Assessing Extent to Which US Southeastern Woody Biomass Supply Can Meet Renewable Electricity Demand in Present and Future Scenarios

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ABSTRACT

Woody biomass has rapidly come to the forefront of renewable energy discussions as a potentially reliable and affordable energy solution. The reason for such is rooted in international and domestic policy evolution. The increasing reliance on alternative energy options is a direct response to the desire for national energy security as well as a commitment to mitigate climate change.

This project attempts to quantify the contribution of Southeastern forest resources to a proposed federal 15% Renewable Electricity Standard demand. Results indicate residual biomass supply can only provide 19% of a 15% RES demand under current population pressures and climate change conditions. More expansive biomass definitions increase the total biomass contribution, yet some of this supply requires unrealistic market expectations. Utilizing the more reasonable expansive supply, unused pulpwood capacity (peak production minus current production) provides, on average, an additional 8% to a 15% demand.

Following initial calculations, biomass supply and electric demand were projected and estimated under future climate change scenarios for the state of North Carolina. Results of future projections suggest biomass can meet anywhere from 8- 17% of a 15% RPS demand. However, these are likely best-case scenarios, as climate change, demand for other products, and social acceptability for forest management all create uncertainties that will likely increase in the future.

It is clear that biomass can only be *a part of* a renewable energy solution, at least in terms of offsetting traditional electric energy demand. Although biomass has the potential to be a significant contributor, policy makers must incorporate a flexible and diversified energy portfolio to establish complete RES compliance or recognize the increased efficiency of biomass in alternative energy applications.

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POLICY ANALYSIS

1. Putting Biomass in a Historical Policy Context

1.1 Why Biomass?

As increased focus turns to biomass utilization for a renewable energy solution, it is important to understand the process by which woody biomass came to the forefront of energy discussions. Arising from both international and domestic policies, woody biomass has gradually risen to the energy prominence it holds today. A detailed look into this energy sector evolution will better explain the role biomass is expected to play, from a historical reference.

1.2 International Underpinnings

Perhaps the greatest lesson of the 1973-1974 Oil Crisis (a series of sharp price increases as a result of selective embargos by OPEC) was the realization that the United States directly relied on foreign countries to source crude oil. After the energy crisis, the developed world gained insight into the importance of national energy security and the reduction of dependence on foreign supply in order to sustain a reliable future economy. Amidst the international chaos, joint international efforts, spearheaded by the United States, established the International Energy Agency (IEA) in 1974.[1] Within the framework of the Organization for Economic Co-operation and Development (OECD), the IEA was designed to establish and implement an international energy program with the goal of preventing future energy crises. This mission of the IEA is to carry out:

…a comprehensive program of energy co-operation among twenty-three of the OECD's twenty-four Member countries (as of 2010, there are 28 participant countries). The basic aims of the IEA are:

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[1] Shams-ud-Din. 1995. Perspectives on the emerging world order. Gyan Publishing House: New Delhi, India. http://books.google.com/books?id=FESoFvmMsQQC&pg=PA288&lpg=PA288&dq=LTPC+IEA&source=bl&ots=sDLgGCfD31&sig=TwoUqb71_itEGGcP2lwYuAC4yPc&hl=en&ei=3v6ETPOSC4SglAeDwdkv&sa=X&oi=book_result&ct=result&resnum=2&ved=0CBgQ6AEwAQ#v=onepage&q=LTPC%20IEA&f=false

i) *Co-operation among IEA participating countries to reduce excessive dependence on oil through energy conservation, development of alternative energy sources and energy research and development;*

ii) *An information system on the international oil market as well as consultation with oil companies*

iii) *Co-operation with oil producing and other oil consuming countries with a view to developing a stable international energy trade as well as the rational management and use of world energy resources in the interest of all countries;*

iv) *A plan to prepare participating countries against the risk of a major disruption of oil supplies and to share available oil in the event of an emergency.*[2]

As declared in the basic aims of the IEA, the development of alternative energy sources became a priority in the U.S. for the first time. Although woody biomass had yet to hold the leading focus in alternative energy options, the general reliance on research and design of renewable sources had been initiated. The importance of such alternative energy developments constituted a significant part of national security.

In 1978, the IEA developed an Implementing Agreement for bioenergy. Under the IEA, Implementing Agreements are frameworks for "international collaboration in energy technology R&D, demonstration and information exchange."[3] IEA Bioenergy is currently the largest of 42 Implementing Agreements—proving the potential important contribution of bioenergy. A recent statement released by IEA Bioenergy states:

[2] Scott, Richard. 1994. "Major Policies and Actions." <http://www.iea.org/textbase/nppdf/free/1990/2-ieahistory.pdf>.

[3] IEA Bioenergy. 2009. "R&D Networks." <http://www.ieabioenergy.com/ImplAgree.aspx>.

Estimates indicate that bioenergy could sustainably contribute between 25% and 33% to the future global primary energy supply (up to 250 EJ) in 2050. It is the only renewable source that can replace fossil fuels in all energy markets—in the production of heat, electricity, and fuels for transport.[4]

Shortly following the need for renewed energy security, world focus shifted to the mitigation of global warming. With the passionate support of Margaret Thatcher and relevant research by the UK's Hadley Center, the "global warming scare" rose steadily in the 1980s. Substantial concern eventually generated the first international congregation in 1992 for the Earth Summit in Rio de Janeiro. Subsequent international climate distress sparked the Kyoto Summit in 1997 (out of which came the Kyoto Protocol) and the creation of the International Panel on Climate Change (IPCC).[5] The IPCC is a scientific body established by the United Nations Environment Program and the World Meteorological Organization to assess the current state of climate change and the subsequent environmental and socio-economic consequences.[6] Thus far, the IPCC has produced four assessment reports, only mentioning the important role biomass and bioenergy can play for carbon emission reduction scenarios in the most recent, fourth assessment, published in 2007 (Working Group III, Chapter 4). However, based on chapter grouping of all renewable energy, it is clear that biomass has yet to be recognized as a major solution.[7]

In the European Union, a dedication to reduce carbon emissions and develop national energy security inspired the adoption of the Energy Policy for Europe on February 14, 2007. The European Parliament

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[4] IEA Bioenergy. 2009. "What is IEA Bioenergy?" <http://www.ieabioenergy.com/IEABioenergy.aspx>.
[5] Hecht, Alan D. & Dennis Tirpak. 1995. "Framework Agreement on Climate Change: A Scientific and Policy History." *Climatic Change.* 29: 371-402.
[6] IPCC. "Organization." 9 Oct 2010. <http://www.ipcc.ch/organization/organization_history.htm>.
[7] Metz B. & O.R. Davidson, P.R. Bosch, R. Dave. & L.A. Meyer (eds). 2007. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, United Kingdom and New York, NY: Cambridge University Press.

approved proposals to reduce greenhouse gas emissions by 20% by the year 2020 (compared to 1990 levels), promote global Kyoto agreements, reduce carbon emissions from primary energy sources by 50% by the year 2050, and require a minimum target of 10% for the use of biofuels.[8] To help achieve these goals, the EU's 2007 Forest Action Plan included a key proposal which "promote[s] the use of forest biomass for energy generation."[9] Furthermore, the Forest Action Plan attempts to clarify the role woody biomass can play in an ambitious EU alternative energy portfolio. "More than half of the EU's renewable energy already comes from biomass, 80% of which is wood biomass. Wood can play an important role as a provider of biomass energy to offset fossil fuel emissions, and as an environmentally friendly material."[10] The EU's dedication to carbon reductions and reliance on renewable biomass energy has helped focus global attention on woody biomass potential.

The implications of heightened climate attention and international legislation have furthered global concentration on energy policy, forcing domestic initiatives to focus on renewable energy options. The desire to invest in renewable technology thus began as both a national security priority, and a solution to combat and mitigate climate change.

1.3 Domestic Initiatives

In response to the 1973 Oil Crisis, the United States passed the Public Utility Regulatory Policies Act (PURPA) under the 1978 National Energy Act. Faced with estimates suggesting the world price of oil would rise to $100 a barrel, Congress passed PURPA to reduce dependence on foreign oil sources and promote (for the first time) alternative energy, energy efficiency, and a diversified electric power

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[8] Commission of the European Communities. 2007. "An Energy Policy for Europe." Communication from the Commission to the European Council and the European Parliament. Brussels: COM(2007) 1 final.
[9] "European Union forest action plan." 2007. Europa: Summaries of EU Legislation. <http://europa.eu/legislation_summaries/agriculture/environment/l24277_en.htm>.
[10] Directorate-General for Agriculture and Rural Development. 2007. The EU Forest Action Plan: 2007-2011. European Commission on Agriculture and Rural Development.

industry. The most important result of PURPA was to create a market for non-utility power producers, requiring utilities to buy power from independent companies that produce alternative energy cheaper. "PURPA has been the most effective single measure in promoting renewable energy. Some credit the law with bringing on line over 12,000 megawatts of non-hydro renewable generation capacity. The biggest beneficiary of PURPA, though, has been natural gas-fired cogeneration plants."[11]

However, no comprehensive long-term domestic energy policy has yet been proposed and adopted.[12] Three Energy Policy Acts have been passed (1992, 2005, and 2007) which have included provisions for energy conservation, energy development, and various grants and tax incentives for renewable energy.[13] The following lists some recent and popular tax incentives, grants, and subsidies:

1) Renewable Energy Subsidies: from 2002-2008, the US spent $29 billion on renewable energy subsidies (compared to $72 billion in subsidies spent on fossil fuels).[14]
    a. Corn based ethanol production received more than half ($16 billion) of the subsidies through the Volumetric Ethanol Excise Tax Credit Program ($11 billion) and the corn-based ethanol grant program ($5 billion).[15]
    b. Renewable electricity generation projects received approximately $6 billion in subsidies, mostly through the Production Tax Credit ($5 billion), the Investment Tax Credit ($250 million), the Modified Accelerated Cost Recovery System ($200 million), and the Clean Renewable Energy Bond Program ($85 million).[16]

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[11] Union of Concerned Scientists. 2010. "Public Utility Regulatory Policies Act (PURPA)." Union of Concerned Scientist, Clean Energy. 09 October 2010. <http://www.ucsusa.org/clean_energy/solutions/big_picture_solutions/public-utility-regulatory.html>.

[12] Bamberger, Robert. 2004. "Energy Policy: Historical Overview, Conceptual Framework, and Continuing Issues." Congressional Research Service, The Library of Congress.

[13] Energy Independence and Security Act of 2007, H.R. 6, 110th Congress, 1st Session. (2007).

[14] Environmental Law Institute. 2009. "U.S. Tax Breaks Subsidize Foreign Oil Production." <http://www.eli.org/pressdetail.cfm?ID=205>.

[15] Ibid.

[16] Ibid.

