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North Carolina's Role in the Global Biomass Energy Market

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The Biofuels Center of North Carolina has the long-term task of developing a large-scale biofuels industry sector to reduce the state's dependence on imported petroleum. North Carolina's Strategic Plan for Biofuels Leadership sets the goal of replacing 10 percent of the petroleum imported into North Carolina with biofuels locally grown and produced. The Biofuels Center was created in 2007 and is permanently funded by the North Carolina General Assembly to implement the strategic plan so the state's farmers, biofuels manufacturers, biofuels workers, and consumers benefit from this emerging multimillion-dollar, locally grown industry.

The Frank Hawkins Kenan Institute of Private Enterprise is a research and consulting organization based at the University of North Carolina at Chapel Hill's Kenan-Flagler Business School. We conduct sponsored research and analysis on issues, trends and processes that impact company and community competitiveness. Our work helps clients gather and make sense of the information they need to plan and make good decisions and develop tools to implement them. Our consulting services include: renewable energy development; economic and community development; entrepreneurship support; research commercialization; and logistics and supply chain management.

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Biomass has always been an important energy source for human beings, from burning wood for cooking, to chemical conversion of agricultural waste into liquid biofuels, to co-firing a coal power plant with biomass pellets. Most forms of biomass are plant-based materials that store the sun's energy in carbon molecules. As a result, both energy and carbon dioxide are typically released when biomass is combusted. Unlike fossil fuels, most of the carbon in biomass would eventually end up in our atmosphere as the biomass decomposes. Therefore, the European Union (EU) and other nations around the world are turning to biomass as a lower climate impact alternative to fossil fuels.

In the United States, woody biomass is used for electricity generation primarily for industrial applications while conversion into liquid biofuels is less established.[1] In 2007 and 2009, the EU committed to reduce greenhouse gas emissions by 20%, increase the renewable share of total energy consumption to 20%, and increase energy efficiency by 20% compared to 1990 levels, all to be achieved by the year 2020. While there is no mandated EU target specifically for biomass, it currently contributes the highest proportion of renewable energy for electricity, heating, and transportation in Europe—more than solar or wind. In fact, biomass use for heat and power will likely need to double between 2010 and 2020 for the EU to achieve its targets. As a result an export industry for US woody biomass pellets has been created over the past decade.

The main driver for the growth in North Carolina's pellet industry is policy-driven demand from Europe. The EU's 20-20-20 policy has created an international market for biomass pellets. Co-firing biomass in a coal power station or converting a coal boiler to biomass is less expensive than other, lower-CO2 options, e.g. gas turbines or nuclear.[2] The United Kingdom (UK), The Netherlands, Belgium, and Denmark are the top importers of US wood pellets. Pellet exports from North Carolina and the South have increased sharply with the demand from Europe

The wood pellet industry in North Carolina is too new to reliably predict local level production trends. Until the mid-2000s, US wood pellets were primarily produced at smaller (<100,000 tonnes/yr) pellet plants for the domestic market for use in heating. The US currently consumes over 1.5 million tonnes of US-produced pellets; however, production has surpassed consumption since 2010. In the past few years, Enviva LP has built two pellet plants in northeastern North Carolina, one in southeastern Virginia, and two in Mississippi with a total

[1] US Energy Information Agency, "Biomass for Electricity Generation," http://www.eia.gov/oiaf/analysispaper/biomass/
[2] Hydroelectric and geothermal are both viable base-load power sources; however, they have significant geographic restrictions.

announced operating capacity of 1.5 million tonnes/year. Given the incompleteness of country-level EU biomass regulations, rapid increase in EU imports, and rapid proliferation of large pellet facilities across the southern US, and underutilization of installed capacity, a precise prediction of future NC exports would be premature.

Eastern North Carolina wood resources are sufficient to sustainably support installed pellet capacity by US Forestry Service estimates of sustainable supply. The three large pellet plants near northeastern NC will require ~226,000 thousand cubic feet of timber if running at full capacity, well below the 50-mile radius sustainable supply (~464,000 thousand cubic feet). Between 2010 and 2020, North American pellet production is predicted to more than double with the southeastern US and eastern Canada being responsible for the majority of that increase. Without new competition for forest resources, Eastern NC forests could sustain at least 7 more pellet plants each with a capacity of ~350,000 tonnes/yr, effectively tripling current capacity.

The domestic US pellet industry is vulnerable to changes in EU carbon emission and sustainability requirements. The European Union has committed to reducing GHG emissions; however, some types of biomass (e.g. European agricultural waste) have a smaller carbon footprint than others (e.g. North American roundwood pellets) due to emissions from trans-Atlantic shipping, trucking from pellet plants to port, and land use impacts. In the UK, biomass-energy receives the same incentive as solar energy, regardless of the type of biomass. Given that the growth in the North American wood pellet market is predicated on policy-driven EU demand, the regulatory risk to the US pellet industry is high if EU and UK regulations change to disfavor pellets as a primary source of biomass feedstock for energy production.

Competition for low quality wood resources in eastern North Carolina is currently low; however, future demand may make the region less attractive for liquid biofuel production.
The recent investment in the southeastern US pellet industry is driven by abundant and inexpensive forest feedstock that is relatively inexpensive to transport to port. Current competition for these resources is depressed due to broader economic causes. Future competition between the pulp and paper, pellet, and liquid biofuel industries for logging residues, fuelwood, and hardwood pulpwood may endanger the prospects of a liquid biofuel industry in some regions. However, past a certain point going west in North Carolina (approximately, I-95), forest products are not competitive for pellet manufacturing feedstock because of inland transport costs. Therefore, western or piedmont forest resources may be the optimal woody inputs for North Carolina biofuel production. As most of the in-state biofuel consumption would likely be in the Piedmont, there may be a viable niche.

1. Introduction

As many developed nations put policy and incentives in place to increase the amount of energy generation that is derived from renewable sources, the search for the right renewable source to fit the needs of consumer and industrial demand has intensified. In Europe, the primary driver for renewable energy development is climate change and a desire to reduce emission of greenhouse gasses. Of the various forms of renewable energy, biomass derived products provide an advantage over other forms of alternate energy, both for their constant load and abundance of supply. While different sectors utilize different feedstocks for this biomass energy, the primary feedstock of biomass for electricity and heat generation is woody biomass. Wood pellets offer some advantages over other forms of wood biomass, including a 61% increase in calorific value from non-pelleted, non-dried wood, low moisture content (5-7 percent vs. 40-60 percent for non-pelleted wood) and low ash (1-2 percent vs. 5 percent for non-pelleted wood) wood pellets ship in standard dry bulk vessels - good for improving the shipping economics. Finally, the size and shape of pellets make it easy for them to be a tradable commodity.

Global consumption of wood pellets more than doubled in the years 2006-2011, indicating the strong demand for wood pellets as a source for woody biomass products[3]. As a result, production capacity grew 22% between 2009 and 2010, reaching over 28 million tonnes. The greatest increases in production capacity were seen in the US and Canada[4].

However, despite these increases, a dramatic increase in both production and production capacity is required to meet long-term demands for wood pellets. The southeastern states, and specifically North Carolina, are well positioned to meet this demand due the abundance of required natural resources. This paper will examine in depth the global market for wood pellets, and identify specific opportunities for North Carolina in this marketplace.

