,732	4	-	-
Net Available Mill Residue	12,086	6,043	102,731	1	-	-
Urban Wood Waste	621,000	621,000	10,557,000	101	26	192
Total Wood Biomass				**1,599**	**423**	**3,148**

1. The potential of Southern Scrub Oak of 48,792 green tons per year assumes sustainable harvesting of the existing base at a rate of 2% annually.
2. To calculate dry tons of material, a moisture content of 50% of green biomass is assumed, except for urban wood waste which has relatively low moisture content.
3. The assumed heat content of wood biomass material is 8,500 btu/dry lb of biomass.
4. Potential MW calculation assumes direct-fired plants with 14,000 btu/kWh heat rate and a capacity factor of 85%.

**Practical Potential is the maximum potential that might reasonably be expected to be implemented*

Description of Wood Biomass Categories

- Data from Forest Inventory and Analysis (FIA) and Timber Product Output (TPO).
  - Calculation of technical potential was based on estimates of wood residue and other wood products using sampled acres and applied to all timberland.
- To estimate **practical potential**, the technical potential was reduced by 50% to account for some inaccessible timberland.
- **Practical potential** was then further reduced through fuel cost considerations, which will be described later.

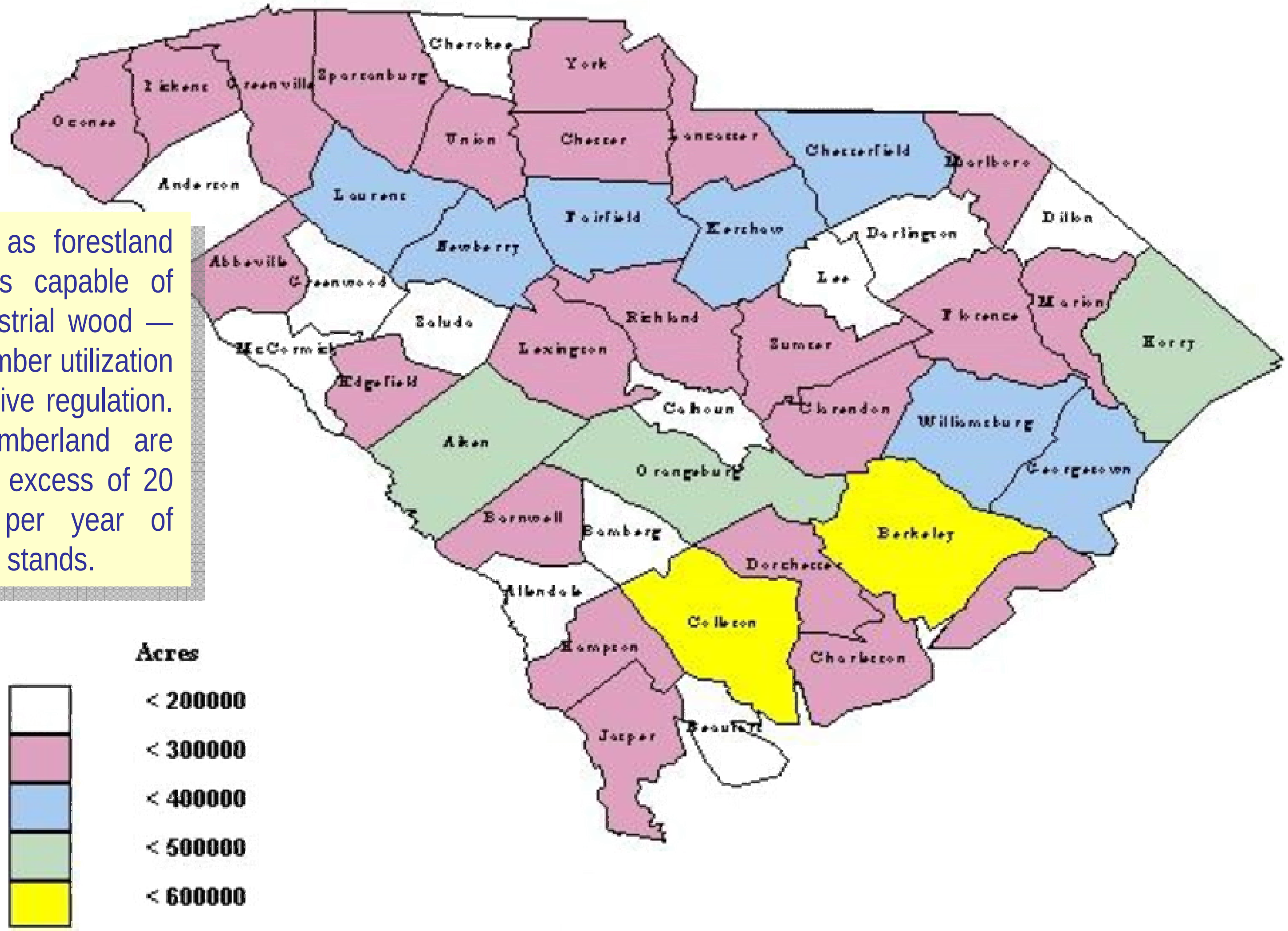
Wood Types	Definitions
Logging Residue	Unused portions of growing stock trees cut or killed by logging and left in the woods.
Thinnings	Silvicultural operation whereby smaller and less desirable trees are removed to enhance production of more valuable trees.
Pre-Commercial	Involves removal of saplings from a stand, usually <5.0 inches DBH*.
Commercial	Mainly merchantable-sized pulpwood >5.0 inches DBH, assumed 50% currently consumed by pulp and paper industry. Remaining available for fuel.
Southern Scrub Oak	Composed of low-quality hardwood species such as turkey oak that do not have timber value, so are not currently harvested.
Mill Residue	Bark and wood material that is generated in mills (i.e. slabs, edgings, trimmings, miscuts, sawdust, shavings, etc…) but most are consumed on site for heat and/or power.

Source: "Final Report to the South Carolina Forestry Commission on Potential For Biomass Energy Development in South Carolina," Harris, Robert et al. (2004)

* DBH = Tree diameter in inches (outside bark) at breast height (4.5 feet above ground level).

Timberland by County

Timberland is defined as forestland that is producing or is capable of producing crops of industrial wood — and not excluded from timber utilization by statute or administrative regulation. Areas qualifying as timberland are capable of producing in excess of 20 cubic feet per acre per year of industrial wood in natural stands.



Source: USDA Forest Service, Forest Inventory and Analysis 2001

Biomass

Description of Urban Wood Waste

- The calculation of technical potential of urban wood waste is calculated based on population and industrial activity by county.
- Due to diverse mix of clean and contaminated materials, the **practical potential** is assumed to be only 25% of the total estimated urban wood waste. This reflects clean (untreated and unpainted) and segregated wood waste for use in electricity generation.
- Avoided landfill tipping costs in South Carolina is about $36/ton.
  - However, the net cost of fuel from urban wood waste is assumed to be $0/ton including transportation costs.
- Expected growth in the resource as population grows with more availability in dense population centers.

Waste Types	Definitions
Municipal Solid Waste	Material discarded from individual residences/small businesses, such as tree service companies. Materials may include household yard waste, remodeling scrap, tree trimmings, and wooden shipping containers.
Industrial Wood Waste	Discarded material from companies that work with wood, such as pallet, cabinet, furniture, and custom building companies.
Clearing/ Demolition Waste	Wood originating from the clearing of land or demolition of buildings.

Source: "Final Report to the South Carolina Forestry Commission on Potential For Biomass Energy Development in South Carolina," Harris, Robert et al. (2004)

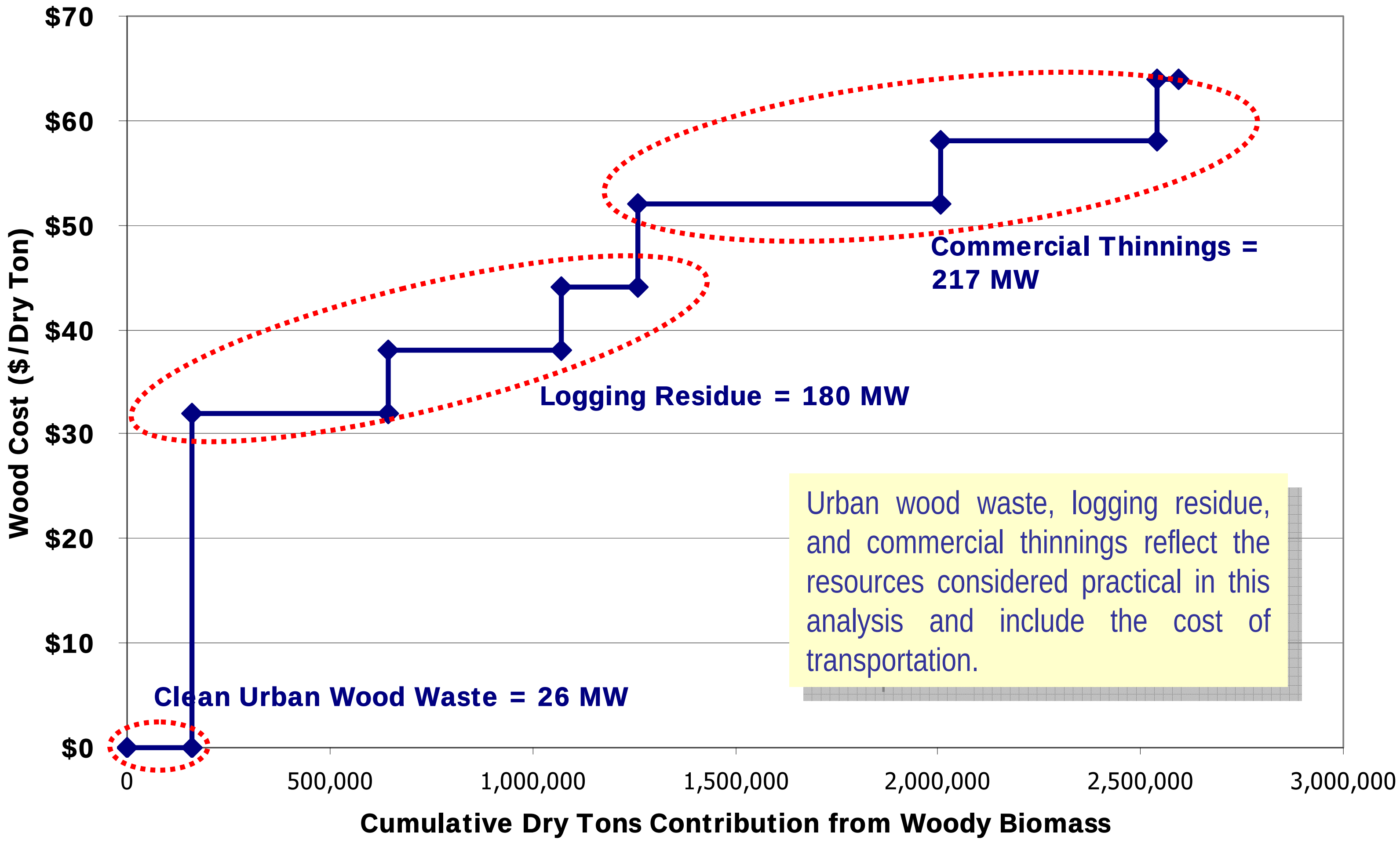
Methodology for Wood Biomass Supply Curve

- **Fuel costs on the supply curve are differentiated by the following cost components for each biomass resource:**
  - Harvesting/gathering/collecting/chipping ($13−$23/green ton*)
  - Transport ($3/mile per shipment of 25 green tons)
- **Biomass resources are reviewed by county to determine transportation costs based on delivery radius.**
  - Counties are divided into three groups based on level of biomass resource potential and then assigned a transportation radius to determine cost of delivered fuel.**
    - High biomass potential: 25 miles
    - Medium biomass potential: 50 miles
    - Low biomass potential: 75 miles
  - Transportation costs for biomass from each group of counties are calculated based on transporting green tons within each delivery radius.
- **Fuel costs are then converted from $/green ton to $/dry ton,*** assuming 50% moisture content.**

**Green ton refers to the actual weight of biomass material, including moisture content.*
***The delivery radius represents the average distance that the biomass material in each county may need to be transported to reach the nearest biomass power facility. Typically, biomass facilities will try to locate as close to biomass resources as possible and, thus, closer to higher biomass potential counties.*
****Dry ton refers to the weight of biomass material with most of the moisture content removed.*

Biomass

Wood Biomass Fuel Supply Curve



Biomass

Comments on Wood Biomass

- The lowest cost biomass fuels in the state will likely come from urban wood waste and logging residue.
- A higher cost, but still moderate, biomass fuel will be commercial thinnings.
- There may be opportunities for co-firing of these fuels in existing coal facilities, but compatibility will be unit specific and limited in the state.
- The preferred, mature technologies for burning biomass are stoker-grate and fluidized-bed technologies with appropriate emissions controls.
  - The biomass fuels used in these generators would be a mix of locally sourced biomass that may contain wood residue, urban wood waste, and agricultural by-products.
  - The mix of biomass fuels used at each facility will depend on which resources are within close proximity of the facility.
- An emerging technology that was not assessed – and may have some potential in the future – is biomass gasification. Gasification costs need to be reduced and gasification issues resolved before being competitive with more mature technologies that can utilize biomass.