2) Energy Independence and Security Act, 2007: An original provision of the EISA proposed a Renewable Portfolio Standard which required utilities to produce 15% of their total power through renewable generation. Additionally, this provision included a tax package which would have funded renewable energy developments through the repeal of $21 billion in oil and gas tax breaks. The Senate failed to pass these provisions.[17]

3) Biomass Crop Assistance Program (BCAP), included in the 2008 Farm Bill: Provided significant subsidies for the production of eligible crops to bio-energy. The program also assisted landowners with collection, harvest, storage and transportation (CHST) of eligible materials to approved biomass conversion facilities. Specifically, the program pays up to 75% of crop establishment costs while farmers can collect five years of payments (15 years for woody biomass) for the establishment of new energy crops. CHST assistance provides a matching payment of up to $45/ton for a period of two years. Obligated funds (not yet spent) through March 2010 were over $500 million—an amount more than seven times BCAP's estimated budget from the 2008 Farm Bill.[18]

4) American Recovery and Reinvestment Act, 2009: This legislation included more than $70 billion in direct spending and tax credits for clean energy. This represents the largest federal commitment in U.S. history for renewable energy initiatives.[19]

Compared to other renewable options, domestic investment in wood-based energy technology is negligible. The U.S. Energy Information Administration estimated that open-loop biomass facilities

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[17] Currier, Patrick & Caroline Roach & Curt Rich. 2007. "Energy Independence and Security Act Becomes Law; Congress Acts on Additional Energy-Related but Issues Remain for 2008." Washington, D.C.: VanNess Feldman. <http://www.vnf.com/news-alerts-231.html>.

[18] United States Department of Agriculture. 2010. "Farm Service Agency: Biomass Crop Assistance Program." <http://www.fsa.usda.gov/FSA/webapp?area=home&subject=ener&topic=bcap>.

[19] Markowitz, Joel & Ron Pernick & Clint Wilder. 2009. "Clean Energy Trends 2009." Clean Edge: The Clean-Tech Market Authority. <http://www.cleanedge.com/reports/pdf/Trends2009.pdf>.

received about $4 million in tax credits under the Production Tax Credit program (compared to approximately $600 million for wind facilities) in 2007. Combined heat and power and purely thermal facilities received almost no funding whatsoever; furthermore, many biomass-specific grant programs have annual allocations in the $1-$5 million range and individual projects capped somewhere between $50,000 and $500,000.[20]

A detailed history of the United States' renewable energy policy indicates that little attention has been given to the development of renewable energy technology. Furthermore, seemingly negligible attention has focused on the potential for woody biomass energy as a contributor. In particular, the US Southeast faces few renewable energy options. A well developed forest industry and tremendous forest resources indicate that biomass must play a large role in any renewable electric demand. North Carolina is the only state in the Southeast with a renewable energy mandate. North Carolina Senate Bill 3 (S.L. 2007-397) was passed in 2007 and establishes a Renewable Energy and Energy Efficiency Portfolio Standard (REPS), requiring utilities meet up to 12.5% of their energy demand through renewable resources.[21]

[20] Energy Information Administration. 2008. "Federal Financial Interventions and Subsidies in Energy Markets 2007." < http://www.eia.doe.gov/oiaf/servicerpt/subsidy2/index.html>.
[21] North Carolina Utilities Commission. 2008. "Renewable Energy and Energy Efficient Portfolio Standards." <http://www.ncuc.commerce.state.nc.us/reps/reps.htm>.

BACKGROUND

1. Introduction to Biomass Utilization

As pressure for establishing renewable energy standards intensifies, utilities continue to look for viable options. In the Southeast, solar, hydropower, and geothermal options have yet to prove their worth, as a lack of technological innovation and overall availability continue to hinder expansive success. As a significant opportunity for Southeastern renewable efforts, woody biomass is both plentiful and easy to utilize in an energy capacity.[22] Recent studies have focused on the use of residuals and wood waste as underused and undervalued options. Although specific biomass definitions have yet to be universally established, woody residuals generally refer to slash left from logging practices, mill waste, and urban wood waste.[23]

The hope is that this formerly considered "waste" can instead provide additional timber revenue on a biomass energy market. If biomass energy is limited to these waste products, the amount of energy produced will, undoubtedly, be limited by the production of the forests products industry.[24] The effect on timber resources (neglecting the slash-nutrient return issue) will therefore be minimal. On the other hand, a broader biomass definition, particularly including pulpwood, may impact timber resource supply and demand with obvious implications for the forest products industry.

[22] Perlack, Robert D. and Lynn L. Wright, Anthony F. Turnhollow, Robin L. Graham, Bryce J. Stokes & Donald C. Erbach. 2005. "Biomass as Feedstock for a Bioenergy and Bioproducts Industry: The Technical Feasibility of a Billion-Ton Annual Supply." Technical Report, Oak Ridge National Laboratory.
[23] Millbrandt, Anelia. 2005. *Geographic Perspective on the Current Biomass Resource Availability in the United States*. 70 pp.; NREL Report No. TP-560-39181.
[24] Galik, Christopher S. and Robert Abt and Yun Wu. 2009. "Forest Biomass Supply in the Southeastern United States—Implications for Industrial Roundwood and Bioenergy Production." *Journal of Forestry* 107.2: 69-77.

2. Southeastern Forest Resources

In total the United States has over 500 million forested acres in the lower 48 states.[25] However, land ownership is distributed differently across the continent. Particularly in the Southeast, most of the timber land is under private ownership; in fact, the South has over 200 million acres of forest with 88% under private ownership (the largest private presence of any region in the country). Additionally, southern forests contain the highest levels of productivity, with 39 million acres representing some of the most productive timber land in the country.[26] Furthermore, the South has more than 30 million plantation acres,[27] representing 23% of total forest land area.[28] In the end, the amount of woody biomass (however it may eventually be defined) will undoubtedly depend on the distribution of land ownership, the type of timber production (natural versus plantation), and the forest composition. Residual collection rates vary dramatically by forest stand type and logging operation; it is far easier to collect remaining logging slash in pine plantations where most of the logging waste is brought straight to the logging deck. On the other hand, mixed hardwood-pine stands can create a more challenging working environment. Because of this, residual collection can range anywhere from 50-80% of total available residuals on a site. For the purpose of this study, residual collection was estimated at 65% and the corresponding amount will be used throughout the rest of the calculations.[29]

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[25] Smith, W. Brad and Patrick D. Miles, Charles H. Perry & Scott A. Pugh. 2009. "Forest Resources of the United States, 2007." Gen. Tech Rep. WO-78. Washington, DC: U.S. Department of Agriculture, Forest Service, Washington Office. 336 p.
[26] Wear David N. & John G. Greis. 2002. "Southern Forest Resource Assessment." Gen Tech Rep. SRS-54. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 103 p.
[27] Ibid.
[28] National Alliance of Forest Owners. 2009. NAFO 2009 Annual Report. <http://nafoalliance.org/wp-content/uploads/NAFO-2009-Annual-Report.pdf>.
[29] Abt, Robert. Personal electronic mail correspondence. 2 June 2010.

Additionally, much of the primary mill waste is re-used on site or sold for pulpwood production. Based on Millbrandt's (2005) NREL calculations, the following table represents realistic primary mill waste residual contributions and forest/logging residue contributions.[30]

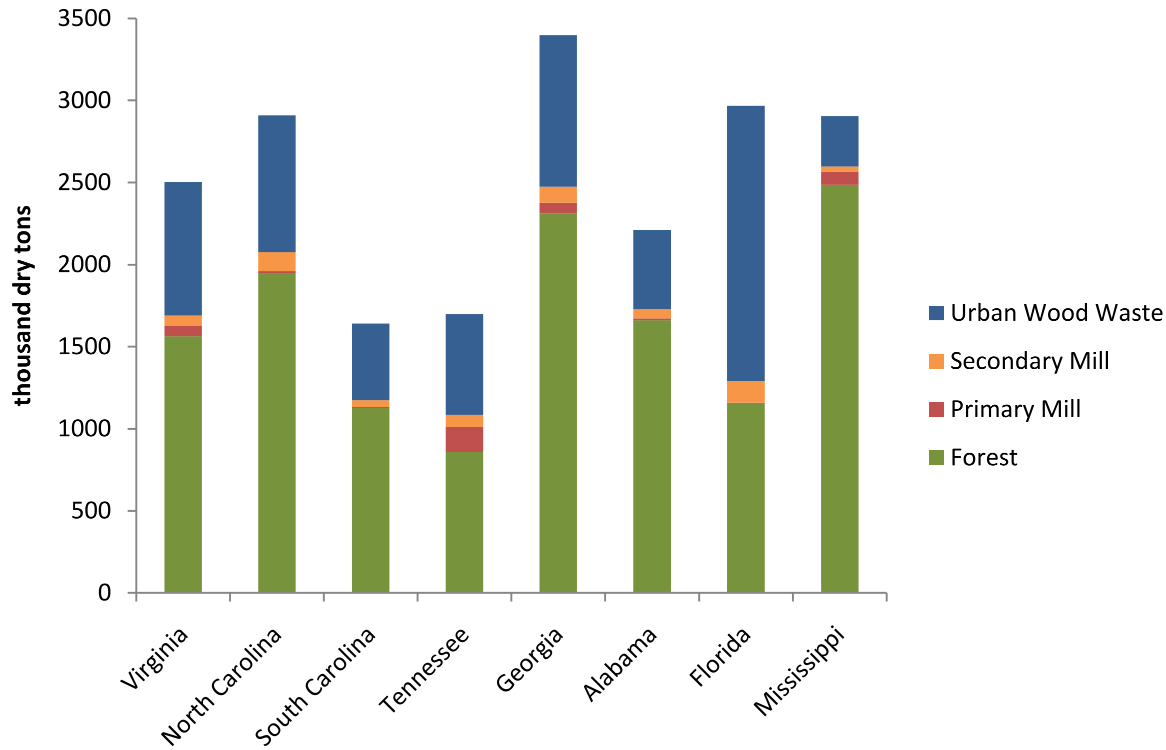
Table 1: Potential available residual woody biomass, corrected for true primary mill waste use and forest residue collection

State	Forestland (MM acres)	Forest Residues (dry tons)*	Primary Mill Residues (dry tons)**	Secondary Mill Residues (dry tons)***	Urban Wood Waste (dry tons)****	Total Residue Biomass
Virginia	15.8	1,561,950	66,000	62,000	813,000	2,502,950
North Carolina	18.7	1,946,750	14,000	115,000	833,000	2,908,750
South Carolina	12.9	1,126,450	9,000	38,000	467,000	1,640,450
Tennessee	14.4	857,350	153,000	75,000	614,000	1,699,350
Georgia	24.3	2,311,400	66,000	97,000	924,000	3,398,400
Alabama	22.7	1,660,750	10,000	57,000	483,000	2,210,750
Florida	16.5	1,155,700	4,000	130,000	1,678,000	2,967,700
Mississippi	19.6	2,486,250	79,000	33,000	307,000	2,905,250
TOTAL	144.9	13,106,600	401,000	607,000	6,119,000	20,233,600

*Derived from USFS Timber Product Output database; includes unused portions of trees cut/killed by logging and left in the woods. Also includes 'other removals' (pre-commercial thinning, weeding, etc).
**Derived from USFS Timber Product Output database. Composed of wood materials and bark generated at manufacturing plants when roundwood products are processed into primary products.
***Data based on number of businesses by county (from US Census Bureau), size of company, and assumptions on wood waste. Includes wood scraps and sawdust from woodworking shops, furniture factories, wood container and pallet mills, and wholesale lumberyards.
****Data based on assumptions, as it is largely unavailable (Refer to A.Millbrandt, NREL). Includes MSW wood (wood chips, pallets, and yard waste), utility tree trimming and/or private tree companies, construction/demolition wood.