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[3] **Direct firing**—Biomass is the only fuel used at a given power plant. The feedstock is fed into a boiler, which in turn powers a steam turbine to generate electricity. The direct firing method attains efficiencies of up to 40 percent. **Co-firing**—Biomass is substituted for a portion of the coal burned in a coal-fired power plant. A coal-fired power plant can be modified to accommodate biomass and use it to supply up to 20 percent of its fuel requirements. This method reaches efficiencies between 33 and 37 percent. **Cogeneration**—Fuel is burned to produce both electricity and heat. As with direct firing, the biomass fuel powers a steam turbine generator. However, unlike direct firing, cogeneration uses the resulting exhaust flow for further electricity generation or heat generation. The advantage of cogeneration is improved efficiencies between 75 and 90 percent. **Gasification**—Feedstock is processed in a hot oxygen-starved area to produce a gas, composed mostly of carbon monoxide and hydrogen. This gas fuels a turbine to produce electricity. This method reaches efficiencies of up to 60 percent. From http://www.fs.fed.us/pnw/pubs/pnw_gtr861.pdf

[4] Global Wood Pellet Industry Market and Trade Study. IEA Bioenergy. 2011. Maurizio Cocchi et al.

This study assesses the current global market for wood pellets with specific focus on Europe. The report compiles and analyzes global and domestic public policy and the impact of these policies on the global markets that relate to renewable energy generation. We also assess the demand for pellets, develop a wood pellet price projection, and investigate North Carolina's production capacity. Transportation and port facilities have been assessed in an effort to assess NC's ability to achieve biofuel goals with woody biomass feedstock and balance other competing markets.

1.1 Wood Pellet Manufacturing Process

Pellet production facilities are located across the globe, supplied by two types of feedstock: by-product sawdust (secondary product from other lumber production) or more recently, virgin woody biomass feedstock is becoming more widespread as demand grows. Total production capacity across the globe was roughly 30 million tonnes in 2011 while current production capacity in North Carolina and coastal neighbors (VA, SC, and GA) is ~4 million tonnes.

The basic process of producing wood pellets in the United States for electricity production in Europe is outlined in Figure 1. The example builds on a case study of a Canadian supplier of wood pellets to a Dutch electrical generation plant; however, the Southeast has recently eclipsed Canada as the largest source of imported pellets for European markets.[5,6] Wood pellet supply has two major variants, depending upon whether the pellets produced are by-products of another process, such as furniture-making, or the primary product of the operation. Accessing feedstock at sawmills and wood product facilities implies modest transportation costs, relatively clean, and relatively drier input. Harvesting in the forest and delivery to a processing facility is needed when pellets are the primary product.

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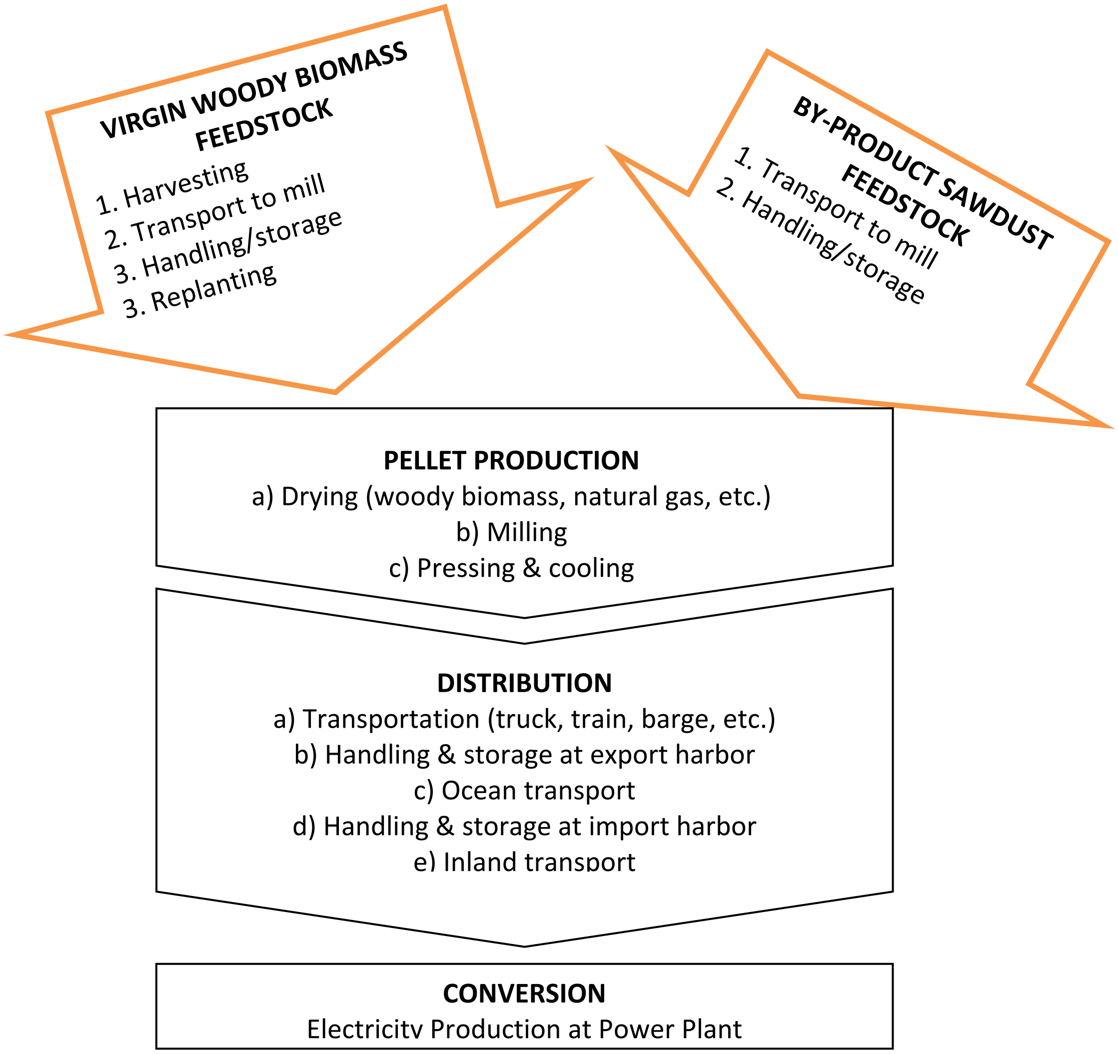
[5] Adapted from Sikkema et al. 2010, Biofuels, Bioprod. Bioref. **4**:132-153 (2010).

[6] According to a Wood Resources International report summarized in Biomass Magazine 10 September 2012.