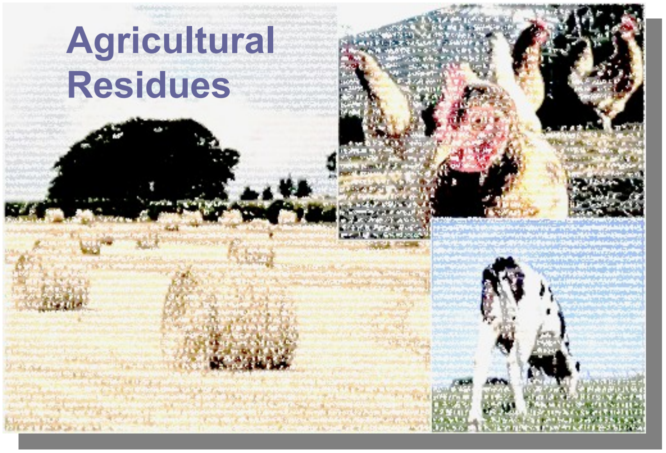
Agricultural By-Products

Description

Historically, agricultural residue and by-products, such as poultry litter and animal waste, have not been used to a significant degree in power generation. Reasons include low energy density, cost of collection, and use as soil amendments.

National Installed Capacity: >75 MW*

SC Installed Capacity: 0 MW



Mature Technologies

- **Co-firing in Coal Plants:** While the technology is mature, co-firing with agricultural residues are still in mostly demonstration phases.
- **Stoker or Fluidized Bed:** Technology is the same as wood-fired generation, but sites must be adapted to handle agricultural products.
- **Anaerobic Digester Coupled with ICE or Microturbine:** Generation technologies are mature, but integration faces many obstacles.

Emerging Developments

- **Gasification and Pyrolysis:** Produces gas and liquid bio-fuels.
- **Anaerobic Digester Coupled with Fuel Cells:** Methane from digester is cleaned and used in fuel cells, which are still in pilot stages.

** Estimates based on data from the U.S. Environmental Protection Agency AgStar 2006 Report, anaerobic digesters totalled over 20 MW in 2005 representing about 100 installations. According to AgStar, another 80 installations planned for 2006 were not included in the total. Capacity estimate includes a 55 MW FibroMinn project utilizing poultry litter.*

Summary of Agricultural Resources Potential

It is assumed that these biomass resources are co-fired in direct-fire applications with other biomass fuels, such as wood residue, or in coal plants to generate electricity, except for Swine Waste which would utilize an anaerobic digester/combustion engine generator set configuration.

Agricultural Resources	Maximum Fuel (MMbtu)	Assumed Capacity Factor	Technical Potential (MW)	Practical Potential* (MW)	Practical Generation (GWh)
Agricultural Crop Residue					
Corn	7,480,346	85%	72	36	267
Wheat	3,370,815	85%	32	0	0
Soybean	3,337,936	85%	32	0	0
Cotton	4,145,582	85%	40	0	0
Switchgrass	16,790,918	85%	142	0	0
Poultry Litter	4,384,851	85%	42	31	230
Swine Waste	166,922	75%	2	1	7
Total Agricultural By-Products			**362**	**68**	**504**

**Practical Potential is the maximum potential that might reasonably be expected to be implemented*

Agricultural Waste

Description of Agricultural Residues

- Crop residues are materials left in agricultural fields after harvest.
  - Most residues are plowed into soil for enrichment or burned prior to planting of next crop.
  - Residues are concentrated mainly in the Coastal Plains region.
- Estimates are derived from grain production and acreage values reports for each crop by the South Carolina Agricultural Statistics Services.
- Wheat, soybean, and cotton are likely not practical for direct-fire applications, so not included in the total practical resources.

Crop Residues	Definitions / Discussions
Corn	Most likely material for energy production, as no crop is planted after corn harvest. Currently used in co-firing with other wood biomass or coal. Assumed 50% are left on fields for enrichment and soil erosion control.
Wheat	Wheat is harvested in late May/early June, but soybean is generally planted immediately following the wheat harvest, which would not allow sufficient time for gathering wheat material for use in energy production. *(Excluded as practical)*
Soybean	No example of direct-firing of soybean residue for electric generation. Better feedstock for bio-fuel production or pyrolysis. *(Excluded as practical)*
Cotton	One demonstration project in Greece concluded cotton is too costly and requires extensive emissions controls. May be better feedstock for bio-fuel production or pyrolysis. *(Excluded as practical)*

Source: "Final Report to the South Carolina Forestry Commission on Potential For Biomass Energy Development in South Carolina," Harris, Robert et al. (2004)

Description of Switchgrass

- Switchgrass is a perennial warm season grass native to North America and can grow in clumps of 3 to 6 feet tall.
- Estimate of technical potential assumes planting of switchgrass on all Conservation Reserve Program (CRP) land in the state .
  - About 1,500 acres are needed per 1 MW of generation.
  - There are over 200,000 acres of CRP land in the state.
- Switchgrass production costs exceed that of other biomass options currently.
  - Costs greatly depend on yield, land use costs, and farming conditions.
- Given the high cost of production, it is more likely a candidate for bio-fuel production rather than in direct-fire electricity generation.* *(Excluded as practical)*

Appendix 3. Cost summaries for the seven scenarios

Scenario	Yield (ton/acre)	Establishment costs (prorated) ($)	Reseeding costs (prorated) ($)	Yearly production costs ($)	Total cost per acre ($)	Total cost per ton ($)
1	1.5	24.47	4.48	168.80	197.75	131.84
	3.0	24.47	4.48	208.90	237.86	79.29
	4.0	24.47	4.48	235.64	264.59	66.15
	6.0	24.47	4.48	289.11	318.07	53.01
2	1.5	23.49	3.55	143.80	170.85	113.90
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	70.32
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	59.42
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	48.53
3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	134.83
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	80.78
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	67.27
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	53.76
4	1.5	24.95	8.97	168.80	202.71	135.14
	3.0	24.95	8.97	208.90	242.82	80.94
	4.0	24.95	8.97	235.64	269.55	67.39
	6.0	24.95	8.97	289.11	323.03	53.84
5	1.5	23.60	8.97	168.80	201.27	134.18
	3.0	23.60	8.97	208.90	241.38	80.46
	4.0	23.60	8.97	235.64	268.11	67.03
	6.0	23.60	8.97	289.11	321.59	53.60
6	1.5	23.97	7.10	143.80	174.87	116.58
	3.0	23.97	7.10	183.90	214.98	71.66
	4.0	23.97	7.10	210.64	241.71	60.43
	6.0	23.97	7.10	264.11	295.19	49.20
7	1.5	24.19	7.10	143.80	175.09	116.73
	3.0	24.19	7.10	183.90	215.19	71.73
	4.0	24.19	7.10	210.64	241.93	60.48
	6.0	24.19	7.10	264.11	295.41	49.23

Costs of switchgrass production range between $50 to $135 per ton (2000$) or **$60 to $165 per ton** in today's dollars, before transportation costs are included.

Source: "Costs of Producing Switchgrass for Biomass in Southern Iowa," Mike Duffy and Virginie Y. Nanhou. Iowa State University, (April 2001)

**There is a demonstration project in Chariton, Iowa that is testing co-firing of switchgrass at a coal plant.*
http://www.iowaswitchgrass.com/technical~agricultural.html

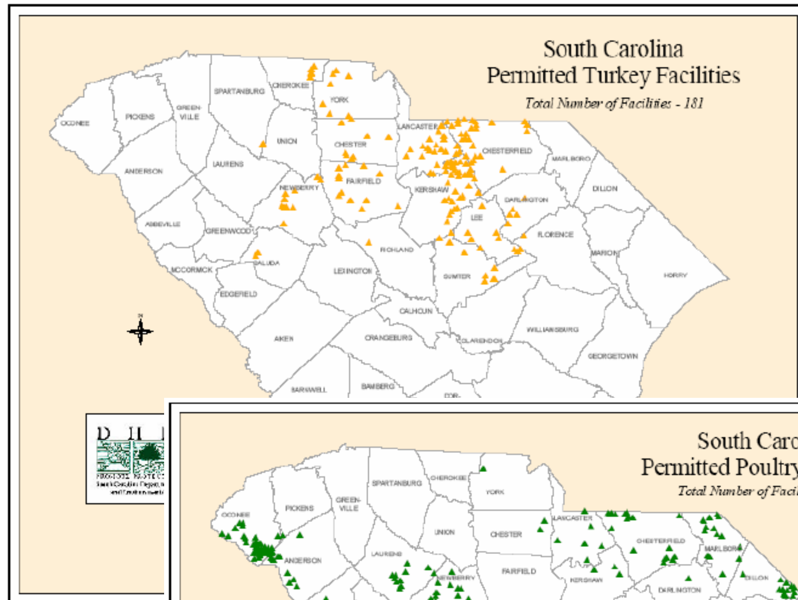
Agricultural Waste

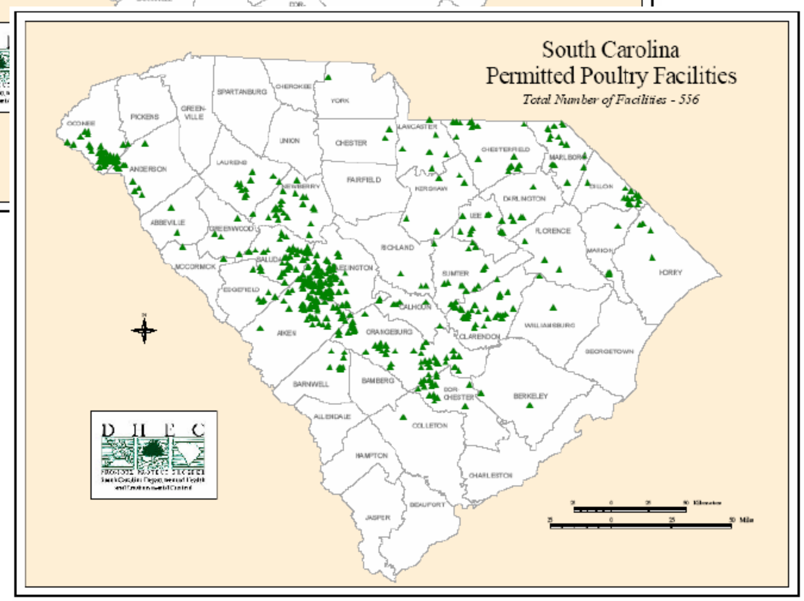
Description of Poultry Litter

- Estimated total potential of poultry litter is based on actual bird production in 2005.
  - Over 220 million birds processed.
  - Estimated over 350,000 tons of poultry litter produced *(about half of what will be consumed in FibroMinn project below).*
  - Practical potential based on top 10 counties of highest poultry litter production.
- Poultry litter is historically used in land applications for soil enrichment.
  - Some concerns over nutrient contamination of groundwater have regulators seeking alternative outlets.
  - Fertilizer value of material is estimated to be $38 to $52 per dry ton.