[30] Millbrandt, Anelia. 2005. *Geographic Perspective on the Current Biomass Resource Availability in the United States*. 70 pp.; NREL Report No. TP-560-39181.

Figure 1: Potential available residual woody biomass for each state



DATA ANALYSIS

1. Electricity Generation in the Southeast

A renewable electricity standard (RES), also known as a renewable portfolio standard (RPS), was proposed in the Energy Independence and Security Act, 2007, to mandate a specified target (15%) of renewable energy resources in electricity providers' supply. This provision of the bill was not passed, but it appears to be the best estimate of a federal target.[31] The Southeast has only one existing state RPS mandate (North Carolina's Senate Bill 3 has a 12.5% renewable mandate) which is relatively low, according to a national average.[32] The following analysis requires estimates of total electricity generation for each state, subsequently calculating an assumed, more realistic 15% RPS for each state (instead of by electric provider) for ease of comprehension and calculation. There are obvious issues with interstate energy flow, yet the hope is that this method will provide a regional snapshot of the electric energy situation in the Southeast. The following table displays the net generation by state for existing electric power facilities (2008 data only).

Table 2: Electric energy generation for 2008
Existing electric power facilities: net generation by state

State	MWh per year	15% RES (MWh per year)
Virginia	72,678,531	10,901,780
North Carolina	125,239,063	18,785,859
South Carolina	100,978,005	15,146,700
Tennessee	90,663,312	13,599,497
Georgia	136,173,395	20,426,009
Alabama	89,707,279	13,456,092
Florida	219,636,818	32,945,522
Mississippi	48,205,711	7,230,857

*SOURCE: http://www.eia.doe.gov/cneaf/electricity/st_profiles/e_profiles_sum.html

[31] Currier, Patrick & Caroline Roach & Curt Rich. 2007. "Energy Independence and Security Act Becomes Law; Congress Acts on Additional Energy-Related but Issues Remain for 2008." Washington, D.C.: VanNess Feldman. <http://www.vnf.com/news-alerts-231.html>.
[32] North Carolina Utilities Commission. 2008. "Renewable Energy and Energy Efficient Portfolio Standards." <http://www.ncuc.commerce.state.nc.us/reps/reps.htm>.

Although there is an expected nearly 1% annual increase in electricity demand projected for the Southeast, heightened focus on energy efficiency suggests this may not actually occur. A study by Brown et al. 2010 concludes that aggressive energy-efficiency initiatives in residential, commercial, and industrial sectors could prevent energy consumption growth over the next twenty years. Assuming many of these energy-efficiency initiatives will soon be adopted, an increase in consumption has been eliminated from all of the following calculations.[33]

2. Woody Residual Electric Supply Potential

2.1 Restrictive Woody Biomass Supply Potential

There is concern that woody residuals will be an inadequate supply for renewable standard demands. There is also a fear that the traditional forest products industry will suffer from resource competition and forests will be adversely affected by efforts to increase a new energy crop (i.e. more plantations, increased abundance of non-native species, altered forest stand compositions, etc.). It is therefore important to determine the electric potential of each state's current residual woody biomass supply. The following table displays Megawatt-hour per year calculations and the percentage of total state RES demand each state biomass supply can meet. Energy Conversion Calculations can be found in the Appendix (Equation 1).

[33] Brown, Marilyn A. & Etan Gumerman, Xiaojing Sun, Youngsun Baek, Joy Wang, Rodrigo Cortes, & Diran Soumonni. 2010. "Energy Efficiency in the South." Atlanta, Georgia: Southeast Energy Efficiency Alliance.

Table 3: Woody residual electric supply potential; 65% residual collection and realistic primary mill waste assumed

State	RES MWh per year	Total Residue Biomass (dry tons)	Total Residue (MMBtu)*	Total Residue MWh per year	% of RES Requirement
Virginia	10,901,780	2,502,950	37,544,250	2,989,206	27
North Carolina	18,785,859	2,908,750	43,631,250	3,480,102	19
South Carolina	15,146,700	1,640,450	24,606,750	1,963,584	13
Tennessee	13,599,497	1,699,350	25,490,250	2,033,712	15
Georgia	20,426,009	3,398,400	50,976,000	4,058,658	20
Alabama	13,456,092	2,210,750	33,161,250	2,638,566	20
Florida	32,945,522	2,967,700	44,515,500	3,550,230	11
Mississippi	7,230,857	2,905,250	43,578,750	3,471,336	48

*Energy conversion factors from: http://www.interfacesouth.org/woodybiomass/resource_appendix/App_W2E_Conversions.pdf

For most of the Southeast, woody biomass residual can supply anywhere from 11 to 27% of the required renewable energy standard. This amount is obviously dependent upon residual supply from logging/timber/forest management practices which fluctuate yearly (in particular, the traditional forest products industry faced a significant timber price downturn following the 2008 recession, yet latest Timber Mart South prices indicate major upward movement).[34] Florida, not surprisingly, has the lowest residual biomass energy potential, as available forest land is not evenly dispersed across the state and can supply proportionately less due to population demand. Mississippi, on the other hand, has the greatest biomass potential, suggesting biomass could contribute significantly toward an RPS mandate. For the most part, however, the total residual supply is not enough to completely source electric supply demanded by a 15% renewable standard.

[34] Frank W. Norris Foundation. 2009. “Timber Mart-South.” University of Georgia: Center for Forest Business, Warnell School of Forest Resources.

2.2 Expansive Woody Biomass Supply Potential

The next logical progression includes incorporating pulpwood production for energy use. Obviously, pulp mill and energy prices will have a tremendous effect on final pulpwood destination which is not accounted for in the following analysis. However, it is assumed that renewable standards will be accompanied by federal subsidies that might make pulpwood for energy use more enticing. The following table illustrates the total pulpwood supply for each Southeastern state in 2008. Subsequent pulpwood energy supply potential uses the *entire* pulpwood supply for one year—obviously an unreasonable assumption, yet an easy illustration of what, exactly, is required to meet an RPS demand.

Note: The following calculations utilize pulpwood production from roundwood only. There are several factors behind this reasoning. For starters, roundwood makes up more than 70% of pulpwood production, and is therefore the dominant contributor. The remaining 25-30% of pulpwood is composed of residual waste from mills—a re-use which is already accounted for in the primary mill waste residual calculations. Furthermore, it is difficult to uncover pulpwood residual use, as much of this consists of undesirable roundwood that has been chipped because of various defects (and not actually "true" residuals).[35]

[35] T. Johnson, USFS Southern Research Station. Telephone Interview and http://www.srs.fs.usda.gov/pubs/rb/rb_srs165.pdf.

Table 4: Current pulpwood production electric supply potential

State	2008 Prod (dry tons)	MWh per year	15% RES MWh per year	%of RES Requirement
Virginia	3,135,500	3,927,168	10,901,780	36
North Carolina	4,962,000	6,215,094	18,785,859	33
South Carolina	6,338,500	7,941,996	15,146,700	52
Tennessee	2,100,000	2,629,800	13,599,497	19
Georgia	12,555,000	15,726,204	20,426,009	77
Alabama	10,570,000	13,236,660	13,456,092	98
Florida	4,051,000	5,075,514	32,945,522	15
Mississippi	7,130,000	8,932,554	7,230,857	123

SOURCE: T. Johnson et al, USFS Southern Research Station, Timber Product and Output Data.
http://www.srs.fs.usda.gov/pubs/rb/rb_srs165.pdf

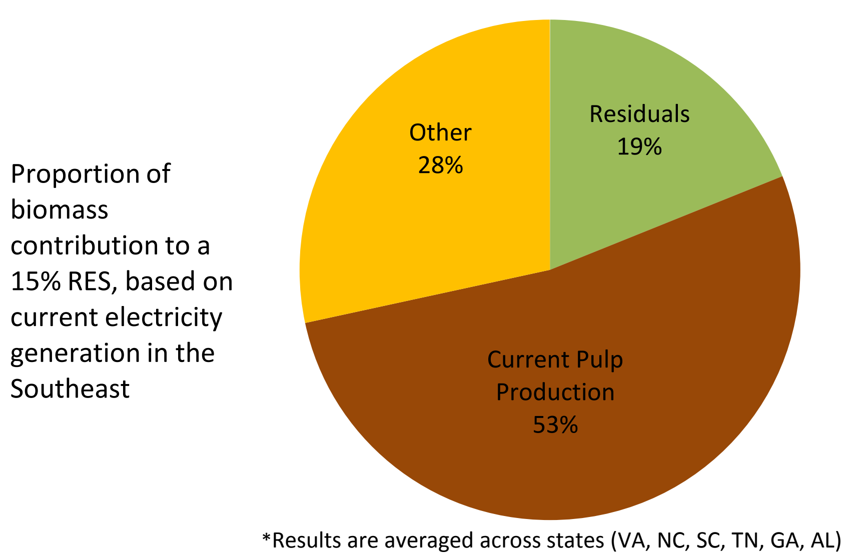
Based on the above calculations, it is clear that pulpwood supply may add significantly to achieve RES mandated renewable supply. The following calculations include *both* residual and pulpwood supply in order to determine whether the target renewable supply can be met. Table 5 reiterates the required RES MWh per year for each state, the amount of residual energy potential available, the amount of pulpwood energy potential available (based on 2008 production), and the percentage of total state RPS requirement each state's combined pulpwood and residual biomass supply can meet.

Table 5: Combined pulpwood and residual biomass supply potential

State	RES MWh per year	Total Residue MWh per year	Pulpwood MWh per year	TOTAL Forest MWh per year	TOTAL % of Requirement
Virginia	10,901,780	2,989,206	3,927,168	6,916,374	63
North Carolina	18,785,859	3,480,102	6,215,094	9,695,196	52
South Carolina	15,146,700	1,963,584	7,941,996	9,896,814	65
Tennessee	13,599,497	2,033,712	2,629,800	4,663,512	34
Georgia	20,426,009	4,058,658	15,726,204	19,784,862	97
Alabama	13,456,092	2,638,566	13,236,660	1,585,226	118
Florida	32,945,522	3,550,230	5,075,514	8,616,978	26
Mississippi	7,230,857	3,471,336	8,932,554	12,403,890	172

Incorporating pulpwood supply as a biomass energy source appears to significantly increase the percent of an RES mandate each state can meet. Mississippi and Alabama both exceed the requirement. The remaining states (with Florida notably lower than all the rest) still have a deficit. Perhaps the two states with excess supply could export resources to neighboring states, yet the most troubling aspect remains that for most of the Southeast, incorporating *all* of the industry pulpwood supply (with devastating effects on a dominant component of the traditional forest products industry) is not enough. Without implementation of energy efficiency initiatives, population and development pressures will raise electricity demand considerably, and the deficit gap will only increase further. Figure 2 displays the average RES supply across 6 Southeastern states (Virginia, North Carolina, South Carolina, Tennessee, Georgia, Alabama). Less than a quarter of the requirement can be achieved through the use of woody residuals, yet even combining unrealistic industry sources, woody biomass is an inadequate supply. Florida and Mississippi were both left out of the following averages for different reasons. Florida will have to rely heavily (nearly 75%) on other alternatives while Mississippi's biomass resources are more than enough. Graphics displaying the atypical nature of Florida and Mississippi appear in the Appendix (Appendix Figures 1 & 2).