Figure 1 - Using North American Wood to Generate European Electricity



The reliance on sawmill residues led to imbalances between supply and demand for biomass as the sawmilling sector retrenched in the 2008-2009 recession. This led pellet mills to turn to roundwood or other non-sawmill sources of biomass. In 2008, wood pellet production in the United States massed 1.8 million tonnes, just 66% of capacity as a result of limited mill residue availability that constrained plant activity output.[7]

Using round wood increases the costs of production because 1) it needs to be prepared (debarked and chipped before processing and 2) it is wetter than by-products, requiring more

[7] Global Wood Pellet Industry Market and Trade Study. IEA Bioenergy. 2011. Maurizio Cocchi et al.

drying, which is energy-intensive and thus costly. Pellets are produced by compressing woody material which has first passed through a hammer mill to provide a uniform dough-like mass. This mass is fed to a press where it is squeezed through a die having holes of the size required (normally 6 mm diameter, sometimes 8 mm or larger). The high pressure of the press causes the temperature of the wood to increase greatly. The lignin in the wood plasticizes slightly to form a natural "glue" that holds the pellets together as they cool.[8] The major steps in the process are:

1) Drying - Moisture content is a critical variable it needs to be maintained at approximately 15 percent. If too dry, the heat build-up induced by friction in the pelletizer burns the surfaces. If too moist, the trapped steam pressure weakens internal bonds, resulting in increased breakage and dust during handling. Green wood may have moisture content in excess of 50% while shipped pellets are typically below 10%.

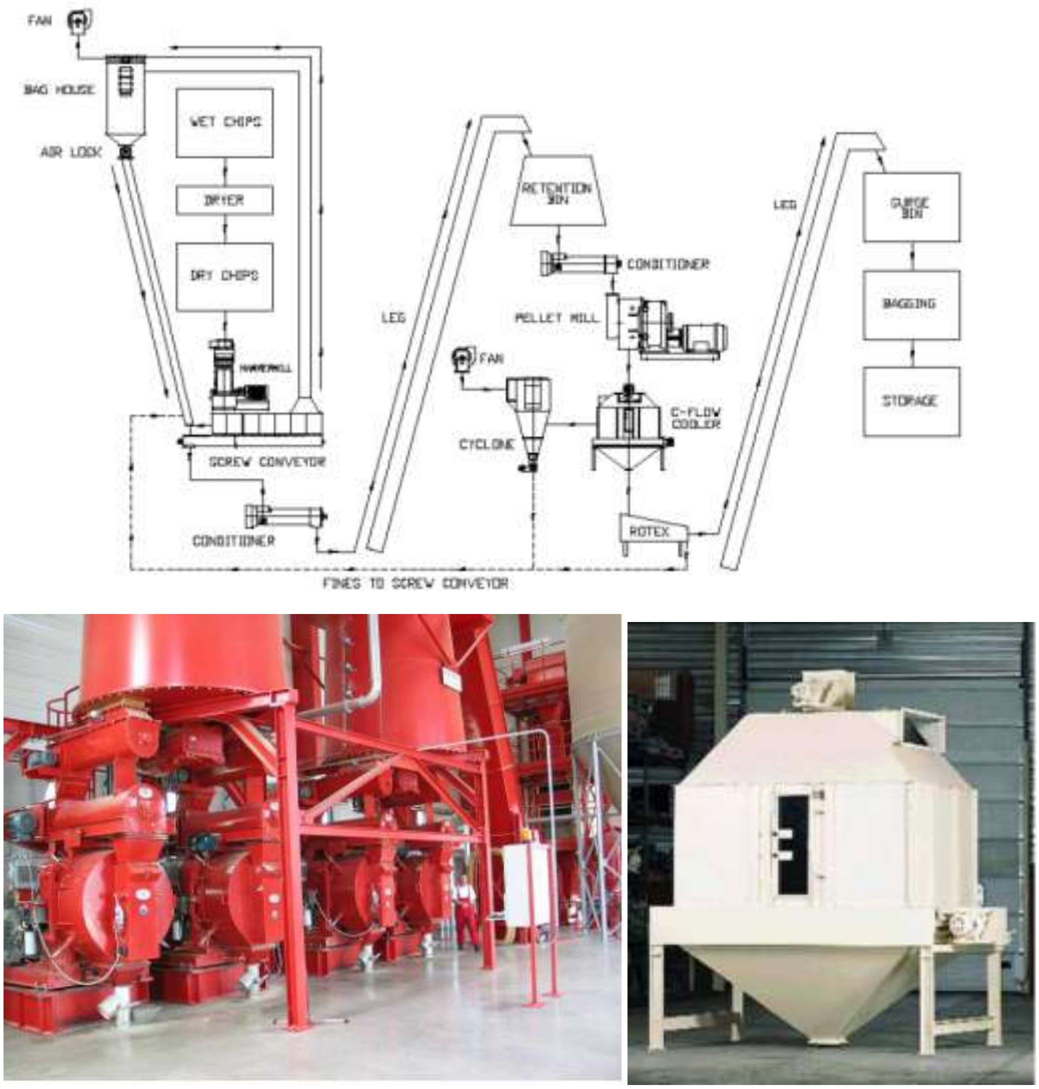
2) Milling - A hammer mill is often used to reduce the size of the feedstock if wood chips or other large inputs are used. Several types of conditioning may then be applied, e.g. steam conditioning to soften the lignin that binds the cellulose together to facilitate pellet formation during extrusion. Binding agents may be used to minimize breakage during transport. Some additives may improve chemical characteristics.

3) Pressing - The resulting mix is extruded through dies and the emerging ribbons are cut to desired lengths. Figure 2 below shows a bank of pellet mills.

4) Cooling - The hot pellets are cooled in a counter-flow cooler to allow the lignin to reset and form a hardened, compact unit. Finally, because many existing pellet mills are small and produce for regional markets, the finished product is being bagged. The more relevant case would be shipping in bulk to market. Figure 2 shows a pellet dryer.

[8] http://en.wikipedia.org/wiki/Pellet_fuel

Figure 2 - Pellet Manufacturing Process (top); Pellet Mills (lower left); Pellet Dryer (bottom right)[9]



1.2 North Carolina Wood Pellet Production

North Carolina's 2013 operational and proposed capacity is over 600,000 tonnes/yr (in 2009, the entire South's installed capacity was just over 700,000 tonnes/yr). The total capacity of North Carolina and our coastal neighbors (VA, SC, and GA) is nearly 4 million tonnes/yr (Table 1).

[9] CPM Roskamp Champiuon

Table 1 - Commercial Scale Wood Pellet Plants in Georgia, North Carolina, and Virginia

(See Appendix 3 for a complete list of US Pellet Manufacturers)