55 MW FibroMinn, a dedicated poultry-litter project in Minnesota, became the first commercial facility in 2007 in the U.S.

- Expected consumption of 700,000 tons of poultry litter per year, supplemented with wood and agricultural residue.
- Ash from plant will be processed and re-sold as fertilizer.





Source: Availability of Poultry Manure as a Potential Bio-Fuel Feedstock for Energy Production (SC Energy Office, September 2006) http://www.scbiomass.org/Publications

Agricultural Waste

Description of Swine Waste

- 900 Hog/Swine Farms in South Carolina
  - Only 37 have >2,000 head
  - Only 21 have >5,000 head
- AgStar (EPA) recommends >2000 head operations for anaerobic digesters.
  - Cost effective operations are likely to require >5,000 head, used in practical potential assessment.
  - Total methane production may support about 1 MW of total capacity in state, with average generators sized about 100 kW per site.
  - Opportunities are very limited in the state.
- Costs and designs are very site specific.
  - Combined heat and power opportunities
  - Some potential for aggregation of waste material or collection of methane from mulitiple sites.
  - Issues related to maintenance and training for farmers/operators

Barham Farms has an anaerobic digester coupled with a combustion engine generator.

- The farm operation is a 4,000 head farrow-to-wean operation located in Zebulon, North Carolina.
- Methane gas is used in electric generation and heating for a greenhouse.

Agricultural Waste

Comments on Agricultural By-Products

- Many of the agricultural by-products that are determined practical, may have more value as a fertilizer or an input to future biofuel production.
- The lowest cost agricultural by-products that can be co-fired with other biomass (wood) or coal in direct-fire applications will likely be poultry litter and corn stover.
  - However, both may pose problems related to opportunity costs related to fertilizer value in land application, management of increased ash content, and more emissions controls needed.
  - Also, availability of supply may be sporadic depending on season and growing cycles and, in the case of animal waste, disease may also limit supply.
- The costs related to planting and harvesting of switchgrass make the resource cost prohibitive for direct-fire electric generation in the near-term.
- There is limited potential for anaerobic digester development using swine waste due to few swine operations with the requisite herd size in South Carolina.

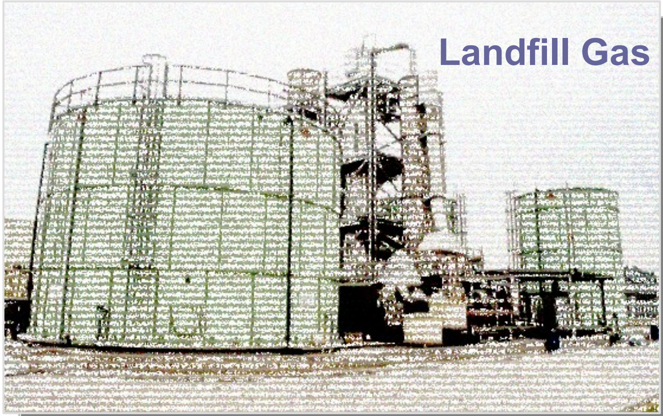
Landfill Gas-to-Energy

Description

Landfills produce a variety of gases, a majority being methane, as waste decomposes. The EPA now requires flaring of the gas at most landfill sites of a certain size in the U.S. Instead of flaring, the gas can be conditioned for use in electric generation or direct thermal use.

National Installed Capacity: 1250 MW*

SC Installed Capacity: 24 MW*



Technologies

- **Reciprocating Engines or Internal Combustion Engines (ICE):** Over 50% of installed capacity.
- **Gas Turbines:** A growing trend.
- **Cogeneration:** Co-locating with industrial load for heat and electricity consumption.

Emerging Developments

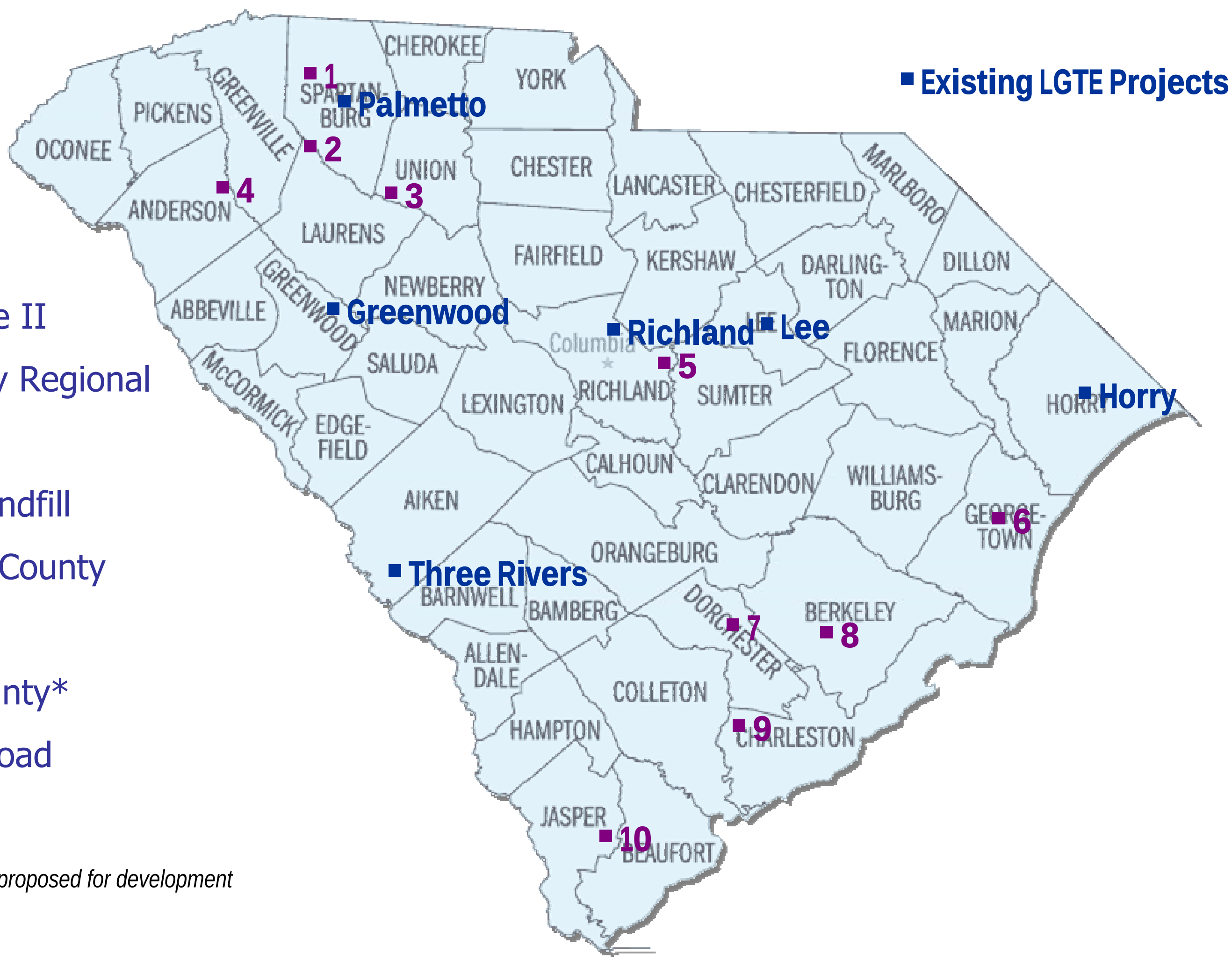
- **Fuel Cells and Microturbines:** May provide better efficiencies and lower emissions, but costs are still relatively higher for these technologies.

** Estimates based on compilation of data from sources including Energy Information Agency, National Renewable Energy Laboratory, Environmental Protection Agency, and other web-based sources.*

Potential Future Landfill Gas to Energy Sites

1. Wellford
2. Enoree Phase II
3. Union County Regional
4. Anderson*
5. Northeast Landfill
6. Georgetown County
7. Oakridge*
8. Berkeley County*
9. Bees Ferry Road
10. Hickory Hill*

** Under development or proposed for development*



Landfill Gas

Landfill Gas to Energy Projects *(Existing)*

Name of Site	County	On-line (MW)	Incremental Planned Expansions* (MW)	Use
Horry County MSWLF	Horry	3	2.0	Electricity
Lee County Landfill, LLC	Lee	5.4	9.1	Electricity
Richland Landfill, LLC	Richland	5.5	3.5	Electricity
Palmetto MSWLF	Spartanburg	10	2.0	Combined Heat and Power
Total Electric Generation at Existing Sites		**23.9**	**16.6**	
Three Rivers MSWLF	Aiken	N/A	N/A	Direct-use
Greenwood County MSWLF	Greenwood	N/A	N/A	Direct-use

**Planned expansions by 2011*

Landfill Gas

Landfill Gas to Energy Projects *(Additional Potential)*

Name of Site	County	Technical Potential (MW)**	Practical Potential (Planned Development) (MW)***
1. Wellford MSWLF	Spartanburg	2.1	1.5
2. Enoree Phase II MSWLF	Greenville	4.5	3.2
3. Union County Regional MSWLF	Union	13.0	8.8
4. Anderson Regional Landfill*	Anderson	10.7	6.9 (2.0)
5. Northeast Landfill, LLC	Richland	2.6	1.6
6. Georgetown County MSWLF	Georgetown	2.5	2.2
7. Oakridge NSWLF*	Dorchester	17.6	13.1 (3.2)
8. Berkeley County MSWLF*	Berkeley	7.4	5.1 (1.0)
9. Bees Ferry Road MSWLF	Charleston	2.5	1.8
10. Hickory Hill MSWLF*	Jasper	10.9	8.9 (3.2)
11. Williamsburg County MSWLF	Williamsburg	too small	too small
12. Abbeville County MSWLF	Abbeville	too small	too small
Total New Landfill Gas		**73.5**	**53.0 (9.4)**