Figure 2: Contribution of current biomass supply to a proposed 15% RES demand, including potential deficit and need for alternative sources



Preliminary analysis investigated electric energy potential of all the pulpwood produced in 2008, assuming a complete redirection away from the forest products industry. Instead of unrealistically assuming the entire pulpwood production will be available to source renewable energy, this approach determines maximum pulpwood production, current (or most recent) pulpwood production, and the difference between the two. In general, pulpwood production in the South peaked in the late 1990s when demand and price were high. The market has since fallen, and subsequent production has decreased. Because of this, a significant amount of potential pulpwood production remains unused. The following table displays pulpwood production (in dry tons) from 1995-2008, the difference between maximum and current production, and the amount of electric energy (in MWh per year) that can be produced from this unused amount.

Table 6: Peak productions in dry tons (underlined), unused capacity, and energy potential of unused capacity

	VA	NC	SC	TN	GA	AL	FL	MS
1995	3,621,781	5,904,280	5,712,952	2,018,983	11,043,042	12,627,753	<u>5,639,832</u>	8,313,474
1997	<u>3,963,500</u>	<u>6,366,500</u>	6,152,500	2,239,500	10,986,000	<u>13,907,000</u>	5,305,000	<u>8,726,000</u>
1999	3,157,500	4,885,500	6,170,000	2,231,500	10,753,000	11,842,500	4,820,500	7,463,000
2001	3,088,000	4,344,000	5,142,000	<u>2,342,500</u>	9,609,000	10,287,500	4,809,500	5,818,500
2003	3,382,000	4,707,500	5,353,000	2,231,500	10,393,000	9,611,000	5,048,000	5,575,000
2005	3,627,500	4,915,000	6,128,000	2,229,000	9,828,000	10,456,500	3,975,000	6,762,500
2007	2,924,500	5,088,500	5,917,000	2,157,000	11,176,500	10,770,000	4,466,500	7,403,000
2008	3,135,500	4,962,000	<u>6,338,500</u>	2,100,000	<u>12,555,000</u>	10,570,000	4,051,000	7,130,000
Unused Capacity (Peak-YR2008)	828,000	1,404,500	0	242,500	0	3,337,000	1,588,832	1,596,000
MWh per of Unused Capacity	**1,034,388**	**1,761,966**	**0**	**306,810**	**0**	**4,181,382**	**1,989,882**	**1,998,648**

SOURCE: TPO Data http://srsfia2.fs.fed.us/php/tpo_2009/tpo_rpa_int1.php; T. Johnson et al, http://www.srs.fs.usda.gov/pubs/rb/rb_srs165.pdf

As expected, most of the states experienced maximum pulpwood production in the late 1990s. Additionally, most states have a significant amount of available pulpwood which is currently (as of 2008) unused. This excess, for most states, has the potential of sourcing a significant amount of energy. The following two figures visually illustrate total pulpwood production and unused pulpwood energy potential for the Southeastern states.

Figure 3: Total roundwood pulpwood production trend from 1995-2008, by state

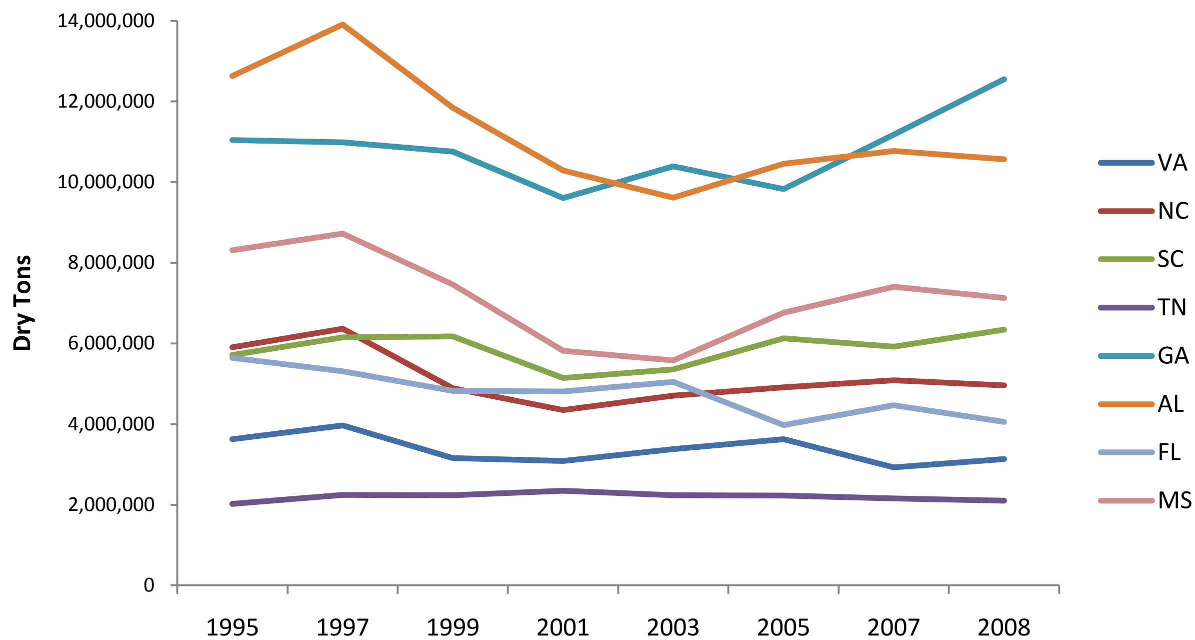
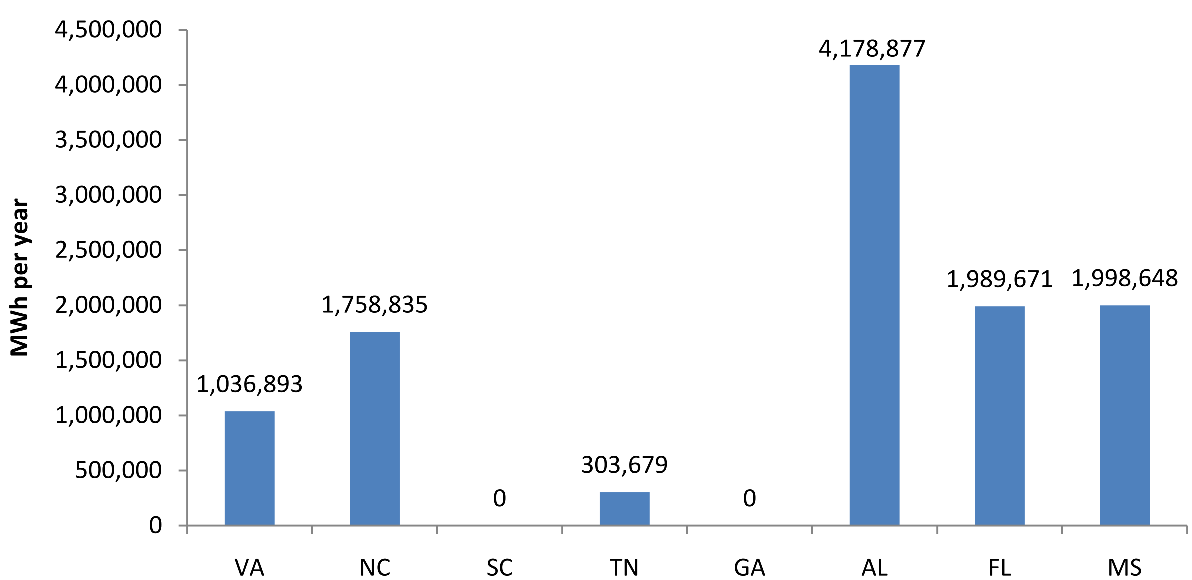


Figure 4: Electric energy potential of unused pulpwood capacity



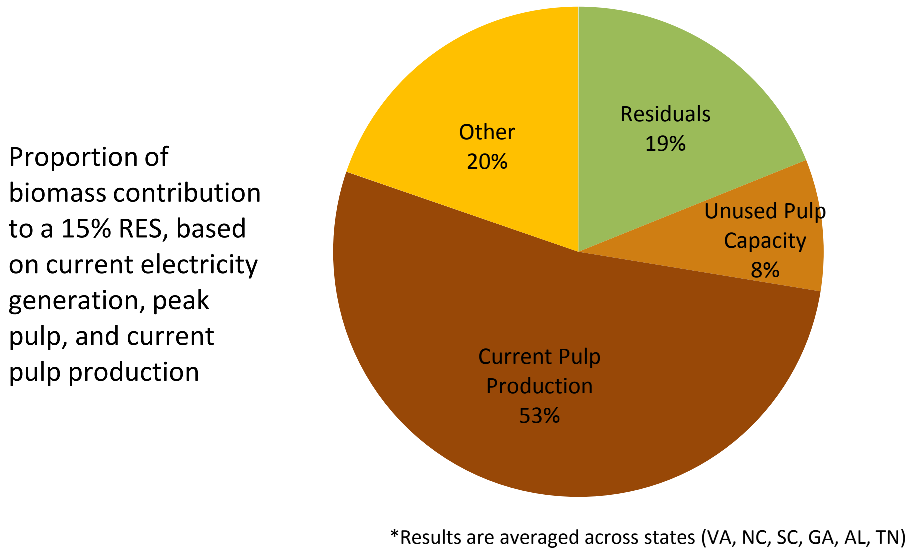
As a percent of a 15% RES mandate, unused pulpwood may actually provide a significant source of electric energy for several states. The following table displays the contribution of unused pulpwood to these mandates.

Table 7: Unused pulpwood contribution to a 15% RES, by state

State	15% RES (MWh per year)	MWh of Unused	% of Requirement
Virginia	10,901,780	1,034,388	10
North Carolina	18,785,859	1,761,966	9
South Carolina	15,146,700	0	0
Tennessee	13,599,497	306,810	2
Georgia	20,426,009	0	0
Alabama	13,456,092	4,181,382	31
Florida	32,945,522	1,989,882	6
Mississippi	7,230,857	1,998,648	28

Finally, the figure below updates total woody biomass contribution by incorporating unused pulpwood (based on peak production levels). It is more realistic to assume pulpwood usage in this capacity, and combined with residuals, accounts for nearly 25% of a 15% RES mandate (averaged across six states). Mississippi and Florida are, again, left out of the following for completely different reasons.

Figure 5: Contribution of biomass supply to RES demand using residuals, 2008 roundwood pulpwood production, and unused pulpwood capacity



To summarize, the most realistic source of woody biomass energy can provide, on average, 27% of the mandated renewable electric energy. Specific contributions by state are displayed in Table 8. Again, it is important to note that even this realistic, expansive definition of biomass fails to meet the entire 15% RES demand.