Company	Plant	State	Woody Feedstock	Capacity (tonnes/yr)	Status
First Georgia BioEnergy	First Georgia BioEnergy	GA	Soft	374,785	PROPOSED
Fram Renewable Fuels LLC	Appling County Pellets LLC	GA	Hard and Soft	220,460	OPERATIONAL
Fulghum Fibres Inc	Fulghum Fibres Inc	GA	Hard and Soft	200,000	CONSTRUCTION
Georgia Biomass	Georgia Biomass	GA	Undisclosed	827,000	OPERATIONAL
SEGA Biofuels LLC	SEGA Biofuels LLC	GA	Soft	100,000	PROPOSED
Varn Wood Products	Varn Wood Products	GA	Soft	80,000	CONSTRUCTION
Woodlands Resources	Woodlands Resources	GA	Hard and Soft	165,300	PROPOSED
Enviva LP	Enviva Pellets Northampton	NC	Hard and Soft	402,000	OPERATIONAL
Enviva LP	Enviva Pellets Ahoskie	NC	Hard and Soft	99,000	OPERATIONAL
Nature's Earth Pellet Energy LLC.	Nature's Earth Pellets NC	NC	Soft	75,000	OPERATIONAL
Riverside Pellets LLC	Riverside Pellets LLC	NC	Hard and Soft	50,000	PROPOSED
Equustock Wood Fibers LLC	Equustock - Troy	VA	Hard and Soft	36,000	OPERATIONAL
American Wood Fibers	American Wood Fibers - Marion	VA	Hard and Soft	75,000	OPERATIONAL
Ensign-Bickford Renewable Energies	Biomass Energy LLC	VA	Hard and Soft	110,000	OPERATIONAL
Enviva LP	Enviva Pellets Southampton	VA	Hard and Soft	551,000	PROPOSED
Equustock Wood Fibers LLC	Equustock - Chester	VA	Hard and Soft	5,000	OPERATIONAL
Franklin Pellets	Franklin Pellets	VA	Hard and Soft	500,000	PROPOSED
Lignetics	Lignetics of Virgina Inc.	VA	Soft	Undisclosed	OPERATIONAL
O'Malley Wood Pellets	O'Malley Wood Pellets	VA	Hard	85,000	OPERATIONAL
Potomac Supply Corp.	Potomac Supply Corp.	VA	Soft	Undisclosed	OPERATIONAL
Turman Hardwood Pellets	Turman Hardwood Pellets	VA	Hard	25,000	OPERATIONAL

2. Public Policy Drives Demand

Much of the increase in biomass pellet demand worldwide is driven by policy to increase use of renewable energy and reduce carbon emissions, primarily in Europe. These policies come in the form of mandates, regulations and incentives. As in the case of the EU with their member countries, overall guidelines exist at the federal and state level. Furthermore, most policies are related to the broader renewable energy or carbon reduction goal with carve outs for biomass/woody biomass.

2.1 European Public Policy Drivers and Demand

The European Union is the largest market for wood pellets in the world. Consumption of wood pellets in the EU was 85% of global wood pellet demand at 11.4 million tonnes. This represents a 43.5% increase from 2008 to 2010. In addition, at 9.2 million tonnes, EU production was 61% of overall global production[1]. For these reasons, it is important to examine policy in Europe as a basis for understanding what is driving their contributions to production and consumption. Table 2 below outlines policies that pertain to use of biomass in the EU and Table 3 evaluates the specific policy actions from the top importers of US biomass pellets.

The EU set legally binding renewable energy goals in its Directive 2009/28/EC, including targets for each individual member state consistent with the EU's overall '20-20-20' goal and mandates for each state to create national renewable energy action plans outlining their goals. The European Commission (EC) has not created goals or supports for specific technologies, but rather has left individual nations to meet their energy and carbon reduction goals in the best way they see fit. The primary responsibility for formulating sustainability criteria and harmonization of these policies has also been left to member states.[10] The EU National Renewable Energy Action Plans' (NREAP) estimated electricity production from solid biomass to approximately double from 2010 – 2020, from approximately 77 TWh to 155 TWh.[11] In the EC's renewable energy progress report (March 27, 2013), the EC compared the biomass targets established in the national action plans against a conservative estimate of biomass utilization given existing policies, economic conditions and barriers. [12]

[10] See the European Commission's "Report from the Commission to the Council and the European Parliament on sustainability requirements for the use of solid and gaseous biomass sources in electricity, heating and cooling", February 2010.

[11] ECN, "Renewable Energy Projections as Published in the National Renewable Energy Action Plans of the European Member States, Summary Report", November 2011, p. 14.

[12] European Commission, Renewable energy progress report, March 27, 2013.

Table 2 - Relevant European Union-Wide Policies

Date	Policy	Things of note
2005	Biomass Action Plan	• Aim to increase biomass use to around 150 million ton by 2010.
2009	Renewable Energy Directive	• Outlines a mandate for all member states to reach three targets by 2020: 20% total energy consumption from renewable energy sources, 20% reduction in energy consumption, and 20% reduction in GHG emissions. • As part of this legislation, each member state is required to complete a National Renewable Energy Action Plan to outline their individual strategy for meeting the goals, including total production and consumption estimates for biomass.
2010/2011	Report COM	• Considered additional sustainability requirements for solid and gaseous biomass needed in electricity, heating and cooling. The Commission considered three factors when looking at EU-wide sustainability criteria: (1) the effectiveness of dealing with sustainability issues associated with biomass use, (2) cost-efficiency in meeting the EU objectives, and (3) consistency with existing policies (European Commission 2010b).

Table 3 - Country Specific Policies

Country	Date/Policy or Document	Things of Note
Netherlands	2002, Milieukwaliteit ElectriciteitsProductie (MEP) [13]	Feed-in premium provided by the national government, 6 - 7 €ct per kWh electricity produced from woody biomass After 2006, no new projects were allowed to apply for the feed-in premium
	SDE and SDE+	Successor of MEP Excluded large-scale power plants for financial support and focused on smaller scale electricity production (co-)fired by solid, liquid or gaseous bioenergy. Will continue until 2012-2014
	2011, Dutch Energy Report	Netherlands government announced intentions to mandate biomass co-firing at all coal-fired power stations
United Kingdom	2002, Renewable Obligation	The RO requires licensed UK electricity suppliers to source a specified proportion of the electricity they provide to customers from eligible renewable sources. This proportion (known as the 'obligation') is set each year and has increased annually. The process consists of a Renewables Obligation Certificate (ROC) market, whereby the level of annual renewable obligation by suppliers is established the year before it goes into effect.
	Climate Change Act, 2050 Carbon Reduction Target, 2008	Established the 2050 Carbon Reduction Target, aiming to reduce greenhouse gas emissions by at least 80 percent by 2050 and a reduction of emissions by at least 34% by 2020. (against a 2009 baseline).[14]
	2020 Renewables Target (in conjunction with the EU RED), 2009	The 2009 Renewable Energy Directive sets a target for the UK to achieve 15% of its energy consumption from renewable sources by 2020. This compares to 3.3% in 2010. In 2010, biomass sources accounted for 46% of

[13] Global Wood Pellet Industry Market and Trade Study. IEA Bioenergy. 2011. Maurizio Cocchi et al.
[14] UK Bioenergy Strategy. 2012 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/48337/5142-bioenergy-strategy-.pdf