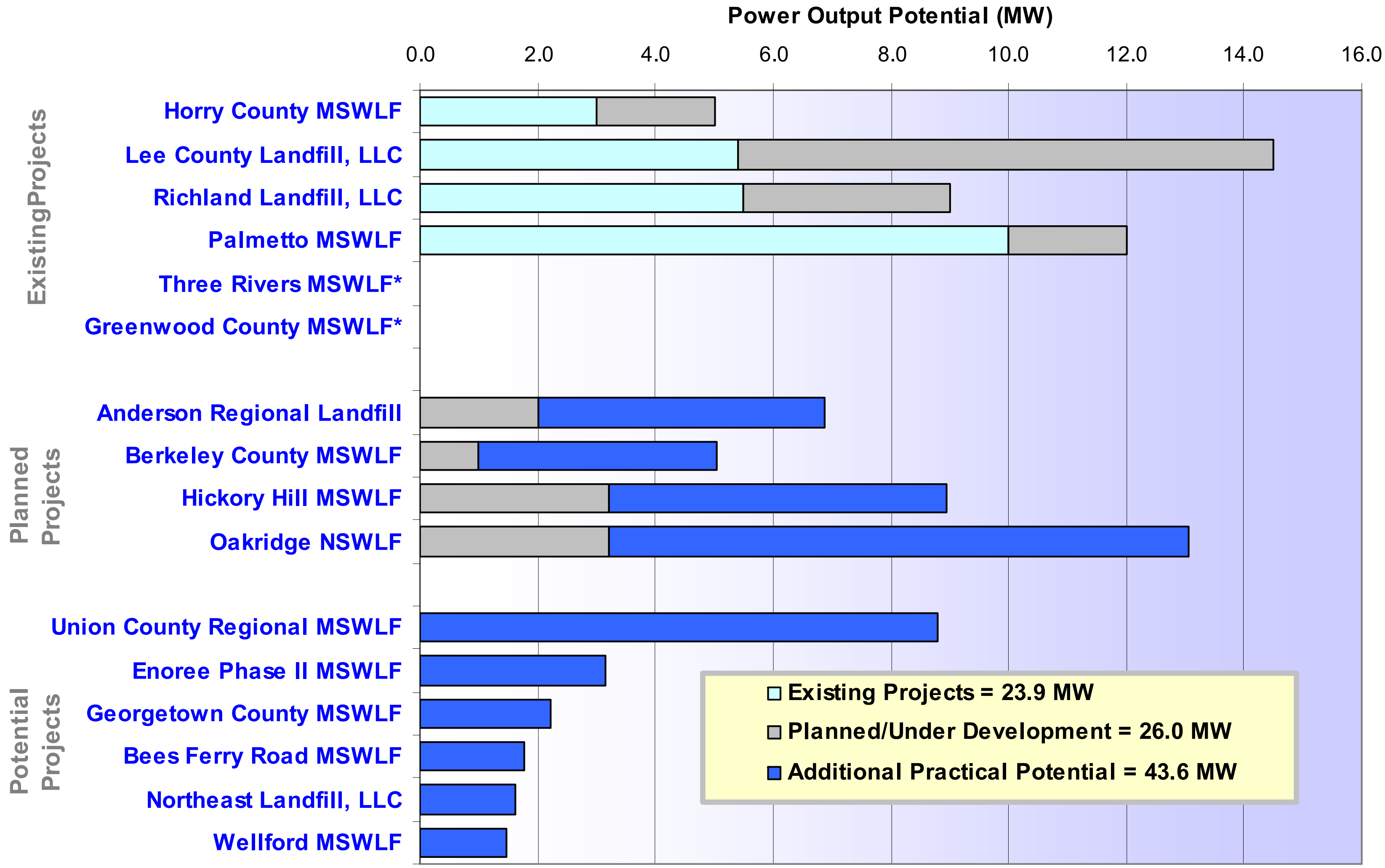
**Planned developments for electric generation by 2011 depicted in parenthesis. Increased developments may be possible after 2011.*

***Estimated technical potential derived from LandGem model that estimates landfill methane production potential. LandGem is a spreadsheet model developed by the EPA that allows users to estimate methane production levels given size and rate of disposal at landfills. Methane production measured over 2008–2027, with the assumption that projects are installed in the 2008–2017 time frame. An 85% capacity factor was assumed.*

****Practical Potential is derived using the lower range of methane production potential for a site for more conservative sizing of a facility. Practical Potential is the maximum potential that might reasonably be expected to be implemented.*

Landfill Gas

Landfill Development Practical Potential



*The landfill gas from these sites are utilized in direct use applications.
**Practical Potential is the maximum potential that might reasonably be expected to be implemented.

Landfill Gas

Comments on Landfill Gas to Energy

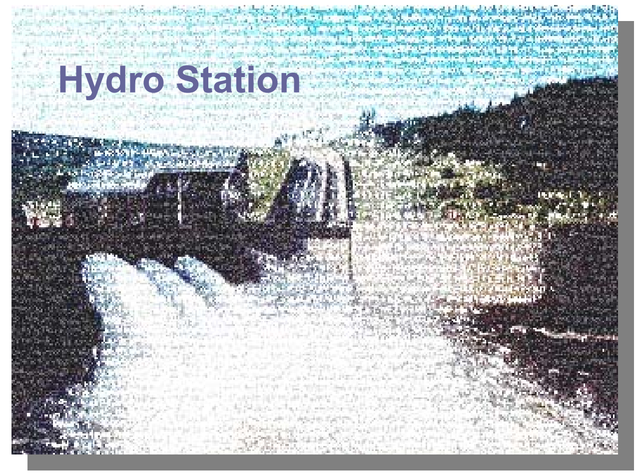
- Landfill gas for electric generation is likely the lowest cost renewable energy option in the state.
- Opportunities to develop projects at almost all of the state's MSW landfills (53 MW), along with expansions at existing sites (16.6 MW), for a total of almost 70 MW of additional capacity over time.
- Size of development will depend on level of waste disposal, build-out of gas collection systems, and methane production at each site currently and in the future.
- Some sites may face competition with direct-use applications of the landfill gas.

Hydro

Description

Hydroelectric generation has been in existence for over a century. It involves the conversion of kinetic hydro energy to electricity by turning a turbine.

National Installed Capacity: 78,700 MW*
SC Installed Capacity: ~3400 MW*



Mature Technologies

- **Conventional with Impoundments**
- **Small Hydro (1 to 30 MWa)**
- **Low Power (Conventional) (<1 MWa)**

Emerging Developments

- **Low power (Unconventional) (<1 MWa)**
- **Microhydro (<100 kW)**
- **Ocean (Tidal, Wave, Current):** Highly site specific for tidal energy, some demonstration projects, but technological issues related to salt water and fish avoidance still need to be resolved.

** Estimates based on compilation of data from sources including Energy Information Agency, National Renewable Energy Laboratory, Environmental Protection Agency, and other web-based sources.*

Summary of Hydroelectric Potential

	Assumed Capacity Factor	Technical Potential (MW)	Practical Potential* (MW)	Practical Generation (GWh)	Notes
>5 MW Conventional	25%	169.1	0.0	0.0	Impoundments at sites listed have not been verified as existing.
1-5 MW Conventional	25%	15.9	3.5	7.7	Only two sites have been verified with existing impoundments.
1-30 MWa New Small Hydro**	N/A	153.0	100.0	876.0	Assumes top 15 of 45 sites are practical based on penstock length evaluation.
<1 MWa Low Power (Conventional)**	N/A	11.0	4.0	35.0	Assumes 14 sites of low-power conventional hydro are practical based on penstock length evaluation.
Total MWa**		**210.3**	**104.9**	**918.8**	

**Practical Potential is the maximum potential that might reasonably be expected to be implemented*

*** Measured in MWa (Average Megawatts) to reflect average energy production rather than capacity.*

Potential Conventional Hydro Sites (>1MW)

Idaho National Laboratory (INL) uses a Project Environmental Sustainability Factor (PESF) to reflect the probability for development. The PESF is used here to reduce total ratings at sites for estimating practical potential. Additionally, many of the potential conventional hydro sites at existing impoundments, as described in INL's database, were unable to be verified as existing, so were not included in practical potential.

Plant Name	County	Dam Status	Rating (MW)	PESF	PESF* Rating (MW)
PARR SHOALS	Newberry	W	5.0	0.5	2.5
BLALOCK	Spartanburg	WO	2.1	0.5	1.0
Practical Potential Total			**7.0**		**3.5**
BLAIR	Newberry	U	109.0	0.5	54.5
COURTNEY ISLAND	Lancaster	U	50.6	0.5	25.3
BURNT FACTORY	Union	U	9.5	0.5	4.7
THOMPSON RIVER	Oconee	U	3.4	0.9	3.1
FORK SHOALS DAM	Greenville	U	2.0	0.9	1.8
VAN PATTON	Laurens	U	3.5	0.5	1.7
Unverified Potential Total			**178.0**		**91.2**

WO = Impoundment Without Existing Turbine Installation W = Impoundment With Existing Turbine Installation U =Unable to Verify Existence of Impoundment

PESF = Project Environmental Sustainability Factor (0.1 for lowest likelihood of development, 0.9 for highest likelihood). INL considered factors such as wild/scenic value, cultural value, fish presence value, geologic value, historic value, recreation value, wildlife value, and federal land in determining PESF

Source: Idaho National Lab (INL) Hydropower Resource Development for South Carolina, FERC Hydro License Database

Hydro Power

Small Hydroelectric Potential

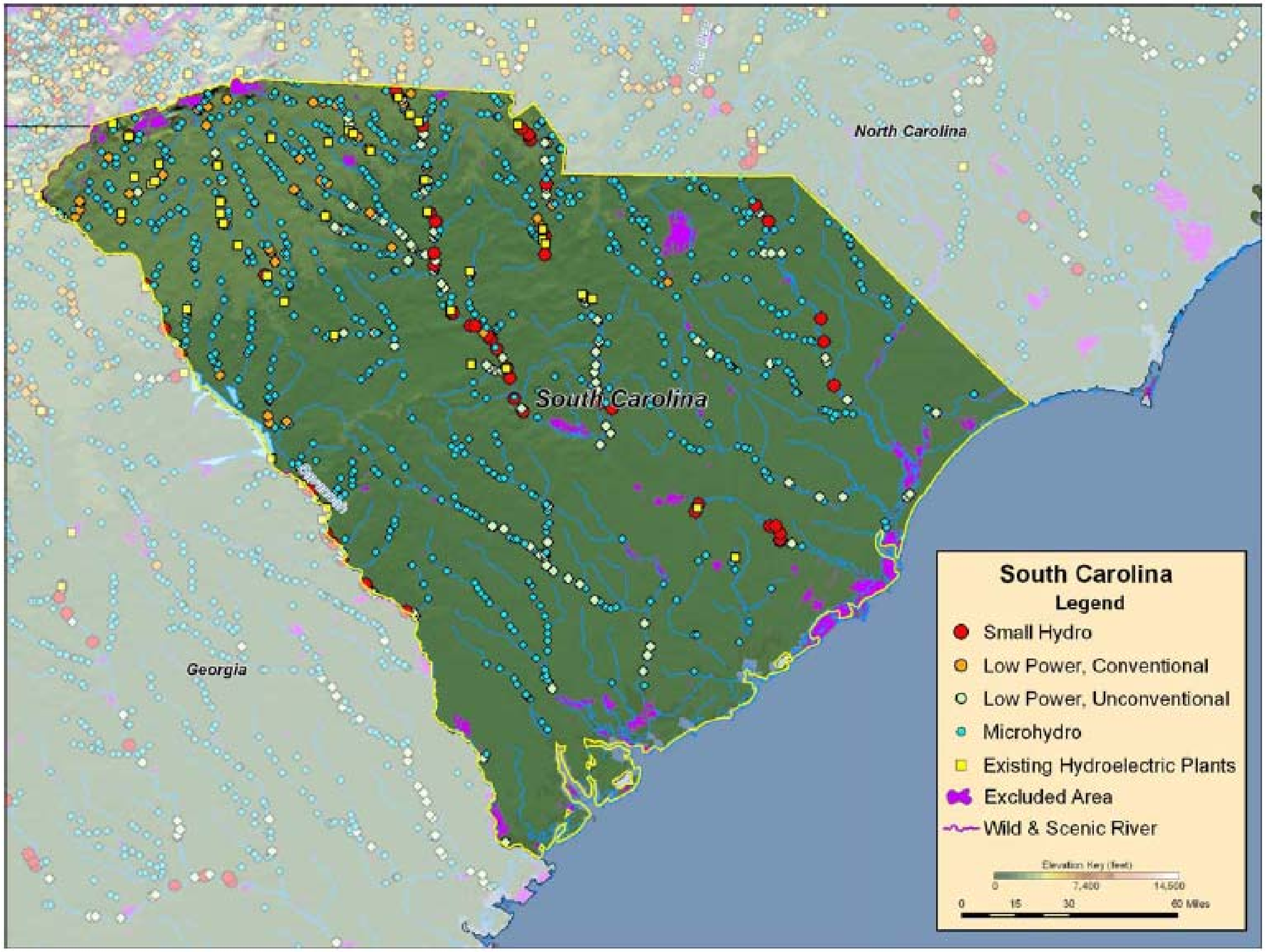


Figure B-200. Low power and small hydro feasible projects, and existing hydroelectric plants in South Carolina.