Table 8: Energy contribution of residual biomass combined with unused pulpwood.

State	RES MWh per year	Total Residue MWh per year	Unused Capacity MWh per year	TOTAL	% of Requirement
Virginia	10,901,780	2,989,206	1,034,388	4,032,360	37
North Carolina	18,785,859	3,480,102	1,761,966	5,233,302	28
South Carolina	15,146,700	1,963,584	0	1,963,584	13
Tennessee	13,599,497	2,033,712	306,810	2,331,756	17
Georgia	20,426,009	4,058,658	0	4,058,658	20
Alabama	13,456,092	2,638,566	4,181,382	6,819,948	51
Florida	32,945,522	3,550,230	1,989,882	5,540,112	17
Mississippi	7,230,857	3,471,336	1,998,648	5,469,984	76

2.3 Forest Market Factors to Consider

Sawtimber production was neither estimated nor incorporated as an energy contributor because literature suggests the current and projected price of sawtimber will exclude this product from an energy market—in other words, energy prices cannot compete with current sawtimber prices. Specifically, it appears as though prices for sawtimber will remain four times that of energy prices. On the other hand, pulpwood prices, although currently higher than energy prices, are more comparable and will more likely experience competition. [36]

A recent study by Abt et al. (2010) also suggests that pulpwood production will experience a reduced supply in the near future. The latest economic recession led forestland owners to postpone harvests, allowing stands to mature beyond pulpwood size. Therefore, the larger cohort of younger, pulpwood-sized trees is smaller than pre-recession harvests and will decrease the total pulpwood supply in the near-term. Following the recession, forestland owners will harvest their mature stands, replant, and eventually re-enter the pulpwood market.[37] However, it is important to note these inevitable market fluctuations when attempting to create a stable energy supply. It is likely that a constant energy demand will stabilize a mixed cohort supply.

[36] Abt, Robert C., Karen L. Abt, Frederick W. Cubbage, & Jesse D. Henderson. 2010. Effect of Policy-based bioenergy demand on southern timber markets: a case study of North Carolina. *Biomass and Bioenergy.* In press.
[37] Ibid.

3. Wood Pellets: Residual Use and Export

3.1 Why Pellets?

In the wood-to-liquid fuel conversion, up to half the embedded energy in the material is lost.[38] When wood is burned to produce electricity, a similar loss occurs unless the waste heat is captured. Burning wood directly for space heating, by contrast, is more energy efficient.[39] Modern stoves produce 85% to 95% of the energy as heat, and when the heating source being displaced is electric, the savings in fuel are magnified.[40]

The market has subsequently responded to a changing energy demand by supplying wood energy in pellet form. Pellet form increases energy density, reduces water content (from 50% to less than 10%), and increases the amount of energy per truckload. By making the wood denser, the energy content per unit of volume is increased and more comparable to that of coal.[41] Because of this, pellets are price competitive (See Figure 6), especially after considering the many other positive externalities.

Figure 6: Fuel price comparison for individual households, 2008.[42]

FUEL	AVERAGE COST (per MMBtu)
Heating Oil	$5.50-7.50
Electricity	$25.00
LP Gas	$9.00-20.00
Natural Gas	$7.00-9.00
Coal	$6.75
Pellets	$9.00

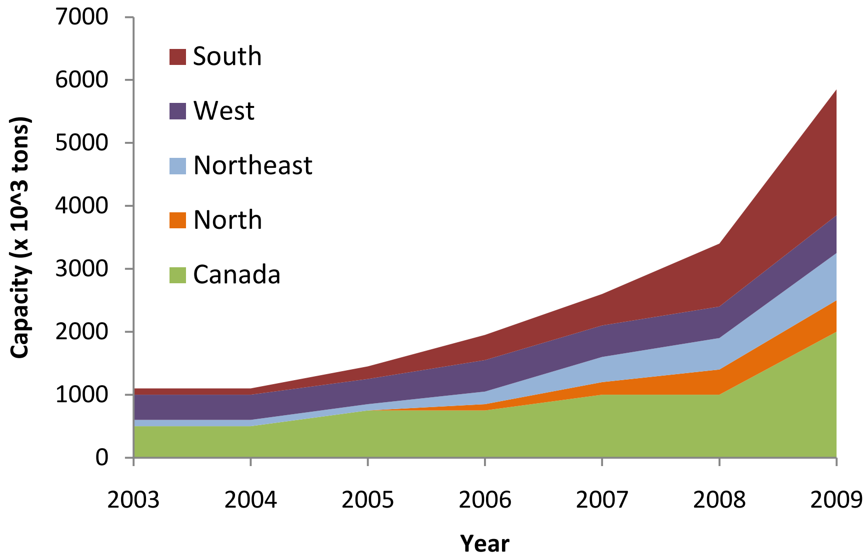
[38] Rakos, Christian. 2008. "The heat market—key for the transformation of our energy system." proPellets: Austria. www.propellets.at/cms/download.php?docId=69.
[39] Richter Jr., Daniel deB & Dylan H. Jenkins, John T. Karakash, Josiah Knight, Lew R. McCreery, & Kasimir P. Nemestothy. 2009. "Wood Energy in America." *Science.* 323: 1432-1433.
[40] Spelter, Henry & Daniel Toth. 2009. "North America's Wood Pellet Sector." USDA Forest Service, Forest Products Laboratory. Research Paper FPL-RP-656. <http://www.fpl.fs.fed.us/documnts/fplrp/fpl_rp656.pdf>.
[41] Ibid.
[42] Pellet Fuels Institute. 2010. <http://www.pelletheat.org/3/commercial/commercialBrochure3.pdf>.

Pellet composition is defined by pellet grade. Pellet mills produce two grades of fuel—Premium and Standard. The difference between the two grades depends on the amount of ash content. Standard grade pellets contain up to 3% ash while premium grade pellets have less than 1 percent. Standard grade pellets are made from materials which produce more residual ash (e.g. bark, agricultural residues, etc) while premium pellets use more hardwood or softwood sawdust. Premium pellets can be burned in all appliances whereas standard pellets require appliances that can handle higher ash content. Standard pellets are suitable for most industrial uses.[43] Given the fact that few pellet stoves exist in residential settings in the Southeast, this analysis will largely focus on the production of standard "dirty chip" pellets (although some Southeastern industrial facilities produce premium pellets).

The North American wood pellet industry is relatively young with a largely insignificant effect on timber resources. However, the industry has experienced increased growth with a promising future market. The following figure was extracted from Spelter and Toth (2009) to illustrate industry growth.[44]

[43] http://www.pelletheat.org/3/industry/index.html
[44] Spelter, Henry & Daniel Toth. 2009. "North America's Wood Pellet Sector." USDA Forest Service, Forest Products Laboratory. Research Paper FPL-RP-656. <http://www.fpl.fs.fed.us/documnts/fplrp/fpl_rp656.pdf>.

Figure 7: North American pellet capacity: 2003-2009



It is clear that the U.S. South is playing a dominant role in wood pellet production and will continue to do so in the near future. However, it is also important to understand exactly how much of the production is being exported to Europe (as pellets constitute a significant source of fuel in the EU's effort to increase renewable energy sources). Spelter and Toth estimate that over 80% of U.S. pellets in 2008 were shipped to in-country destinations.[45] Total wood pellet exports are also displayed in the following Figures.

[45] Ibid.

Figure 8: Destinations of pellet shipments by region in 2008[46]

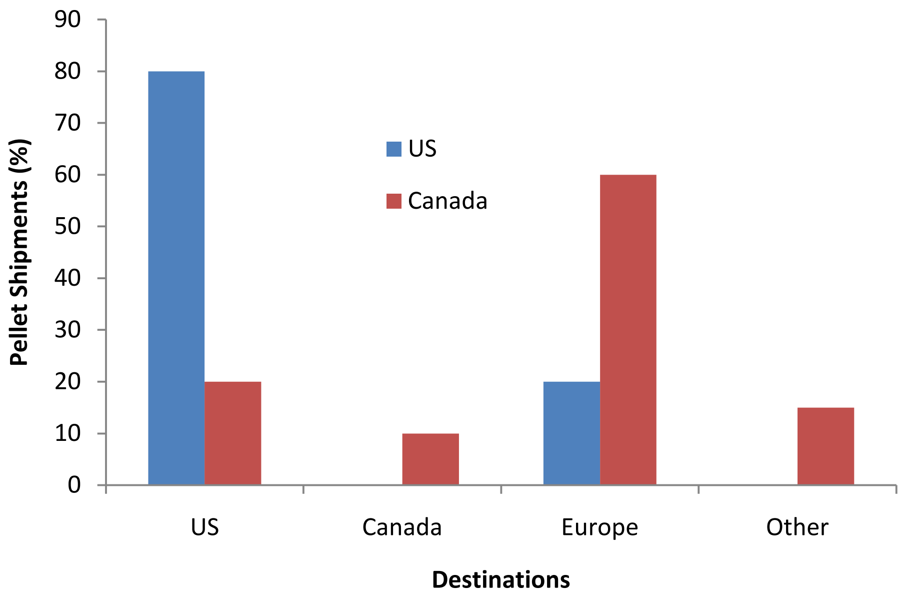
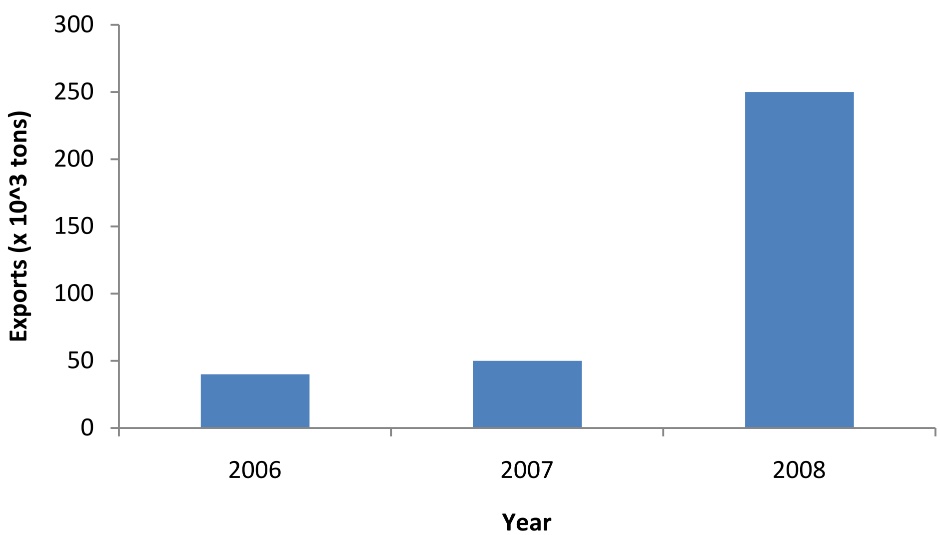


Figure 9: United States pellet and waste wood exports (U.S. International Trade Commission 2009)[47]



As the European Union looks toward a 21% electricity and 20% heat renewable target by 2020, wood pellets must play a significant role in achieving these targets, especially in the heating sector. While Sweden (1.7 million tons), Germany (900,000 tons) and Austria (800,000 tons) are leading pellet

[46] Ibid.
[47] Ibid.

producers, total consumption and future demand necessitate pellet imports. These countries are also leading pellet consumers in the EU, and a pellet market growth of 25-30% in 2009 implies the current European pellet supply is inadequate to fuel a rapidly increasing European demand. In total, annual pellet consumption in Europe amounts to about 6 million tons, with expected future growth. North America and Russia both contribute significantly to the European pellet market, with Canada's 1.3 million tons (in 2008, half of which were exported to Europe) and Russia's 550,000 tons (in 2007, most of which were exported to Europe). With a growing demand and a relatively stable supply, the opportunity for the U.S. South to contribute to the EU pellet market is substantial.[48].