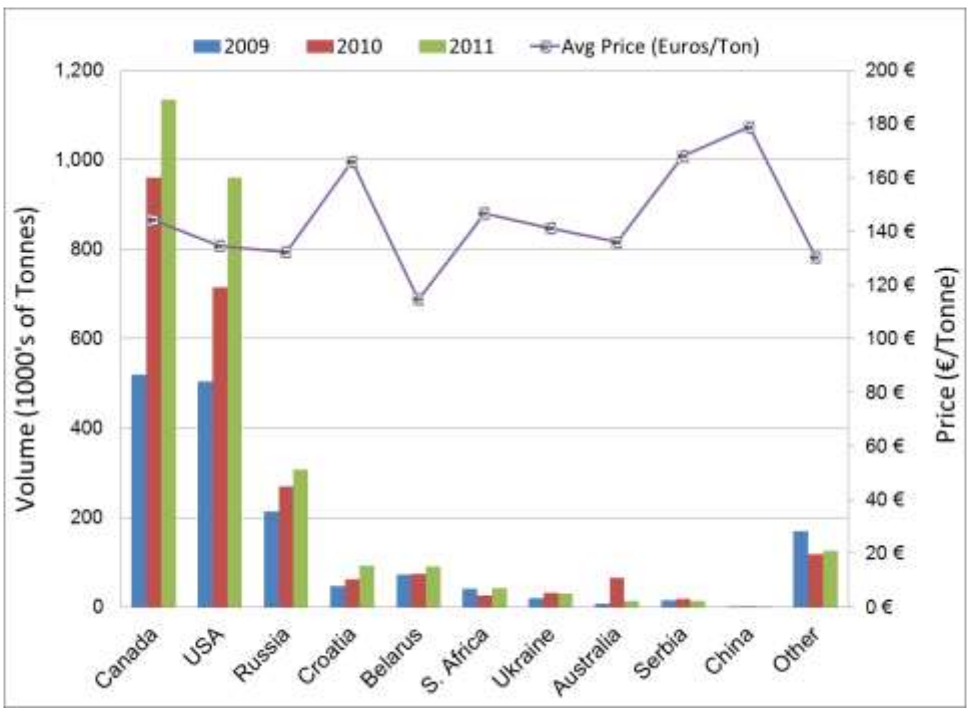
		renewable electricity generation in the UK, a third of which was from landfill gas.[15]
	Feed In Tariff/Export Tariff, 2010[16]	Relevant for distributed generation scenarios, the incentive consists of payments for every kWh of electricity generated, depending of the size, technology and installation date. In addition, small electricity generators receive a payment for the surplus electricity sold to the grid, "paid over and above the generation tariff, either at a guaranteed flat rate of 4.2p/kWh or 3p/kWh (depending on application date) or at the open market value.[17]
	Electricity Market Reform, 2012	Inherent to the EMR are Contracts for Difference. CfD's are a type of derivative contract that will stimulate investment in low-carbon technologies. Low-carbon generation with a CfD will sell their electricity into the market in the normal way, and remain active participants in the wholesale electricity market. The CfD is a long term, private law contract that pays the generator the difference between an estimate of the market price for electricity (the 'reference price') and an estimate of the long term price needed to bring forward investment in a given technology (the 'strike price'). This removes generators' long term exposure to electricity price volatility, secures cash flows, and reduces risk for the generators. [18]
	UK Biomass Strategy, 2012	Released in April 2012 by DECC, DfT and Defra, the strategy outlines a framework for the use of bioenergy in the UK in 2020 and up to 2050. It is based on four principles that will guide policies. The principles outline a goal to deliver genuine carbon reductions in the most cost-effective way, while avoiding adverse effects on the

[15] Bioenergy. UK Houses of Parliament Parliamentary Office of Science and Technology. 2012.
[16] Global Wood Pellet Industry Market and Trade Study. IEA Bioenergy. 2011. Maurizio Cocchi et al.
[17] https://www.gov.uk/feed-in-tariffs/overview
[18] Department of Energy and Climate Change Annex A. Feed-in Tariffs with Contracts for Difference. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/66554/7077-electricity-market-reform-annex-a.pdf Department of Energy and Climate Change Annex A. Feed-in Tariffs with Contracts for Difference.

		wider economy. Without hard and fast targets, this principles-based system is meant to evolve with new information and technology. To this end, it advocates periodic revisions to bioenergy policy at regular 5-yearly intervals. [19]
Belgium	Green Energy & Electricity Certificate Schemes	Similar to the overall REC system in Europe, in Belgium it is largely satisfied by pellet imports The guaranteed minimum value of a certificate is based on a 'financial gap' analysis, which identifies the extra cost in production with reference to the use of fossil fuel. The guaranteed value for biomass was 80 €/GEC and as of 2010 it is 90 €/GEC.[20]

Examination of European imports reveals that Canada, the US and Russia together account for 85% of the total imports to Europe, totaling 2.4 million tonnes (Figure 3).

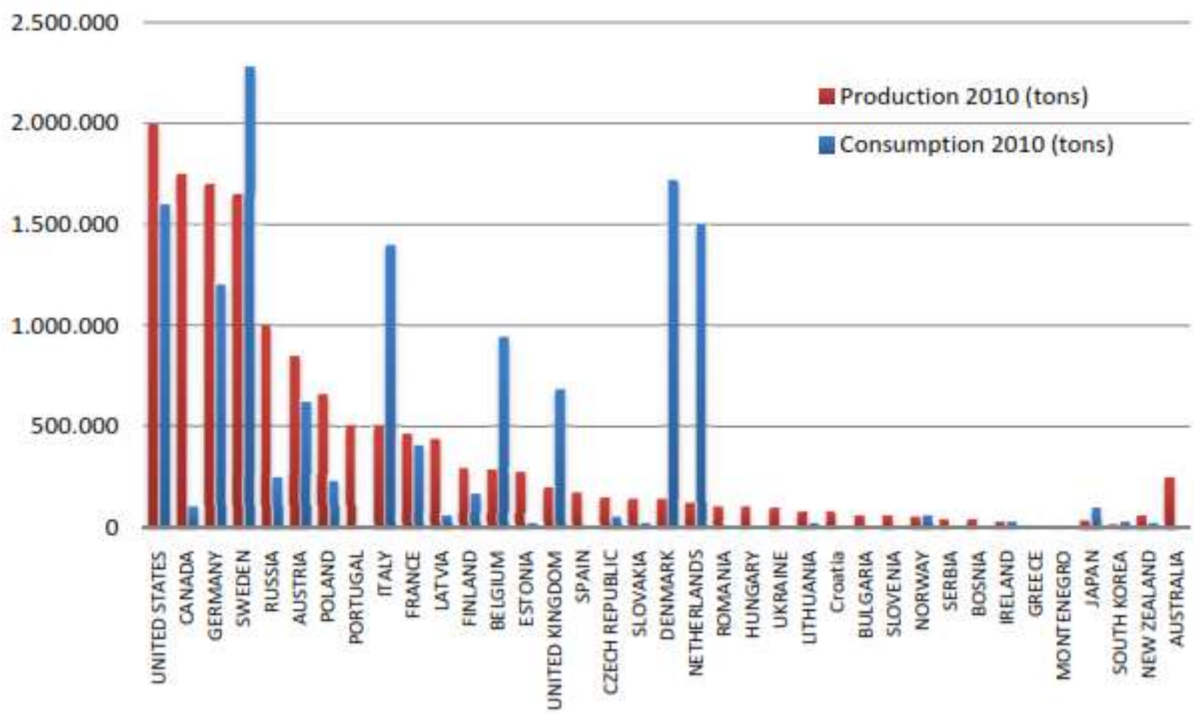
Figure 3 - Wood Pellet Exports to EU[21]



[19] Bioenergy. UK Houses of Parliament Parliamentary Office of Science and Technology. 2012.
[20] Global Wood Pellet Industry Market and Trade Study. IEA Bioenergy. 2011. Maurizio Cocchi et al.
[21] Extracted from Eurostat

Of these three, the United States is the only one that consumes more domestically than they export. One might expect an even higher Russian contribution to European pellet consumption considering proximity and forest reserves (808,900,000 hectares of forest area, more than the combined forest area in Brazil and Canada and 20.5% of the total forest area found across the globe[22]). However, transportation and logistics issues have made it difficult for Russia to reach higher numbers. These issues may be quelled with the construction of the 1 million tonne plant, Vyborgskaya Cellulose, located in northwest Russia, near the border with Finland[23]. Demand for pellets (both heating and electricity) exceeds production in many countries, most notably Denmark, The Netherlands, Italy, Sweden, Belgium, and the UK (Figure 4).