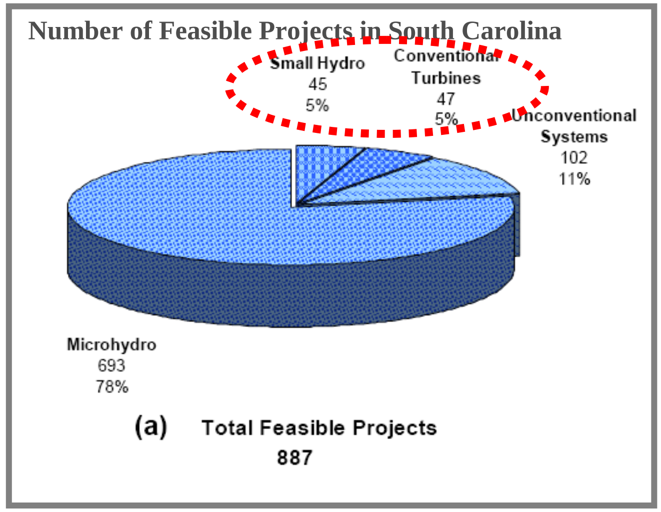
Source: "Feasibility Assessment of the Water Energy Resources of the United States for New Low Power and Small Hydro Classes of Hydroelectric Plants," DOE-ID-11263 (January 2006)

Hydro Power

Small Hydroelectric Potential Methodology

Table B-82. Summary of results of feasibility assessment of water energy resources in South Carolina.

Power Class	Available (MWa)	Feasible Sites (MWa)	Feasible Projects (MWa)
Total Power	**964**	**740**	**211**
Total High Power	**658**	**564**	**153**
Large Hydro	111	111	0
Small Hydro	547	452	153
Total Low Power	**306**	**176**	**58**
Conventional Turbines	139	106	11
Unconventional Systems	70	54	25
Microhydro	97	16	22



Source: "Feasibility Assessment of the Water Energy Resources of the United States for New Low Power and Small Hydro Classes of Hydroelectric Plants," DOE-ID-11263 (January 2006)

- Idaho National Laboratory considered the following for determining Feasible Sites:
  - Site accessibility and load or transmission proximity
  - Land use or environmental sensitivities that would make development unlikely
- Feasible Projects was used for Technical Potential in report.
  - Determined by assuming sites that do not require a dam obstructing the watercourse or the formation of a reservoir (low-impact).

- Practical Potential used in analysis assumes development is limited to conventional hydro technologies ONLY.
  - Unconventional systems and microhydro were excluded.
  - Sites were limited to those with ratios of penstock length (ft) to working head (ft) output that were deemed reasonable for development.

Hydro Power

Comments on Hydroelectric Generation

- Most of the conventional hydroelectric potential (at impoundments) in the state have already been developed.
- Many of the existing impoundments, according to Idaho National Laboratory, that may have development potential have not been verified as actual sites.
- Otherwise, there are about 15 out of 45 sites for small hydro (1−30 MWa*) run-of-river projects determined to be practical for development, totaling 100 MWa* of potential.
  - Hydro permitting continues to be difficult, but these sites may face less barriers as no impoundments are required.
- Additionally, 14 of 47 sites of low power (conventional) hydro may be practical, totaling about 4 MWa*.
- Ocean energy options were not assessed because there are limited studies of the resource potential and most technologies are still in pilot phases.

** New Small Hydro and Low Power are measured in MWa (Average Megawatts) to reflect average energy production rather than capacity.*

Wind (On-Land and Offshore)

Description

A wind energy system transforms the kinetic energy of the wind into mechanical or electrical energy. Propeller-like wind turbines are most prevalent.

National Installed Capacity: 11,700 MW*
SC Installed Capacity: 0 MW

Mature Technologies

- **Propeller (Horizontal) Wind Turbines:** Great advances have been made to these turbines to bring costs down significantly for land applications. Utility-scale turbines range 1 to 3 MW and are installed at about 75 to 100 meters high.
- **Offshore Wind Turbines:** Similar technology as on-land wind turbines, though typically larger (2.5−5 MW) and has added complexities of construction and weatherproofing for ocean conditions. Currently over 800 MW installed world-wide, but none in the U.S.

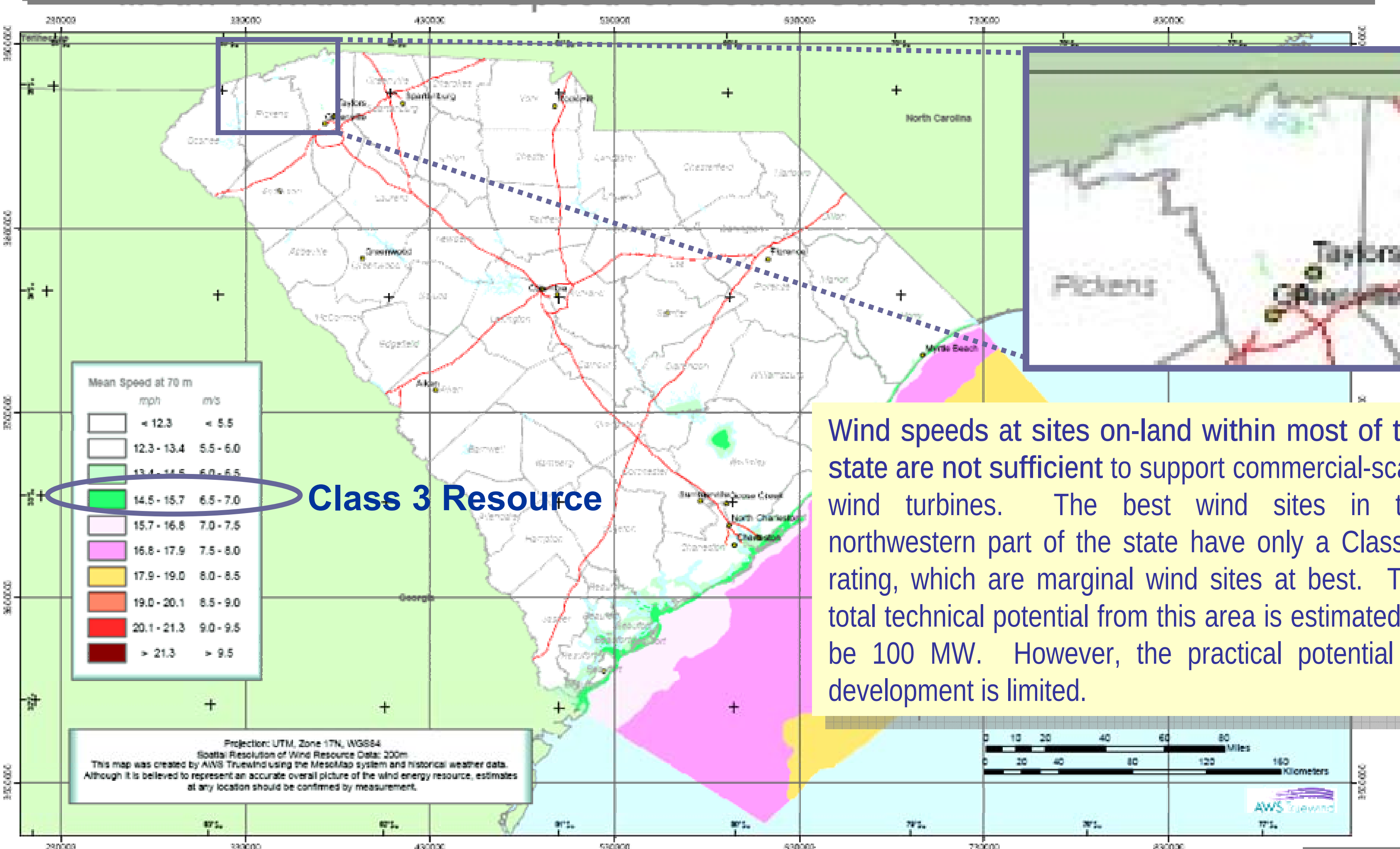
Emerging Developments

- **Vertical-axis Wind Turbines:** The horizontal nature of these turbines may allow for utilization of lower wind speeds and eliminate need for a tower.
- **Extendable Rotor Blades**: Able to adjust wing span of blades depending on wind speed.
- **Wind with Compressed Air Storage**: Mechanical wind energy pumps air into storage cavities underground, and pressure is released for electricity generation when needed.
- **Buoyed Wind Structure:** Wind turbines are placed on buoy-like devices for deep off-shore locations.

** Estimates based on compilation of data from sources including Energy Information Agency, National Renewable Energy Laboratory, Environmental Protection Agency, and other web-based sources.*

Onshore Wind Potential

Mean Annual Wind Speed of South Carolina at 70 Meters



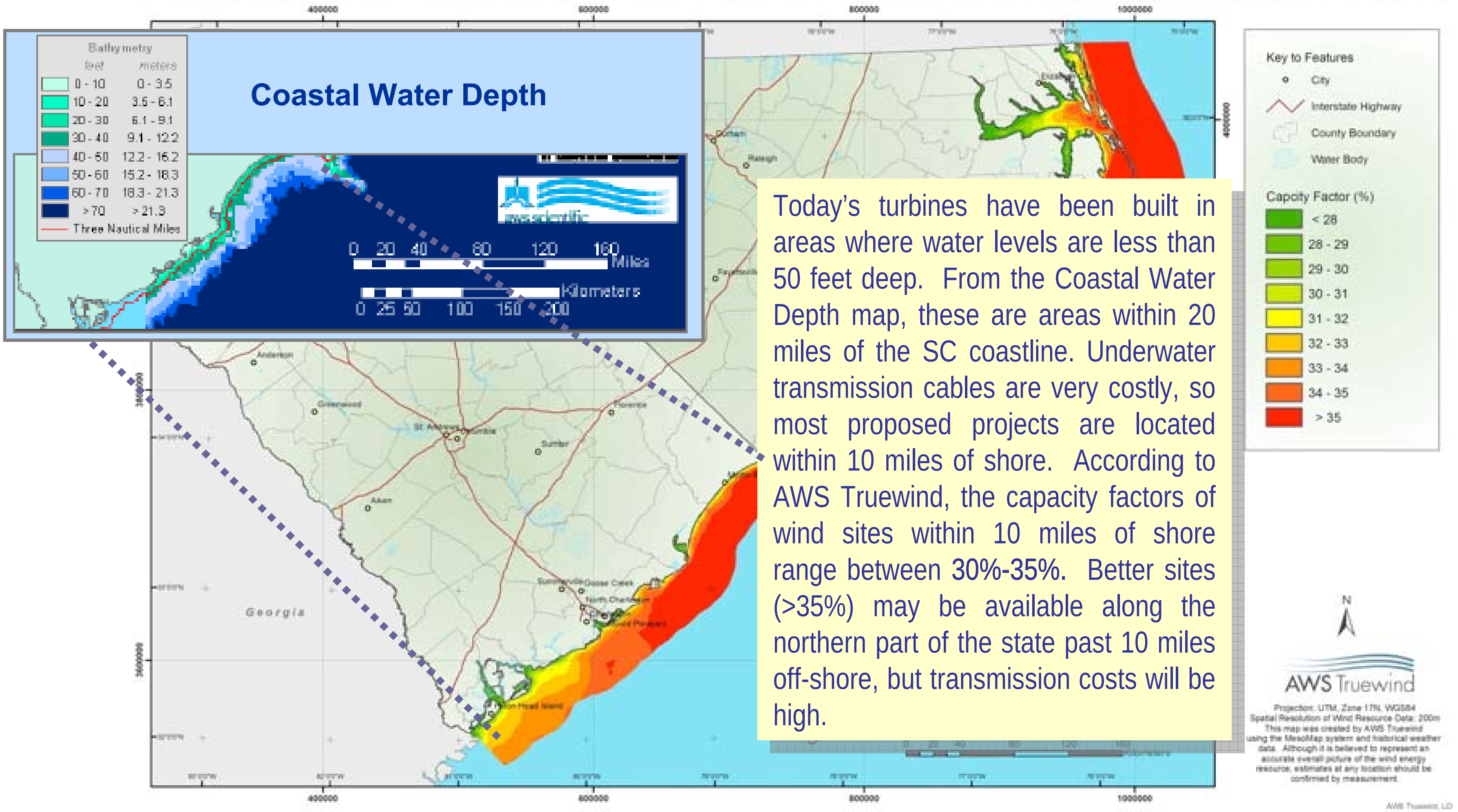
Wind speeds at sites on-land within most of the state are not sufficient to support commercial-scale wind turbines. The best wind sites in the northwestern part of the state have only a Class 3 rating, which are marginal wind sites at best. The total technical potential from this area is estimated to be 100 MW. However, the practical potential of development is limited.