Currently, wood use for energy generation accounts for about half the total roundwood consumption in Europe. Specifically, wood residues account for 49% of total wood energy, while fuel wood from the forest accounts for 45% of total wood energy. Recently, strict regulations on wood disposal have encouraged the re-use of wood waste. A diminishing European supply and regulations regarding the type and source of wood could also increase North American wood pellet demand, particularly in regions (like the Southeast) with considerable room for growth[49]. In fact, "Europe's demand for wood pellets is growing faster than domestic pellet supply. In 2006, total European pellet production was about 4.5 million tons while consumption was estimated at about 6 million tons. The gap between European pellet supply and demand is expected to increase to between four and five million tons by 2010."[50] The following figure displays the projected European trend and the potential for Southeastern markets to take advantage of a rapidly escalating demand.

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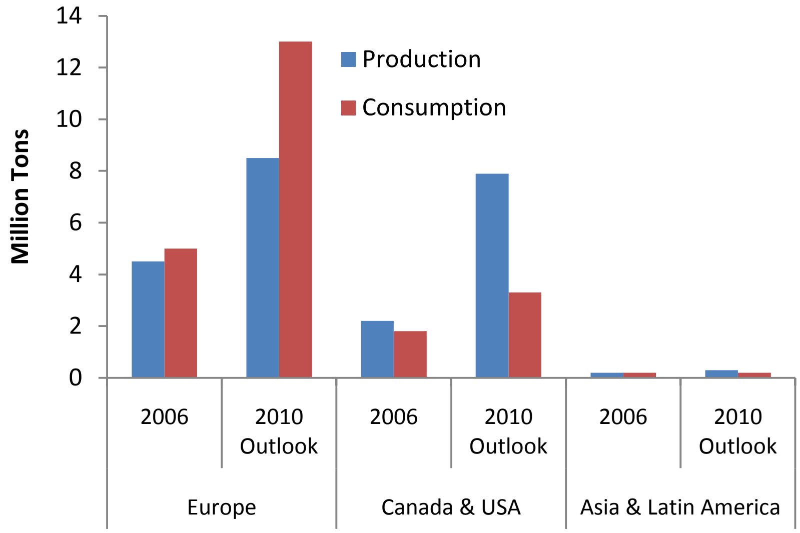
[48] Ukranian Biofuel Portal. " Current Trends of the Wood Pellet Market." http://pellets-wood.com/current-trends-of-the-wood-pellet-market-o2639.html
[49] Wahl, Antje. 2008. "Wood Market Trends in Europe." FP Innovations & Natural Resources Canada. http://www.solutionsforwood.ca/_docs/reports/EuropeMarketTrends.pdf
[50] Ibid.

Figure 10: World production and consumption of wood pellets
Source: Pellet Italia[51]



Unfortunately, data does not indicate which region dominates the wood pellet export market within the U.S. Based on climate and pellet stove use, it can be assumed that the North, West, and Northeast are more inclined to use pellets produced regionally. The South, on the other hand, has little residential use for wood pellets and most of production is either for domestic industry use or exportation. It is likely that anywhere from 50-100% of wood pellets produced in the South are exported (actual data unavailable).

3.2 Effect of Southern Wood Pellet Industry on Available Residual Biomass

The following table begins to assess this market by identifying a few existing or proposed pellet facilities in the Southeast. The production per plant, the total residual in each state (from Table 1), the percent of this total consisting of wood pellets (assuming pellet production relies solely on residuals), and the subsequent percent of pellets/residuals on the international market by state (after researching individual facilities' market intentions) are displayed in Table 9.

[51] Ibid.

Table 9: Proposed/existing wood pellet plants and effects on woody residual supply; export estimates by facility

Plant	State	Proposed /Existing	Facility Production (dry tons)	Residual available (dry tons)	Pellet % of Total Residual	%Residuals International Market
Lee Energy Solutions Plant	AL	E	116,000	2,210,750	5	0
Green Circle	FL	E	560,000	2,967,700	19	19
Appling County Pellets, LLC	GA	E	145,000	3,398,400	4	4
Woodlands Alternative Fuels	GA	E	300,000	3,398,400	9	5
AG Waycross Fuel Pellets	GA	P	135,000	3,398,400	4	0
Georgia Biomass, LLC	GA	P	750,000	3,398,400	22	22
Briar Creek Pellets	GA	E	75,000	3,398,400	2	1
				TOTAL	41	33
CKS Energy	MS	E	45,000	2,905,250	2	1
Piney Wood Pellets	MS	E	50,000	2,905,250	2	0
				TOTAL	3	1
Carolina Wood Pellets	NC	E	68,000	2,908,750	2	1
Nature's Earth Pellet Energy	NC	P	120,000	2,908,750	4	2
				TOTAL	6	3
WoodFuels VA Plant	VA	E	100,000	2,502,950	4	0
Wood Fuel Developers, LLC	VA	P	300,000	2,502,950	12	6
				TOTAL	16	6

Additionally, Spelter and Toth conducted a study on North America's wood pellet industry through the U.S. Forest Service Forest Products Laboratory (2009). The study interviewed 111 wood pellet plants in the U.S. and the results serve as the best estimate for regional activity in the Southeast. However, the study certainly lacks a holistic representation of the wood pellet industry in the South due to incomplete data in a relatively new industry.[52]

Spelter and Toth conclude that wood pellets are largely comprised of primary mill waste, especially sawmill residues (69%). Other contributors include secondary wood waste from furniture manufacturing facilities (14%) and green material from either logging residues *or* pulpwood supply (16%). Calculations estimated scenarios where 69% of the primary mill waste was subtracted for pellet

[52] Spelter, Henry & Daniel Toth. 2009. "North America's Wood Pellet Sector." USDA Forest Service, Forest Products Laboratory. Research Paper FPL-RP-656. <http://www.fpl.fs.fed.us/documnts/fplrp/fpl_rp656.pdf>

use, 14% of the secondary mill waste was subtracted for pellet use, and *either* 16% *or* 0% of the forest residue was subtracted for pellet use. The remaining available biomass is displayed in Table 10.[53]

Table 10: Source for wood pellets, residuals available after pellet production, and total residual biomass available after pellet production

State	Estimated Pellet Use (dry tons)	69% Pellets from Primary Mill Waste	Primary Mill Residue Remaining*	14% Pellets from 2ndary Mill Waste	Secondary Mill Residue Remaining*	16% Pellets from Forest Residue	Forest Residue Remaining*
Virginia	118,000	81,420	-15,420	16,520	45,480	18,880	1,543,070
North Carolina	62,000	42,780	-28,780	8,680	106,320	9,920	1,936,830
South Carolina		0	9,000	0	38,000	0	1,126,450
Tennessee	18,000	12,420	140,580	2,520	72,480	2,880	854,470
Georgia	459,000	316,710	-250,710	64,260	32,740	73,440	2,237,960
Alabama	535,000	369,150	-359,150	74,900	-17,900	85,600	1,575,150
Florida	454,000	313,260	-309,260	63,560	66,440	72,640	1,083,060
Mississippi	50,000	34,500	44,500	7,000	26,000	8,000	2,478,250

Summations

State	Total Wood Waste Used w/Forest Residue	Total Wood Waste Used w/o Forest Residue	Remaining total Biomass* (w/16% Forest Residue)	Remaining total biomass* (w/o 16% Forest Residue)
Virginia	116,820	97,940	2,386,130	2,405,010
North Carolina	61,380	51,460	2,847,370	2,857,290
South Carolina	0	0	1,640,450	1,640,450
Tennessee	17,820	14,940	1,681,530	1,684,410
Georgia	454,410	380,970	2,943,990	3,017,430
Alabama	529,650	444,050	1,681,100	1,766,700
Florida	449,460	376,820	2,518,240	2,590,880
Mississippi	49,500	41,500	2,855,750	2,863,750

Note: This study does not break down pellet production by facility but estimates production for each state. The estimates, however, are comparable to Table 9.
*Remaining calculated from initial biomass estimates (Table 1).

Table 11 displays the new available residual biomass and its potential contribution to the energy sector in Megawatt-hours per year. These calculations do *not* incorporate a 16% use of forest residue in an effort to maximize available remaining residuals; additionally, the effect of the wood pellet industry has

[53] Spelter, Henry & Daniel Toth. 2009. "North America's Wood Pellet Sector." USDA Forest Service, Forest Products Laboratory. Research Paper FPL-RP-656. <http://www.fpl.fs.fed.us/documnts/fplrp/fpl_rp656.pdf>.

(at this point) a 1% effect on residual supply so including 16% forest residue would be negligible. This practice will follow for the remaining calculations.

Table 11: Potential woody biomass residual electric supply *after* wood pellet production*

State	RES MWh per year	Total Residue Biomass (dry tons)	Total Residue MMBtu*	Total Residue MWh per year	% of Requirement
Virginia	10,901,780	2,405,010	36,075,150	2,875,248	26
North Carolina	18,785,859	2,857,290	42,859,350	3,418,740	18
South Carolina	15,146,700	1,640,450	24,606,750	1,963,584	13
Tennessee	13,599,497	1,684,410	25,266,150	2,016,180	15
Georgia	20,426,009	3,017,430	45,261,450	3,602,826	18
Alabama	13,456,092	1,766,700	26,500,500	2,112,606	16
Florida	32,945,522	2,590,880	38,863,200	3,094,398	9
Mississippi	7,230,857	2,863,750	42,956,250	3,427,506	47

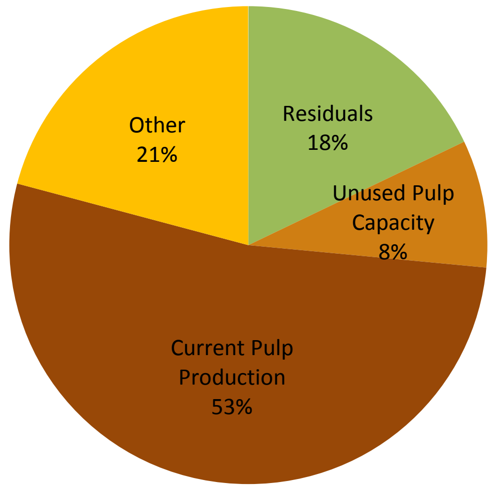
*This also assumes 100% pellet export, diverting biomass used for pellet production away from regional domestic energy supply. This is highly unlikely, but the data is unavailable and the current effect is relatively low.