Figure 4 - Wood Pellet Production and Consumption by Country in 2010 [24]



The 2010 US production surplus is comparable to Poland and Portugal, surpasssed by Russia, and dwarfed by Canada. Since 2010, US production capacity has grown tremendously. As noted earlier, The Netherlands, United Kingdom, and Belgium are the primary international consumers of US wood pellets. Figure 5 shows shares of residential, commercial and industrial uses of wood pellets in EU27 countries. A comparison with production and consumption in

[22] http://www.tradingeconomics.com/russia/forest-area-percent-of-land-area-wb-data.html

[23] The Development of the pellet production and trade in Russia 2012. Dr. Olga Rakitova, The National Bioenergy Union

[24] Global Wood Pellet Industry Market and Trade Study. IEA Bioenergy. 2011. Maurizio Cocchi et al.

Figure 4 reveals the production deficit for countries where wood pellets are primarily used in industrial sector, i.e. large scale power plants use biomass in co-firing. Some of the large scale buyers in Europe are Dong Energy, Drax Group, Electrabel - GDF SUEZ Group, E.ON Energy, Fortum, RWE, and Vattenfall.

Figure 5 - Shares of Residential, Commercial and Industrial in 2010[25]

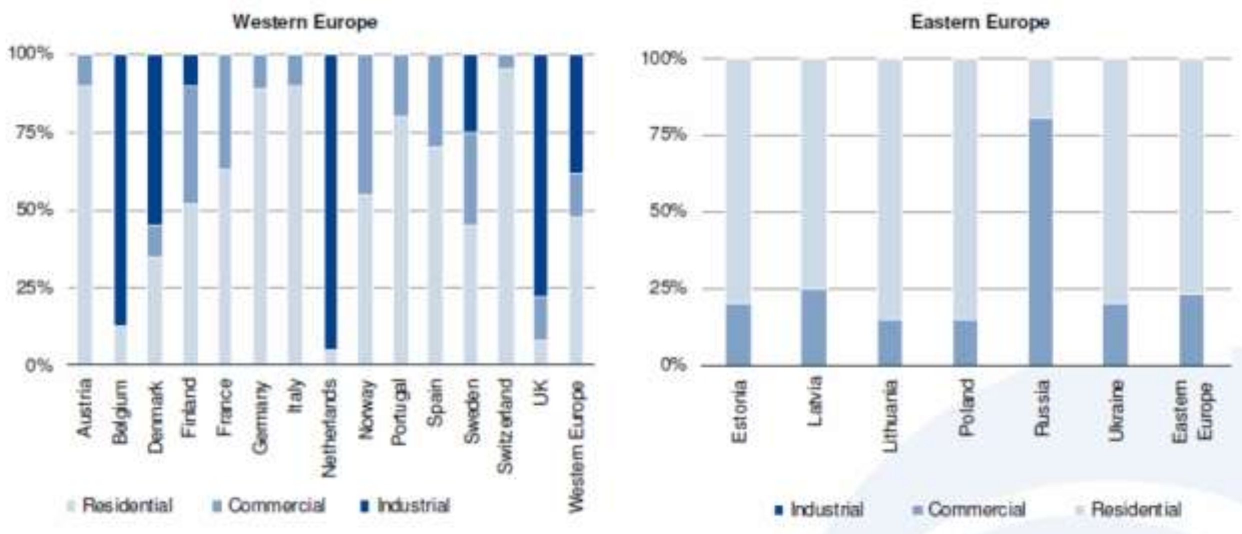
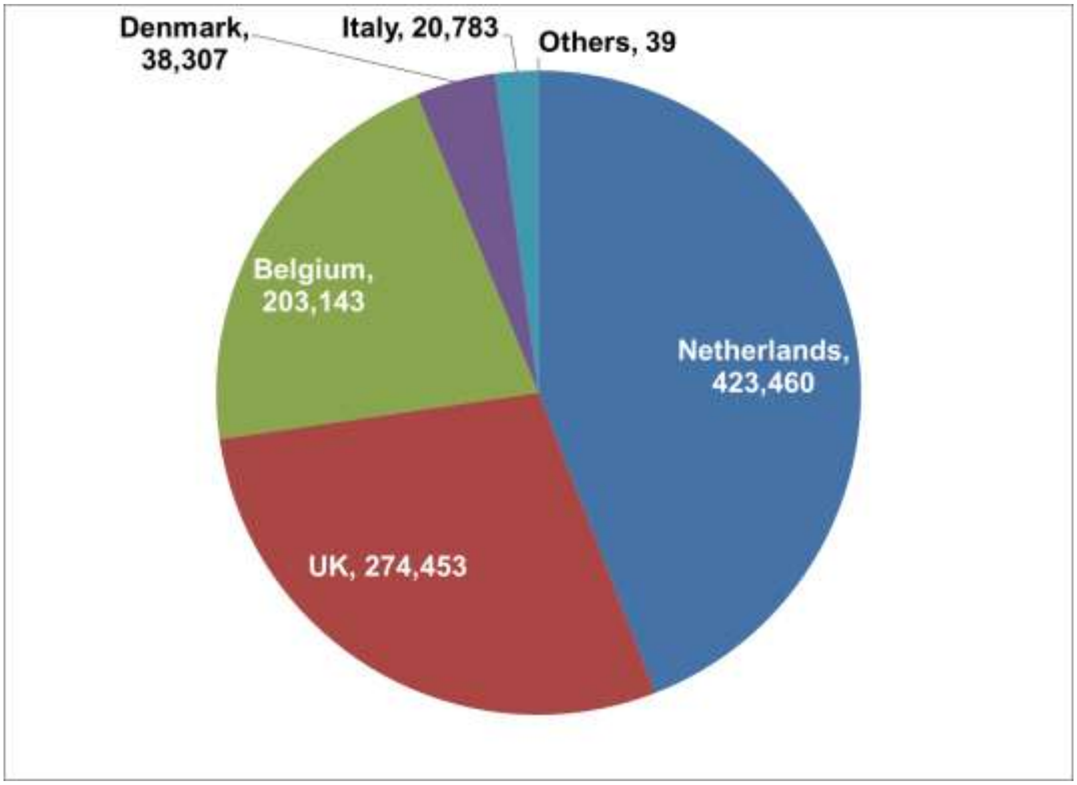


Figure 6 below shows the European importing countries of US wood pellets. The Netherlands, the United Kingdom and Belgium account for 94% of all US exports to Europe. Below we report available data on the top markets for US wood pellets: The Netherlands, UK, Belgium, Denmark, and Italy, see Appendix 4 for complete EU market data. Sweden is also shown because of the completeness of available data.