Source: www.energy.sc.gov

Wind

Some Offshore Potential

Net Capacity Factor – GE 3.6 MW 90 m Hub Height, 111 m Rotor Diameter ***(Assuming 15% Loss Factor)***



Today's turbines have been built in areas where water levels are less than 50 feet deep. From the Coastal Water Depth map, these are areas within 20 miles of the SC coastline. Underwater transmission cables are very costly, so most proposed projects are located within 10 miles of shore. According to AWS Truewind, the capacity factors of wind sites within 10 miles of shore range between 30%-35%. Better sites (>35%) may be available along the northern part of the state past 10 miles off-shore, but transmission costs will be high.

Source: "Offshore Wind Power Potential of the Carolinas and Georgia," Presentation by Jeffrey Freedman, AWS Truewind

Wind

Offshore Wind Development Issues

- **Offshore permitting becomes more complicated when in federal waters (>3 miles offshore) due to approvals needed from both state and federal agencies.**
  - Several offshore wind projects in the U.S. are seeking permits through these agencies and have passed some hurdles already.
  - However, some agencies do not have standards in place or lack any precedence for dealing with offshore wind projects, so proposed projects have experienced delays.
- **Potential risks related to hurricanes.**
  - According to GE Wind, turbine designs currently can sustain up to 130 mph winds (equivalent to Category Three hurricane wind speed).*
  - South Carolina has experienced two Category Four hurricanes in the last 150 years.
- **Costs for underwater transmission and foundation structures will be highly site specific.**

Table 10. Hurricane direct hits on the mainland U.S. coastline and for individual states 1851-2004 by Saffir/Simpson category. Updated from Jarrell et al. (2001).

AREA	CATEGORY NUMBER 1	2	3	4	5	ALL	MAJOR HURRICANES
U.S. (Texas to Maine)	109	72	71	18	3	273	92
Texas	23	17	12	7	0	59	19
(North)	12	6	3	4	0	25	7
(Central)	7	5	2	2	0	16	4
(South)	9	5	7	1	0	22	8
Louisiana	17	14	13	4	1	49	18
Mississippi	2	5	7	0	1	15	8
Alabama	11	5	6	0	0	22	6
Florida	43	32	27	6	2	110	35
(Northwest)	27	16	12	0	0	55	12
(Northeast)	13	8	1	0	0	22	1
(Southwest)	16	8	7	4	1	36	12
(Southeast)	13	13	11	3	1	41	15
Georgia	12	5	2	1	0	20	3
South Carolina	19	6	4	2	0	31	6
North Carolina	21	13	11	1	0	46	12
Virginia	9	2	1	0	0	12	1
Maryland	1	1	0	0	0	2	0
Delaware	2	0	0	0	0	2	0
New Jersey	2	0	0	0	0	2	0
Pennsylvania	1	0	0	0	0	1	0
New York	6	1	5	0	0	12	5
Connecticut	4	3	3	0	0	10	3
Rhode Island	3	2	4	0	0	9	4
Massachusetts	5	2	3	0	0	10	3
New Hampshire	1	1	0	0	0	2	0
Maine	5	1	0	0	0	6	0

Notes:

State totals will not equal U.S. totals, and Texas or Florida totals will not necessarily equal sum of sectional totals. Regional definitions are found in Appenix A

Source: "Offshore Wind Power Potential of the Carolinas and Georgia," Presentation by Jeffrey Freedman, AWS Truewind

** GE Info from http://www.clemson.edu/scies/wind/Presentation-Grimley.pdf*

Comments on Wind Power

- There are virtually no onshore wind sites that can be practically developed in South Carolina.
- There may be some opportunities for development of offshore wind projects, but projects must overcome permitting and performance barriers.
  - The anticipated capacity factors of sites less than 10 miles offshore are 30% to 35%, which are less than more optimal sites with 40% to 45% capacity factors in other parts of the country.
  - The low capacity factor estimates will directly impact the cost ($/MWh) of the generated electricity.
- Higher capacity factors may be achievable if located greater than 10 miles offshore along the northern part of the state.
  - Additional transmission costs and deep water structures may be needed which would increase the development cost of sites.
- Risks associated with Category Four and higher hurricanes will need to be considered in offshore wind development.

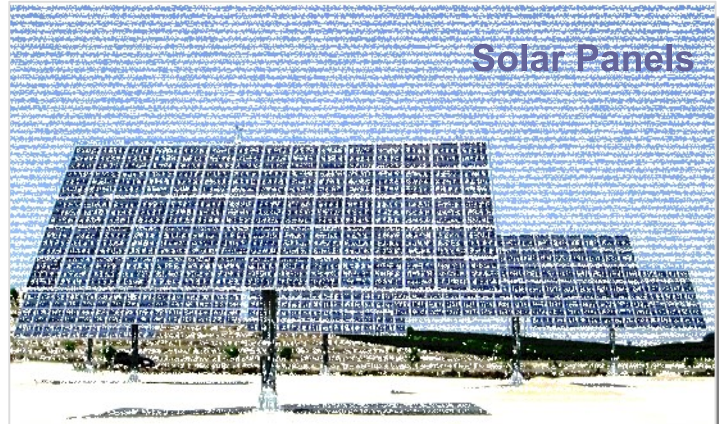
Solar for Electricity

Description

Solar energy can be utilized in several ways, including direct electricity conversion, in-direct electricity conversion, or direct thermal applications. In this section, the focus is on solar for electricity generation.

National Installed Capacity: 450-500 MW*

SC Installed Capacity: <1 MW



Technologies

- **Photovoltaic (PV):** Flat panel of silicon-based material that converts solar energy directly into electricity.
- **Concentrated Solar PV:** Reflective material used to focus light onto PV for increased electricity conversion for smaller area of PV material. Some technical issues still to overcome with heat management.

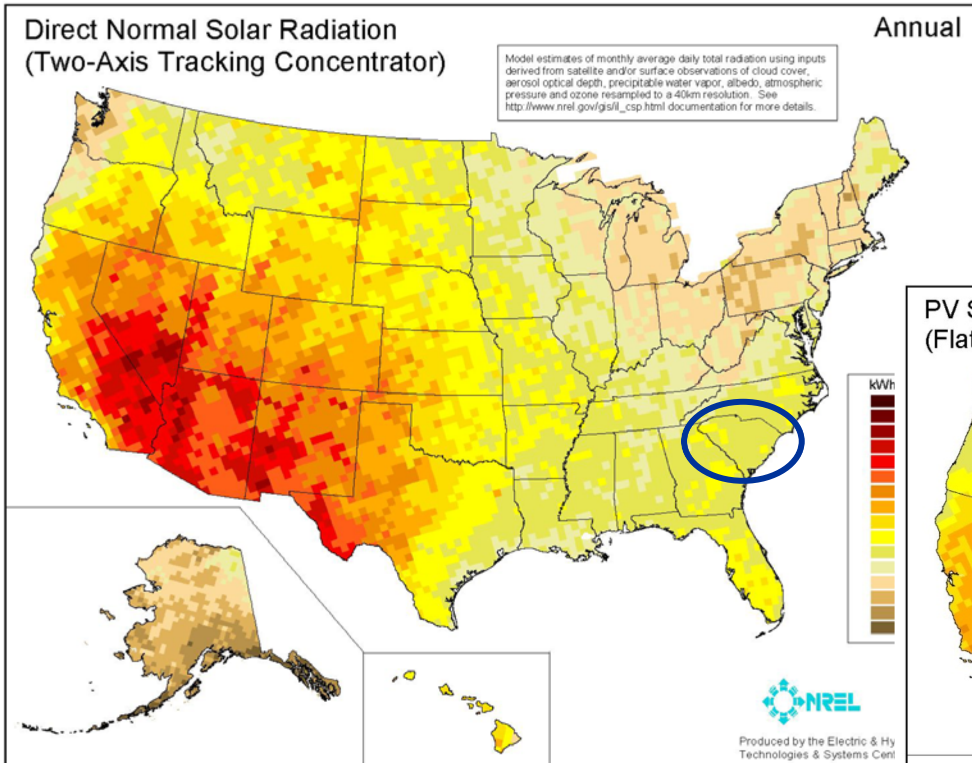
Emerging Developments

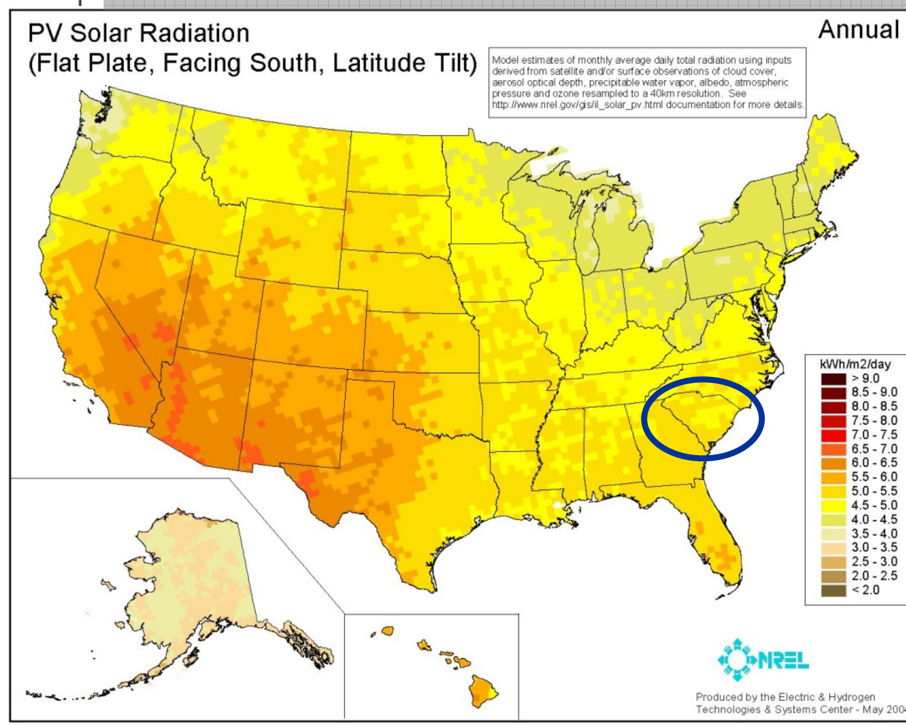
- **Thin-film Materials**
- **Nanosolar**
- **Dish/Stirling Engine**
- **Parabolic Trough System**
- **Power Tower System**

**Estimated from total cumulative historical sales of solar photovoltaic installations in the U.S. by EIA and other web-based sources. This does not include concentrated solar installations.*

National Solar Radiation

Solar Radiation in South Carolina is about average in the U.S., while southwestern states have superior resources. Direct normal solar radiation for concentrator applications range between 4.0 to 5.0 kWh/m2/day. **Solar radiation appears to be better for flat plate, fixed tilt** PV systems **in South Carolina relative to two-axis tracking concentrators.**