4. Summarized Results

In terms of the South's ability to meet an electrical RPS mandate with available residual biomass and unused pulpwood capacity, the contribution is significantly lower than initially anticipated by policy-makers looking for an easy panacea. The average residue energy contribution averaged across the six states decreases to 18% from 19%, after considering such outlying forest market variables as the wood pellet industry. In other words, the wood pellet industry decreases available residuals by 1 percent and is expected to have a greater effect in the near-future. The following pie chart displays these findings. It is clear that biomass can supply, at best, about a quarter of an RES demand. Furthermore, instead of focusing on potential pulpwood for energy, it is more likely a renewable mandate must rely on other alternatives for 70-75% of demand. Biomass cannot be the only option for the Southeast's renewable portfolio, as long as these policies feature electricity and not energy in a broader sense.

Figure 11: Contribution of biomass supply to an RES demand using residuals, current pulpwood production, and unused pulpwood capacity

Proportion of biomass contribution to a 15% RES, based on current electricity generation, peak pulp, and current pulp production



*Results are averaged across states (VA, NC, SC, GA, AL, TN)

SUPPLY AND DEMAND UNDER CLIMATE CHANGE

1. Climate Change Models for the Southeast

As awareness increases on the effects and impacts of climate change, the need to predict and project future electric energy demand and biomass supply under climate change scenarios is increasingly pressing. Unfortunately, as with all climate change predictions, projecting electric demand and biomass supply is highly speculative; however, a few key studies provide a reasonable foundation for uncovering future conditions.

1.1 Climate Change Models

Of all national models, regional predictions for the Southeast are the most divergent. "The Southeast is the only region where climate models are simulating large and opposite variations in precipitation patterns over the next 100 years."[54] The two dominant models for the region are the Canadian Climate Model and the Hadley Center Climate Model.[55] The models are generally characterized as either "hot and dry" or "warm and wet," respectively. Both models predict that there will be little, if any, change in precipitation by 2030, but dramatic changes by 2100. More specifically, the Canadian Model predicts there will be a 3 degree Fahrenheit increase in temperature by 2030, a 10 degree Fahrenheit temperature increase by 2100, and a 10% *decrease* in precipitation by 2100. On the other hand, the Hadley Model predicts a smaller, 1.8 degree Fahrenheit temperature increase by 2030, a 4.1 degree Fahrenheit temperature increase by 2100, and a 20% *increase* in precipitation by 2100.[56,57,58] The

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[54] USDA Forest Service. 2010. "Uwharrie National Forest Plan Revision." Draft. <http://www.cs.unca.edu/nfsnc/uwharrie_plan/plan/climate_change_11182008.pdf>.
[55] Ibid.
[56] Ibid.
[57] Sun, Ge & Steven G. Nulty, Erika Cohen, Jennifer Moore Myers & David Wear. 2005. "Modeling the Impacts of Climate Change, Landuse Change, and Human Population Dynamics on Water Availability and Demands in the Southeastern U.S." Written for presentation at the 2004 ASAE Annual International Meeting. <http://www.srs.fs.usda.gov/pubs/ja/ja_sun011.pdf>.

opposing predictions suggest different vegetative responses for the region. For example, the Canadian Model suggests increased drought frequency will reduce plant resiliency by introducing water stress, more frequent wildfire events, and threat of pests. In contrast, the Hadley Model suggests vegetative response will thrive in slightly warmer, wet conditions that create an optimal growing environment.[59]

1.2 Projected CO_2 Concentrations

Irrespective of the climate model, CO_2 concentrations are expected to continually rise. Current ambient CO_2 concentrations are over 385 parts per million (ppm). Levels are expected to increase to 450 ppm by 2030 and 700-950 ppm by 2100.[60] Research on plant growth response to various CO_2 levels indicates that trees will experience increased growth under elevated concentrations. More specifically, the Free Air Carbon Enrichment study in the Duke Forest in Durham, North Carolina, indicates that trees experience rapid growth in the first few years of exposure to elevated CO_2 levels. Subsequent growth rates appear to decrease somewhat, yet remain higher than ambient CO_2 scenarios until other limiting essential nutrients prevent increased growth rates.[61] However, there is some level of saturation where increased CO_2 concentrations will no longer positively affect growth and photosynthesis remains constant. "At the saturation point, photosynthesis is not limited by the amount of CO_2 available for fixation, but rather limited by the light reactions and availability of nitrogen and other nutrients."[62,63]

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[58] US Global Change Research Program. 2000. "Climate Change Impacts on the United States; The Potential Consequences of Climate Variability and Change. Overview: Southeast." National Assessment Synthesis Team, USBCRP. <http://www.usgcrp.gov/usgcrp/Library/nationalassessment/overviewsoutheast.htm>.
[59] Ibid.
[60] US Environmental Protection Agency. 2010. "Future Atmosphere Changes in Greenhouse Gas and Aerosol Concentrations." USEPA. <http://www.epa.gov/climatechange/science/futureac.html>.
[61] Oren, Ram & David S. Ellsworth, Kurt H. Johnsen, Nathan Phillips, Brent E. Ewers, Chris Maier, Karina V.R. Schafer, Heather McCarthy, George Hendrey, Steven G. McNulty & Gabriel G. Katul. 2001. "Soil fertility limits carbon sequestration by forest ecosystems in a CO2-enriched atmosphere." *Nature*. 411: 469-472.
[62] Bala, Govindasamy & Ranjith Gopalakrishnan, Mathangi Jayaraman, Ramakrishna Nemani, & N. H. Ravindranath. "CO2-fertilization and potential future terrestrial carbon uptake in India." *Mitigation and Adaptation Strategies for Global change.* DOI 10.1007/s11027-010-9260-z.
[63] Bonan GB. 2008. Ecological climatology. Cambridge University, New York.

Saturation occurs at concentrations of about 400 ppm for C_4 plants and about 600-650 ppm for C_3 plants (in most tree species).[64]

1.3 Vegetative Response

In response to elevated carbon levels, vegetation under both climate scenarios will experience increased growth as CO_2 levels increase. The Hadley Model, with optimal growing conditions, should experience maximum growth with CO_2 fertilization (a 10% growth increase in 2030 CO_2 levels and a 30% growth increase under saturation), as suggested by Duke FACE site experiments.[65] However, the vegetative growth response may level off some time before 2100, as the CO_2 concentration will reach and then surpass a saturation level by 2100. The Canadian Model, on the other hand, will experience similar growth by 2030 (a 10% increase). However, as precipitation regimes change, the CO_2 enrichment effect will be reduced by drought stress and soil moisture loss. A recent study by McCarthy et al. (2010) determined that drought and dry conditions will reduce a 30% growth response to elevated CO_2 by 40% for a *total* overall growth increase of about 18%.[66] It is important to note that many of these assumptions are speculative and based on limited research. However, these growth estimates were used to predict future biomass supply in different, future climate change scenarios.

[64] Ibid.
[65] Oren, Ram & David S. Ellsworth, Kurt H. Johnsen, Nathan Phillips, Brent E. Ewers, Chris Maier, Karina V.R. Schafer, Heather McCarthy, George Hendrey, Steven G. McNulty & Gabriel G. Katul. 2001. "Soil fertility limits carbon sequestration by forest ecosystems in a CO2-enriched atmosphere." *Nature*. 411: 469-472.
[66] McCarthy, Heather R. & Ram Oren, Kurt H. Johnson, Anne Gallet-Budynek, Seth G. Prtichard, Charles W. Cook, Shannon L. LaDeau, Robert B. Jackson & Adrien C. Finzi. 2010. "Re-assessment of plant carbon dynamics at the Duke free-air CO2 enrichment site: interactions of atmospheric [CO2] with nitrogen and water availability over stand development. *New Phytologist*. 185: 514-528.

1.4 Projected Electric Demand

In order to determine the role projected biomass supply will play in a renewable energy mandated future, the electric demand for both 2030 and 2100 must be similarly estimated. To begin with, the EIA estimates that electric demand in residential, commercial and industrial sectors will increase 16% by 2030 (a 20 year time period) for an overall annual increase of 0.8% per year. Although seemingly low, this stands as one of the only future projections for electric demand. Therefore, this estimate was held constant and extrapolated to achieve demand in 2100. It does not take energy efficiency or renewable energy application increases into account.[67] To estimate electric demand under future climate scenarios, projections were calculated for both the Canadian Model and Hadley Model. Scott and Huang (2007) suggest that electric demand will change with increasing temperature based on the change in cooling and heating demand. Although these effects will vary by region, the average national impact ranges from a 5-20% increase in electric demand for cooling and a 3-15% decrease in electric demand for heating for a net increase of 2-5% for every 1.8 degree Fahrenheit temperature increase.[68] Based on the EIA projections, a low and high electric demand increase, and the temperature projections for the two climate change models, the future electric demand was calculated for 2030 and 2100.

2. Analyzing Future Biomass Supply and Electric Demand

Finally, the following estimates of future biomass supply and electric demand were based on previous calculations of present day data. The following table include biomass contributions (various combinations, as previously mentioned) to a 15% RPS electric demand under low and high projections of two different climate change models (the 15% RPS is preserved for consistency). This investigation

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[67] Brown, Marilyn A. & Etan Gumerman, Xiaojing Sun, Youngsun Baek, Joy Wang, Rodrigo Cortes, & Diran Soumonni. 2010. "Energy Efficiency in the South." Atlanta, Georgia: Southeast Energy Efficiency Alliance.

[68] Scott, M.J. & Y.J. Huang. 2007. "Effects of climate change on energy use in the United States." Effects of Climate Change on Energy Production and Use in the United States. T.J. Wilbanks, V. Bhatt, D.E. Bilelloet al. Washington, D.C., U.S. Climate Change Science Program. Synthesis and Assessment Product 4.5:8-44.

purposefully concentrated on the state of North Carolina, for ease of understanding, organization, and relevance (as this is currently the only state in the Southeast with an RPS).

Table 12: Climate change scenario: North Carolina future woody residual supply

Model	Year, Lo/Hi	RES MWh per year	Biomass (dry tons)	Total Residue (MMBtu)	Residue MWh per year	% of 15% RES
CURRENT	CURRENT	18,785,859	2,908,750	43,631,250	3,480,102	19
Hadley	2030 lo	22,227,429	3,199,625	47,994,375	3,828,112	17
	2030 hi	22,881,177	3,199,625	47,994,375	3,828,112	17
	2100 lo	38,366,629	3,781,375	56,720,625	4,524,133	12
	2100 hi	40,813,218	3,781,375	56,720,625	4,524,133	11
Canadian	2030 lo	22,515,078	3,199,625	47,994,375	3,828,112	17
	2030 hi	23,600,300	3,199,625	47,994,375	3,828,112	16
	2100 lo	43,752,064	3,432,325	51,484,875	4,106,520	9
	2100 hi	54,276,804	3,432,325	51,484,875	4,106,520	8

Although the results are highly speculative and differ significantly between models, it is still clear that biomass will never be able to completely meet a 15% Renewable Electricity Standard demand. Future supply never meets more of an RPS demand than current estimates. Most importantly, if electric demand continues to grow as projected, biomass will only be to meet less than a quarter of a 15% RES demand despite even the best vegetative growth responses. Tables displaying percent contributions with more expansive biomass definitions (as discussed in previous analysis) are available in the Appendix (Appendix Tables 1 & 2).