[25] Industrial Wood Pellets Report, Laborelec - GDF SUEZ, 2012
http://www.enplus-pellets.eu/wp-content/uploads/2012/04/Industrial-pellets-report_PellCert_2012_secured.pdf

Figure 6 - 2011 US Wood Pellet Exports to Europe (tonnes)[26]



2.1.1 – United Kingdom Policy and Demand

The primary regulation currently incentivizing power generation from biomass is the UK's Renewable Obligation (RO).[27] Electricity generators receive a pre-determined number of Renewable Obligation Certificates (ROCs) per unit of electricity produced. These credits can then be traded and the electricity is sold on the wholesale market. Electricity suppliers are required to buy a number of ROCs for every MWh of electricity supplied to consumers, The price of a ROC as of the end of May 2013 was 44.19 pounds/ROC, with the price generally ranging from 40-50 pounds/ROC over the last decade.[28] The number of ROCs/MWh is based on the fuel and technology used. The number of ROCs issued per unit produced has been periodically updated during Renewable Obligation Banding reviews, and the most recent assessment for the period 2013-2017 will be effective for new generation coming online this year through 2017.[29] ROCs are awarded in different proportion to biomass production technologies including co-firing, conversion of existing plants to biomass combustion, dedicated

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[26] Extracted from Eurostat, www.eurostat.eu
[27] Bioenergy May 2012, p. 2
[28] Price data from e-ROC, an ROC auction platform. http://www.e-roc.co.uk/trackrecord.htm
[29] See the number of ROCs issued by technology by year at: https://www.gov.uk/calculating-renewable-obligation-certificates-rocs

biomass production.[30] Table 4 shows the number of ROCs to be awarded to select technologies, e.g. co-firing provides fewer ROCs/MWh than dedicated biomass or solar. Approval for a given generation facility is valid for 20 years.

Table 4 - ROC Support for Select Technologies by Accreditation Year in the UK[31]

Band	Current	13/14	14/15	15/16	16/17
Co-firing (low- range)	0.5	0.3	0.3	0.5	0.5
Co-firing (mid- range)	new band	0.6	0.6	0.6	0.6
Co-firing (high- range)	new band	0.7	0.9	0.9	0.9
Conversion (station or unit)	new band	1	1	1	1
Conversions (station or unit) with CHP	new band	1.5	1.5	band closed	
Dedicated biomass	1.5	1.5	1.5	1.5	1.4
Dedicated biomass with CHP	2	2	2	band closed	
Onshore wind	1	0.9	0.9	0.9	0.9
Offshore wind	2	2	2	1.9	1.8
Building mounted solar PV	new band	1.7	1.6	1.5	1.4

At the end of every annual obligation period, electricity suppliers must present a minimum number of ROCs for every MWh of electricity supplied. The renewable obligation is determined annually as the higher of either a predetermined annual target (specified in the 2009 Renewables Obligation Order) or predicted generation of ROCs in the subsequent year plus 10%.[32] This "headroom" calculation is designed to stabilize the price of the ROCs and ensure that supply of ROCs does not exceed demand by the electricity suppliers. In the 2012/13 year, the predetermined annual target was 0.124 ROCs/MWh supplied whereas the headroom calculation of predicted generation from renewable sources with headroom was 0.158ROCs/MWh, so therefore the headroom calculation resulted in 49.6 million ROCs issued for the year.

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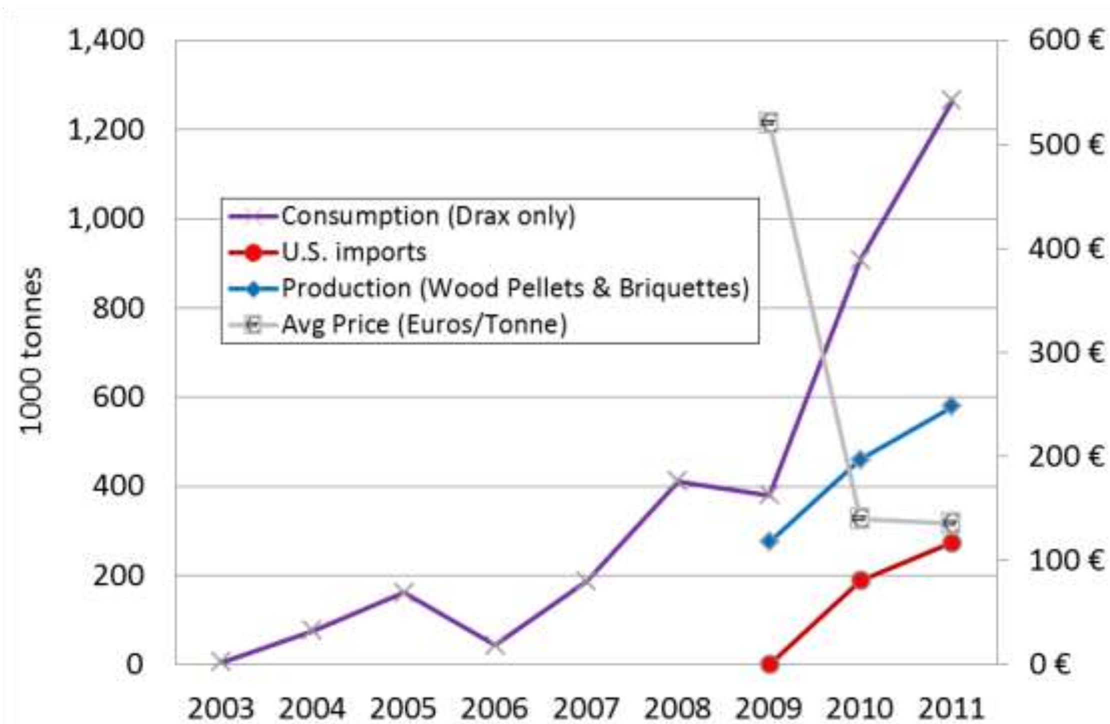
[30] https://www.gov.uk/calculating-renewable-obligation-certificates-rocs. DECC notes in the 2013-2017 banding review that it maintains cautious support for dedicated biomass facilities, and proposes limiting the number of ROCs that suppliers may source from dedicated biomass facilities accredited after March 2013. UK DECC, "Government Response to the consultation on proposals for the levels of banded support under the Renewables Obligation for the period 2013-17 and the Renewables Obligation Order 2012", July 2012, p. 11.

[31] https://www.gov.uk/calculating-renewable-obligation-certificates-rocs

[32] The predetermined annual target specified in the 2009 Renewables Obligation Order rises to .154 ROCs/MWh in the 2015/16 period and remains constant thereafter. 2009 no. 785 – Electricity, England and Wales. The Renewables Obligation Order 2009. March 24, 2009. Schedule 1 Calculation of the ROC Obligation. UK National Renewable Energy Action Plan, p. 109.

The main driver of growth in demand for wood pellets is co-firing at power plants; however, most data on specific purchase agreements is confidential. The single largest consumer of biomass in UK is Drax power plant.[33] Drax Environmental Performance Review 2011 gives below figures for historical biomass, although not necessarily wood pellets, consumption. As such, available statistics for both the UK and Drax are shown in
Figure 7.