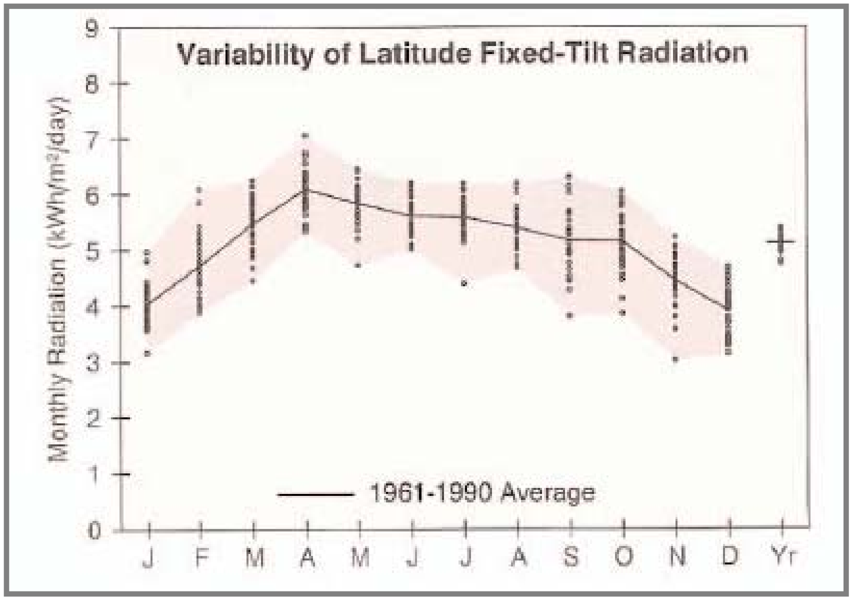




Solar

South Carolina Solar Radiation

Solar Radiation for Flat-Panel Fixed Tilt System for South Carolina



Source: "Solar Radiation Data Manual for Flat-Plate and Concentrating Collectors," NREL <http://rredc.nrel.gov/solar/pubs/redbook/>

- **Current photovoltaic (PV) systems can achieve about 10% net energy conversion efficiency, after accounting for system losses.**
- **Range of average annual solar radiation is 4.6 to 5.1 kWh/m²/day in South Carolina.**
  - 0.46 to 0.51 kWh/m²/day of electricity production from a flat-panel fixed tilt system (average installation ~100 watts/m²).
  - Estimated capacity factor potential is 19% to 21% in the state.

Recently, there was a groundbreaking of the largest utility-scale PV system in the U.S. of 8.2 MW in Colorado on 82 acres. That is equivalent to about 100 kilowatts (kW) per acre. The expected annual energy production is 17,000 MWh (equivalent to 23.6% capacity factor).

Emerging Concentrated Solar Power Technologies (CSP)

While there are a few CSP projects being planned in southwestern U.S., **the potential of CSP in South Carolina appears limited** due to a lack of consistent, high direct solar radiation (>6.75 $kWh/m^2/day$ is recommended). The direct solar radiation in the state averages only 4.0 to 5.0 $kWh/m^2/day$.

Parabolic Trough

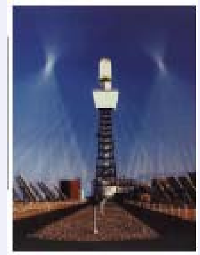
Parabolic-trough systems

- Concentrate solar energy through long rectangular, curved (U-shaped) mirrors.
- The energy heats oil flowing through the pipe, which is then used to boil water in a conventional steam generator to produce electricity.
- Requires direct normal solar radiation (>6.75 kWh/m2/day) and large flat land areas for cost-effective operation.
- A 65 MW solar trough is planned for Nevada.

Solar Dish

Dish/engine system
(Stirling Engine)

- The dish-shaped surface collects and concentrates the sun's heat onto a receiver.
- The heat causes fluid to expand against a piston or turbine to produce mechanical power, which then runs a generator or alternator to produce electricity.
- Stirling Engine has started construction of a test site (<1 MW) that may eventually grow to a 500 MW to 800 MW project in California.



Power Tower

Power tower system

- Uses a large field of mirrors to concentrate sunlight onto the top of a tower, where a receiver sits.
- Molten salt flowing through the receiver is heated and the heat is used to generate electricity through a conventional steam generator.
- Previous demonstration projects were mothballed and no new systems planned in the U.S.

Comments on Solar Potential

- In general, solar PV deployment is not limited by resource availability but rather by cost and technological barriers. Therefore, the solar potential for electric generation was not estimated.
- CSP deployment does appear limited in the state due to insufficient direct solar radiation.
  - The direct solar radiation (4.0-5.0 kWh/m²/day) in the state appears to be less than the recommended level for concentrator applications of 6.75 kWh/m²/day or higher found in southwestern states.
  - Additionally, with very few CSP projects in existence, most being demonstration projects, the commercial costs associated with these projects are difficult to estimate.
- In some states, with substantial subsidies or tax incentives, the cost of energy produced from solar projects is becoming more cost-competitive with other generation options.
  - However, South Carolina does not offer solar incentives for electricity production, only for thermal water heating.

Financing and Cost Assumptions

1. Assess Available Resources
2. Select Generation Technologies
3. Determine Technical Potential of Resource
4. Determine Practical Potential of Resource
5. Develop Financing and Cost Assumptions
6. Calculate Levelized Cost per MWh

Financing Assumptions as Tax Exempt Entity

- Tax exempt ownership is assumed for most utility-scale generation.
  - Assumed Weighted Average Cost of Capital (WACC) = 6.0%
- Costs are calculated to estimate ratepayer impact.
- CREBs financing is not included in financial assessment since subsequent rounds are uncertain.

Clean Renewable Energy Bonds (CREBs)

- CREBs are non-interest bearing loans
- Taxpayer (holder of bond) credit is entitled to a tax credit instead
- 2006 Round provided $800 million
  - Average size of the 85 accepted cooperative projects was $6.5 million
- 2007 Round is for $400 million and deadline is July 13, 2007

Tax Benefits for Tax-Paying Entities

- **Production Tax Credit is due to expire by the end of 2008.**
  - Currently worth ~$20/MWh and increases with inflation adjuster.
  - Several bills proposed for another 5-year extension.
  - Projects receive PTC for 10 years.
- **5-Year Modified Accelerated Cost Recovery System (MACRS) allowed for some.**
- **It is assumed that non-tax paying (tax-exempt) entities are not able to take advantage of these tax incentives for purposes of this analysis.**

Financial Assumption	Production Tax Credit ($/MWh)*	Accelerated Depreciation
Biomass (Open-loop)	~$20	
Biomass (Close-loop)	~$10	
Wind	~$20	MACRS
Incremental Hydro	~$10	
Solar Residential**		MACRS
Solar Business**		MACRS

**This is the estimated level for the PTC in 2007, after taking into account inflation.*

***Solar installations receive other tax credits as discussed in next section.*

Financing Assumptions Used

- **Tax-exempt entity ownership is assumed for most utility-scale generation, so tax incentives are not utilized.**
  - CREBs financing is not included since availability after 2007 is uncertain.
- **Exceptions to tax-exempt entity ownership are for Solar PV and Anaerobic Digesters.**

Financial Assumption	Tax Exempt Entity	Merchant PV Owner	Residential PV Customer	Anaerobic Digester Owner
Weighted Average Cost of Capital (WACC)	6.0%	7.0% (after-tax equity req. for 100%)	4.8% (after-tax mortgage rate)	7.0% (after-tax equity req. for 100%)
Project Life	20 years	20 years	20 years	20 years
Tax Credits	None	30%/ (10% after 2007)	$2000 cap per panel	50% of PTC (~$10/MWh)
Depreciation	None	5-year MACRS	None	7-year flat
Discount Rate	6.0%	7.0%	7.0%	7.0%
Calculated Carrying Charge	**8.72%**	**6.63% (9.35%)**	**7.72%**	**11.08%**

Renewable Costs and Characteristics

Renewable Technologies	Size (MW)	Capacity Factors	Average Installed Cost (2006$/kW)	High Installed Cost (2006$/kW)	Fixed O&M (2006$/kW)	Variable O&M (2006$/MWh)	Heat Rate (Btu/kWh)
Landfill Gas ICE (>5 MW)[1]	5-10	80%-85%	$1,750	$2,000	$100	$12	9,500
Landfill Gas ICE (<5 MW)[1]	1-5	80%-85%	$2,500	$3,000	$100	$12	9,500
Biomass (Co-fire Blending)[2,3,5]	5%	70%-75%	$75	$100	$12	$5	12,000
Biomass (Co-fire Retrofit)[2,4,5]	15%-20%	70%-75%	$230	$300	$12	$5	12,000
Biomass (Stoker)[5]	25	80%-90%	$2,700	$2,970	$75	$10	13,000
Biomass (Fluidized Bed)[5]	25	80%-90%	$3,000	$3,300	$75	$10	13,800
Anaerobic Digester (Swine Waste)	0.10	70%-80%	$4,000	$6,000	$270	$0	14,000

1. Fuel cost range for Landfill Gas projects assumed to be $0.50 to $1.50/mmbtu (2006$).

2. Co-firing costs are calculated as incremental costs of avoiding coal consumption for generation ($2.25/mmbtu (2006$) coal cost assumed).

3. Blending refers to retrofitting coal plants with the ability to blend some biomass (up to 5% of fuel consumption of site) with coal fuel.

4. Retrofit refers to greater capital improvements needed to accommodate higher levels of biomass co-firing (15%-20% of fuel consumption of site) with coal.

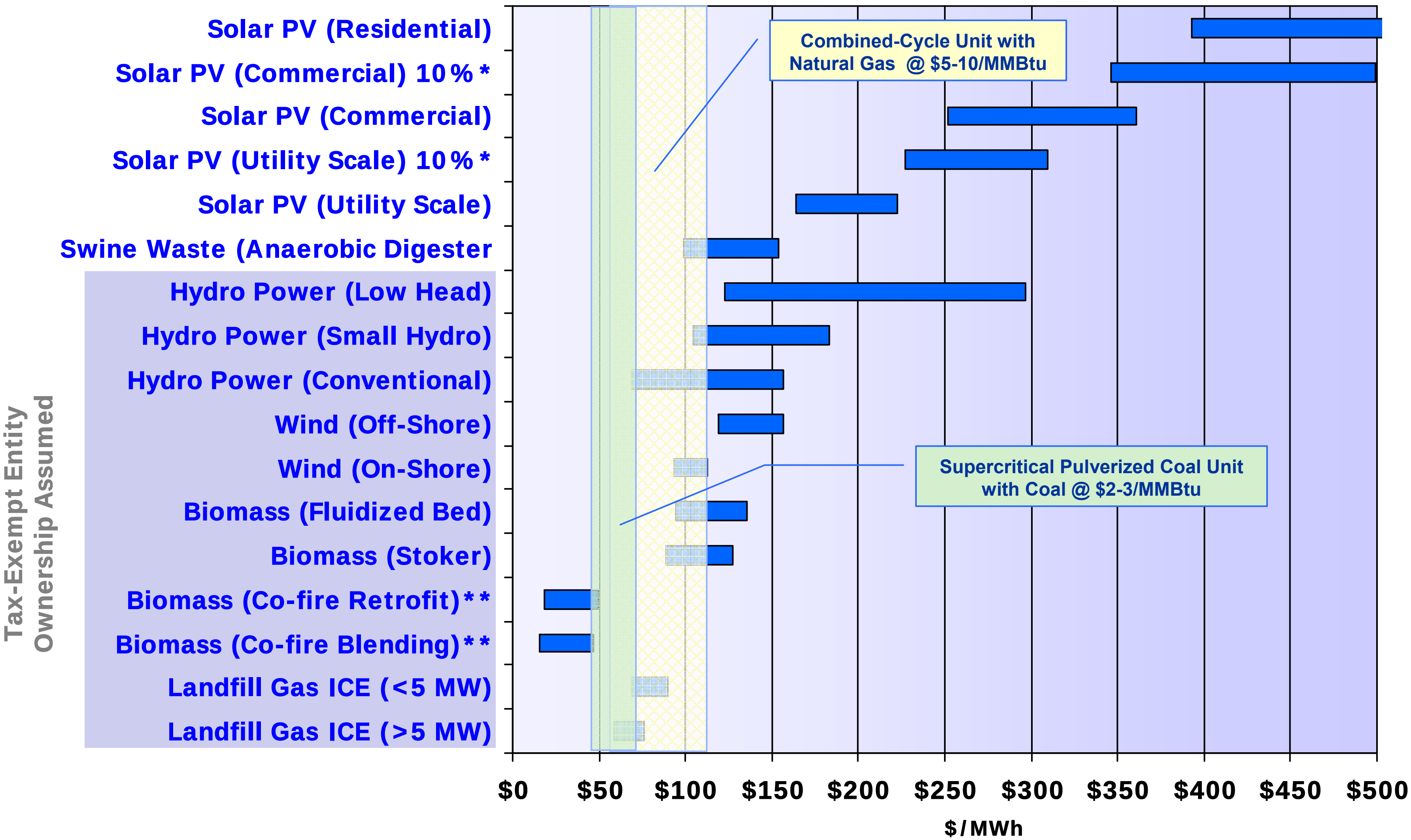
5. Biomass fuel cost range assumed to be $1.88/mmbtu to $3.90/mmbtu (2006$).