Furthermore, this does not take other forestland pressures into account. Landuse conversion is known to be one of greatest threats to biomass supply and can negatively affect future available biomass.[69] Even if the Southeast contains the same amount of forested acres today as it does tomorrow, increasing

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[69] Murray, Brian C. & Robert C Abt, David N. Wear, Peter J. Parks & Ian W. Hardie. 2003. "Land allocation in the Southeast U.S. in response to climate change impacts on forestry and agriculture." *World Resources Review*. 13.2: 239-251.

fragmentation and smaller land parcelization may make biomass collection increasingly difficult.[70] Furthermore, climate change may also affect the incentives for forest management investment, particularly in plantations. Climate fluctuations may increase risk associated with forest management investments, decreasing total plantation acreage, and subsequently decreasing potential biomass supply.[71] In the end, land use conversion, land allocation variances, and population pressures may prove increasingly problematic for maximum total available biomass.

Additionally, these projections do not account for such extreme weather events as natural disasters, floods, droughts, or disease/pest outbreaks, as these events are nearly impossible to predict and quantify. Experts generally expect that wildland fire frequency will also increase. These usually rare phenomena will have the potential to completely eliminate a sustainable, future biomass supply with one large-scale event.[72]

Climate scientists also predict extreme weather events as increasingly likely.

> *"New results since the IPCC Second Assessment Report indicate a possible increase of extreme heat stress events in a warmer climate, an increase of cooling degree days, an increase of precipitation extremes such that there is a decrease in return periods for 20-year extreme precipitation events."*[73]

These extreme events will undoubtedly place greater stress on vegetation, decreasing growth rates.

[70] Wear, David. 2005. "Forests Under Siege: Fragmentation accelerates in the South." *Compass*. 1.4 U.S. Department of Agriculture, Forest Service, Southern Research Station.
[71] Ibid.
[72] Helmer Madeleen & Dorothea Hilhorst. 2006. "Natural Disasters and Climate Change." Product of an international conference on 'Challenges of Complexity in Coping with Climate-related Disasters,' held 14-15 June 2004, organized by the Department of Disaster Studies, Wageningen University, Netherlands. Sponsored by UNESCO-Netherlands.
[73] Meehl, Gerald A. & Francis Zwiers, Jenni Evans, Thomas Knutson, Linda Mearns & Peter Whetton. 2000. "Trends in Extreme Weather and Climate Events: Issues Related to Modeling Extremes in Projections of Future Climate Change." *Bulletin of the American Meteorological Society.*

CONCLUSIONS

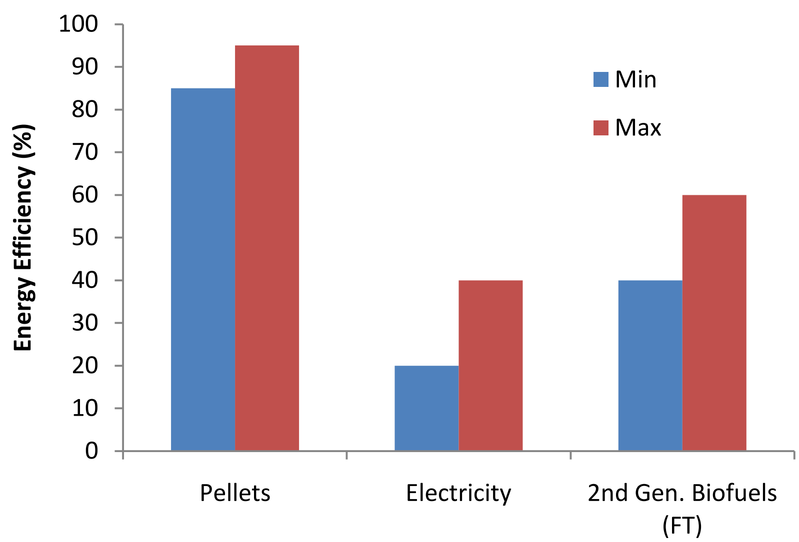
Recent excitement over the potential for woody biomass to play a significant role in renewable energy generation has seemed to overshadow warnings suggesting subsequent demand may exceed Southeastern forest resource supply. Rudimentary calculations attempt to estimate exactly how much residual woody biomass resources can supply a 15% RPS mandated electricity demand. Although significant, the supply accounts for 27% of a renewable electric demand, at best. Under future climate change scenarios, biomass supply meets even less of a renewable demand. Estimates suggest that electric demand under future population and climate pressure will increase more than vegetative response, suggesting that biomass will play an even smaller role in meeting a future renewable mandate demand.

It is obvious that residual biomass cannot be the sole component of a renewable electric portfolio. Additional stresses on the supply include a growing wood pellet industry, currently exporting to a voracious European market. It appears as though a high RPS mandate should include few specific energy source carve-outs and instead encompass a wide variety of renewable options. Otherwise, a decreased mandate may more reasonably be sourced by woody residual supply.

Furthermore, initiatives aimed at reducing overall energy consumption can play a large role in decreasing the regional energy consumption footprint. Energy efficient technology is beginning to play a significant role in consumer consumption portfolios. Additionally, alternative energy technologies are entering the market at an extremely fast pace. Although biomass cannot be the South’s only renewable option, it has real potential, combined with other initiatives, to dramatically reduce fossil fuel energy consumption in the Southeast.

Finally, is woody biomass even the right option for the Southeast? With little demand for heat supply, the Southeast will largely draw upon electric energy or fuel. However, chillers may make thermal applications more applicable to the Southeast, by converting heat into cool air.[74] Energy efficiency is dramatically reduced for all such uses (as displayed in the following figure). On the other hand, current coal-fired facilities have an energy efficiency rate of around 30%, indicating even the least efficient woody biomass energy options may be a significant improvement over the status quo.

Figure 12: The significant differences in energy losses for the conversion of biomass to solid fuels, to liquid fuels and to electricity; indicated variations represent the current state of technology[75]



The true potential of woody biomass energy has yet to be fully understood. Technological innovation will undoubtedly increase usefulness and alleviate many of the most pressing concerns. It appears as though energy providers are trending toward this renewable source, and the extent of potential ramifications will become more apparent over time.

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[74] Richter Jr., Daniel deB & Dylan H. Jenkins, John T. Karakash, Josiah Knight, Lew R. McCreery, & Kasimir P. Nemestothy. 2009. "Wood Energy in America." *Science.* 323: 1432-1433.

[75] Rakos, Christian. 2008. "The heat market—key for the transformation of our energy system." proPellets: Austria. www.propellets.at/cms/download.php?docId=69.

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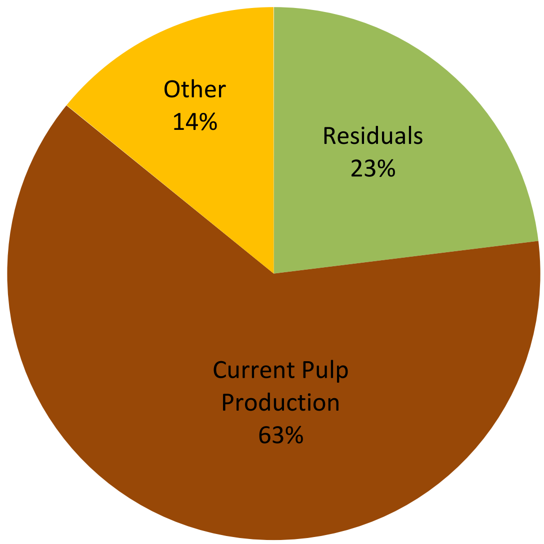
APPENDIX

Equation 1: Energy Conversion Calculations

Biomass (dry tons) * 15Btu / 1 dry ton * 1 MW / 110,000 MMBtu * 8766 MWh / 1 MW

Figure 1: Average biomass contributions to a proposed RES, including the state of Mississippi.

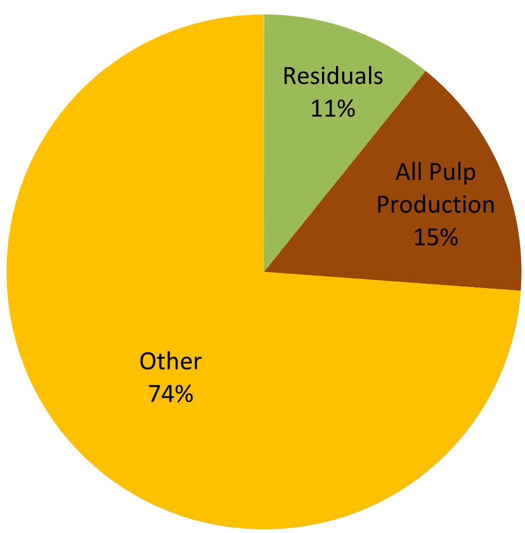
Proportion of biomass contribution to a 15% RES, based on current electricity generation in the Southeast



*Results are averaged across states (VA, NC, SC, TN, GA, AL, MS)

Figure 2: Average biomass contributions to a proposed RES for the state of Florida.

Proportion of biomass contribution to a 15% RES, based on current electricity generation in Florida



*Results are strictly for the State of Florida, as this state displays results atypical from the rest of the Southeast.

Table 1: Climate change scenario: North Carolina combined roundwood pulpwood and residual biomass supply, North Carolina projected electric demand, and amount that supply can meet future RES demand.

Model	Year, Lo/Hi	RES MW per year	Residue MW per year	Pulpwood MW per year	Total Forest MW per year	% of an RES
CURRENT	CURRENT	2,143	397	709	1,106	52
Hadley	2030 lo	2,536	437	780	1,217	48
	2030 hi	2,610	437	780	1,217	47
	2100 lo	4,377	516	922	1,438	33
	2100 hi	4,656	516	922	1,438	31
Canadian	2030 lo	2,568	437	780	1,217	47
	2030 hi	2,692	437	780	1,217	45
	2100 lo	4,991	468	837	1,305	26
	2100 hi	6,192	468	837	1,305	21

Table 2: Climate Change Scenario: North Carolina combined unused pulpwood capacity and residual biomass supply, North Carolina projected electric demand, and amount that supply can meet future RES demand.

Model	Year, Lo/Hi	RES MW per year	Residue MW per year	Unused MW per year	Total Forest MW per year	% of an RES
CURRENT	CURRENT	2,143	397	201	597	28
Hadley	2030 lo	2,536	437	221	657	26
	2030 hi	2,610	437	221	657	25
	2100 lo	4,377	516	261	776	18
	2100 hi	4,656	516	261	776	17
Canadian	2030 lo	2,568	437	221	657	26
	2030 hi	2,692	437	221	657	24
	2100 lo	4,991	468	237	704	14
	2100 hi	6,192	468	237	704	11