Renewable Costs and Characteristics

Renewable Technologies	Size (MW)	Capacity Factors	Average Installed Cost (2006$/kW)	High Installed Cost (2006$/kW)	Fixed O&M (2006$/kW)	Variable O&M (2006$/MWh)
Wind (On-Shore)	25-50	25%-28%	$1,800	$2,000	$45	$2
Wind (Off-Shore)	50-400	30-35%	$2,800	$3,300	$80	$2
Hydro Power (Conventional)	1-50	25%-35%	$2,000	$3,500	$12	$3
Hydro Power (Small Hydro)	1-30*	25%-35%	$3,000	$4,000	$20	$5
Hydro Power (Low Head)	<1*	20%-35%	$4,000	$5,000	$50	$10
Solar PV (Utility Scale)	1-10	19%-21%	$4,000	$5,000	$15	
Solar PV (Commercial)	0.025-0.050	19%-21%	$6,000	$8,000	$30	
Solar PV (Residential)	0.002	19%-21%	$8,000	$10,000	$50	

** Size of hydro facilities are measured in MWa, based on annual average flow rather nameplate capacity.*

Levelized Cost Comparison (2008$)



*Cost estimates include reduction of federal solar tax credits to 10% after 2007 for commercial/utility scale installations.
**Co-firing costs are calculated as incremental costs of avoiding coal consumption for generation ($2.25/mmbtu (2006$) coal cost assumed).

Financing and Costs

Conclusions

- **Landfill gas** is the state's lowest cost renewable energy option for electric generation; the practical potential is about 70 MW, with levelized costs of <$90 per MWh.
- **Biomass** (urban wood waste, logging residue, commercial thinnings, corn, and poultry litter) used in direct-fire generation can provide the next lowest cost renewable energy option for the state, contributing up to 490 MW in total, with costs ranging from $90 to $135 per MWh.
  - With incremental costs of $15 to $50 per MWh (above coal generation costs), **co-firing** may be an option, but will be limited by compatibility issues.
- **Small hydro (without impoundments)** may provide about 100 MWa of energy for the state, but costs may vary widely depending on site-specific issues and capacity factors. Permitting may also be an issue.
- There are virtually **no onshore wind sites** that can be practically developed in South Carolina.
- There may be some opportunities for the development of **offshore wind** projects, but projects must overcome permitting and performance barriers. The levelized cost of electricity range between $120 to $155 per MWh.
- In general, **solar PV** deployment is not limited by resource availability but rather by cost ($165 to $500+ per MWh) and technological barriers.

End of Report

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   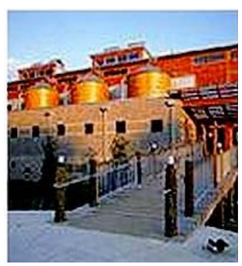 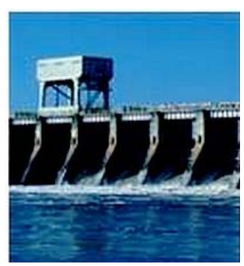 

Appendix A: Detailed Summary of Resources

		Maximum Fuel (MMbtu)	Assumed Capacity Factor	Technical Potential (MW)	Practical Potential (MW) *	Practical Generation (GWh)	Notes
Biomass	Logging Residue	37,497,750	85%	360	180	1,339	Most economic option. 50% reduction due to some areas being inaccessible.
	Precommercial Thinnings	72,724,266	85%	698	-	-	Costs for harvesting are higher due to smaller stands of 1-5 inches diameter.
	Commercial Thinnings	45,356,000	85%	435	217	1,617	Costs for harvesting are greater than logging residue but less than precommercial due to larger stand sizes.
	Southern Scrub Oak	414,732	85%	4	-	-	Low density and low distribution in SC, so uneconomic to harvest.
	Net Available Mill Residue	102,731	85%	1	-	-	Majority consumed on-site at mills.
	Urban Wood Waste	10,557,000	85%	101	26	192	Low cost alternative to tipping fees, must be clean wood (unpainted, untreated).
	Subtotal (Biomass)			***1,599***	***423***	***3,148***	
Landfill Gas	New Landfill-to-Energy	5,470,128	85%	73	53	394	Includes all large-size MSW landfills in South Carolina, except for two that are too small.
	Expansions of Existing	1,236,036	85%	17	17	124	Includes planned expansions to existing facilities.
	Subtotal (Landfill Gas)			***90***	***70***	***518***	
Agricultural Waste	Agricultural Crop Residue						
	Corn	7,480,346	85%	72	36	267	Some potential but must be co-fire with other fuels.
	Wheat	3,370,815	85%	32	-	-	Soybean planting immediately after wheat harvest makes timing difficult for collection.
	Soybean	3,337,936	85%	32	-	-	Limited demonstration projects for soybean, potential issues in firing.
	Cotton	4,145,582	85%	40	-	-	Limited demonstration projects for cotton, potential issues in firing.
	Switchgrass	16,790,918	85%	142	-	-	Current costs for harvesting are estimated to be $48-$132/ton (wet) which is more costly than other options.
	Poultry Litter	4,384,851	85%	42	31	230	Insufficient poultry litter to supply single dedicated plant economically. Likely to co-fire with other fuels from top 10 counties for practical potential.
	Swine Waste	166,922	75%	1.81	1.03	7	Only 37 farms in SC have >2,000 heads per farm. For practical potential, we use farms >5,000 heads per farm which is only 21 farms.
	Subtotal (Ag Waste)			***362***	***68***	***504***	

**Practical Potential is the maximum potential that might reasonably be expected to be implemented.*

Appendix A: Detailed Summary of Resources (cont'd)

		Maximum Fuel (MMbtu)	Assumed Capacity Factor	Technical Potential (MW)	Practical Potential (MW) **	Practical Generation (GWh)	Notes
Hydro Power	>5 MW Conventional		25%	169	-	-	Impoundments at sites listed have not been verified as existing.
	1-5 MW Conventional		25%	16	4	8	Assumes conventional turbines at sites <5 MW with existing impoundments. Several sites have not been verified.
	1-30 MWa New Small Hydro*		N/A	153	100	875	Additional potential for new small hydro without impoundments (assumes top 15 of 45 sites are practical based on penstock length evaluation).
	<1 MWa Low Power*		N/A	11	4	31	Includes low-head, low-power hydro (14 sites of low-power conventional hydro assumed practical based on penstock length evaluation).
	Subtotal (Hydro Power) MWa*			***210***	***105***	***919***	
Wind	On-Shore (Class 3, 70 m)		28%	100	-	-	Rough estimate based on about 10 miles of ridgeline in northwest part of state with Class 3 resources, likely undevelopable due to transmission limitations and economics
	Off-Shore (Class 4, 90 m)		30%	N/E	N/E	N/E	Low capacity factors for off-shore wind may make projects uneconomic.
	Off-Shore (Class 5, 90 m)		35%	N/E	N/E	N/E	Farther off-shore wind with better capacity factors may require underwater transmission lines greater than 10 miles and face federal permitting.
	Subtotal (Wind)			***100***	***-***	***-***	
Solar	Photovoltaic or Concentrated Solar			N/E	N/E	N/E	Abundant resource is limited by cost and energy density. For PV, approximately 100 kW per acre has been achieved. For concentrated stirling installations, 25kW systems exist for about 1000 sq. ft of surface area.
Ocean	Tidal, Wave, or Current			N/E	N/E	N/E	Still in pilot stages, but there has been no studies conducted of South Carolina's specific potential.

**Hydroelectric potential is measured in average MW based on annual mean flow rates or estimated annual production.*

***Practical Potential is the maximum potential that might reasonably be expected to be implemented*

Appendix B: Levelized Cost of Renewables

Renewable Technologies	2008 Levelized Cost ($/MWh)	2008 High Levelized Cost ($/MWh)	Delta Range	Capacity Factor	Low Capacity Factor	Average Installed Cost (2006$/kW)	High Installed Cost (2006$/kW)	Fixed O&M (2006$/kW)	Variable O&M (2006$/MWh)
Landfill Gas ICE (>5 MW)	$59	$76	$17	85%	80%	$1,750	$2,000	$100	$12
Landfill Gas ICE (<5 MW)	$68	$90	$21	85%	80%	$2,500	$3,000	$100	$12
Biomass (Co-fire Blending)	$16	$46	$31	75%	70%	$75	$100	$12	$5
Biomass (Co-fire Retrofit)	$18	$49	$31	75%	70%	$230	$300	$12	$5
Biomass (Stoker)	$88	$127	$39	85%	80%	$2,700	$2,970	$75	$10
Biomass (Fluidized Bed)	$94	$135	$41	85%	80%	$3,000	$3,300	$75	$10
Wind (On-Shore)	$93	$112	$19	28%	25%	$1,800	$2,000	$45	$2
Wind (Off-Shore)	$119	$156	$37	35%	30%	$2,800	$3,300	$80	$2
Hydro Power (Conventional)	$69	$156	$87	35%	25%	$2,000	$3,500	$12	$3
Hydro Power (Small Hydro)	$105	$183	$78	35%	25%	$3,000	$4,000	$20	$5
Hydro Power (Low Power <1 MW)	$123	$296	$173	35%	20%	$3,000	$5,000	$50	$10
Anaerobic Digester (Swine Waste)**	$99	$154	$55	80%	70%	$4,000	$6,000	$270	-$12
Solar PV (Utility Scale >1 MW)	$164	$223	$58	21%	19%	$4,000	$5,000	$15	
Solar PV (Utility Scale >1 MW) 10%***	$227	$309	$82	21%	19%	$4,000	$5,000	$15	
Solar PV (Commercial 25-50 kW)	$252	$360	$109	21%	19%	$6,000	$8,000	$30	
Solar PV (Commercial 25-50 kW) 10%***	$346	$499	$153	21%	19%	$6,000	$8,000	$30	
Solar PV (Residential <2 kW)*	$393	$529	$136	21%	19%	$8,000	$10,000	$50	
Coal	$45	$65	$20	90%	80%	$1,500	$2,000	$15	$2
CCGT	$55	$110	$55	75%	50%	$500	$850	$8	$2

**Uses Residential/Commercial Carrying Charge*
***Uses Farmer's Return Requirements plus PTC Benefits*
****Uses Merchant Plant Carrying Charge and 10% Allowed Solar Tax Credit*