Figure 7 - UK pellet Production, Drax Consumption, US Imports, and Price (2003-2011) [34]



The ROC system is being phased-out and replaced by the Contracts for Difference (CfD) system, with new generation coming online between 2014-2017 having the option to elect between the RO or CfD system, and all new generation after 2017 corresponding to the CfD system. Under the CfD system, low-carbon generators will receive contracts ensuring minimum payments based on technology, and the CfD contract will reimburse the generator the difference between

[33] Several attempts were made to contact Drax, Enviva, and other producers and buyers of industrial wood pellets. Conversations never led to hard numbers.
[34] Extracted from Eurostat; UK Forestry Commission survey
http://www.forestry.gov.uk/pdf/trprod11.pdf/$file/trprod11.pdf and
http://www.forestry.gov.uk/pdf/trprod12.pdf/$file/trprod12.pdf;
http://www.draxgroup.plc.uk/files/page/916/Annual_performance_Report_2011_FINAL.pdf

the wholesale rate and the guaranteed rate (strike price). The strike prices will be set through a governmental review process, and the initial strike prices are expected to be published by the end of 2013.[35]

The UK's recently implemented carbon price supports, made effective April 1, 2013, will substantially increase the cost of power generation from coal and other fossil fuels by setting a price floor on carbon emissions. Whereas prices of carbon emissions within the EU's Emissions Trading System are expected to remain at approximately 3-4 Euros/Tonne for several years, the cost of carbon emissions in the UK for fossil-fuel based power generation will increase to approximately 18.08 pounds / tonne CO2 in 2015-16.[36]

2.1.2 – The Netherlands Policy and Demand

The Netherlands' primary method to incentivize renewable energy is the SDE+ scheme. The SDE+ contributes a predetermined value per MWh produced to renewable energy generators. The government's contribution under the scheme differs based on technology and size. The SDE+ awards are granted to specific projects in five phases in which each phase has increasing contribution, such that lower cost projects of a specific technology may apply in an earlier phase and more costly projects apply in later phases. The grants are awarded on a first-come first-serve basis, and historically the bulk of funding has gone to projects registered during the first phase.[37] Within biomass categories, the SDE+ scheme is targeted to small and medium-sized generators, and biomass sources will only receive support under the SDE+ scheme if predetermined sustainability requirements are met.[38] Biomass generation receives support under the SDE+ scheme for a 12-year period.[39] As a result of these policies, wood pellet consumption has steadily increased in The Netherlands since 2000. Figure 8 reveals that production has not kept pace with this consumption leading to a sharp and steady rise in pellet imports since 2005.

[35] Feed-in Tariff with Contracts for Difference: Draft Operational Framework, p. 12.

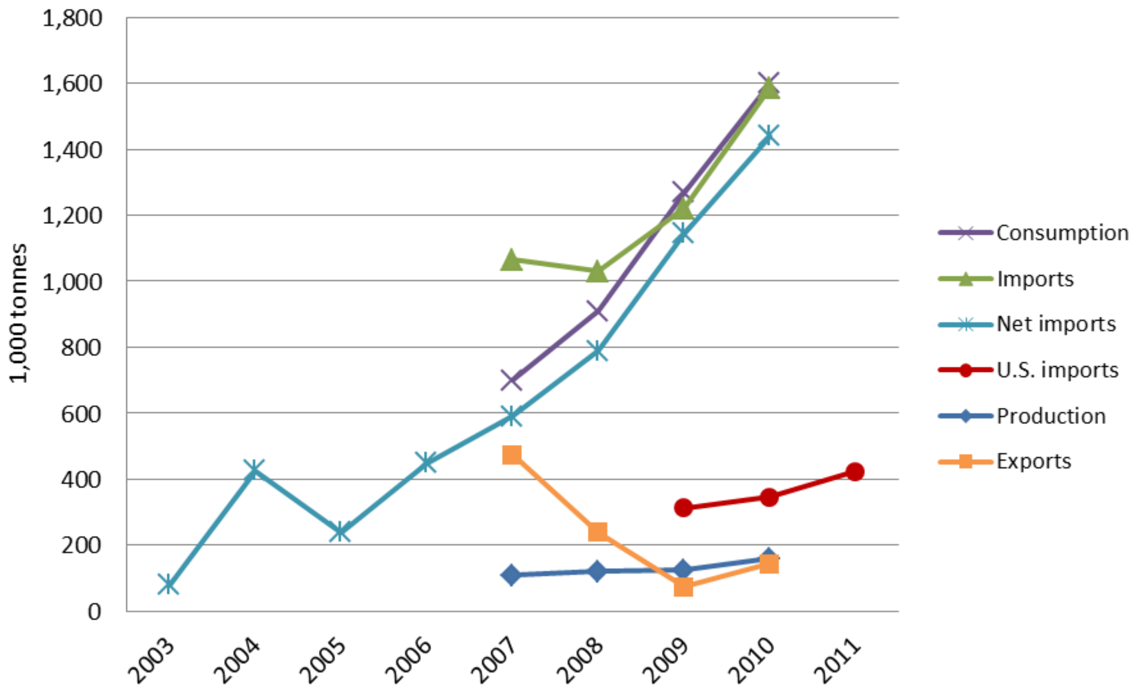
[36] Financial Times, "UK Businesses warn on emissions tax", March 31, 2013; HM Revenue & Customs, "Carbon price floor: rates from 2015-16, exemption for Northern Ireland and technical changes", available at http://www.hmrc.gov.uk/budget2013/tiin-1006.pdf

[37] Energy Delta Institute, "SDE+ Regulation in the Netherlands", http://www.energydelta.org/mainmenu/energy-knowledge/energy-transition-policy-and-legislation-2/sde-regulation-in-the-netherlands

[38] Criteria for Sustainable Biomass Production, http://www.globalproblems-globalsolutions-files.org/unf_website/PDF/criteria_sustainable_biomass_prod.pdf; Toetsingskader voor Duurzame Biomassa, http://www.agentschapnl.nl/sites/default/files/bijlagen/Cramer_toetsingskader_2007_NL.pdf; USDA Foreign Agricultural Service, "The Market for Wood Pellets in the Benelux", January 4, 2013.

[39] ECN – SDE+ advisory on rates for 2012, p. 13.

Figure 8 - Netherlands Pellet Production, Consumption, and Trade (2003-2011) [40]



Before 2007, co-firing of biomass in coal-fired generators and other renewable electricity production was supported by a feed-in premium (called MEP premium). The MEP premium was abolished in 2006; however, those subsidies are expiring over the next several years.[41] Unlike other renewables that are covered under the new SDE+, biomass co-firing will be mandated in all coal-fired power stations.[42] The government signed a "Green Deal" with the Dutch energy industry on October 3, 2011, in which the industry promised to continue co-firing 10% biomass in large-scale coal plants until 2015.[43]

The amount of biomass in co-firing post-2015 has not yet been determined, and some observers note that high requirements could harm the profitability of the plants and motivate the producers to shutdown the plants rather than comply.[44] The government is also considering

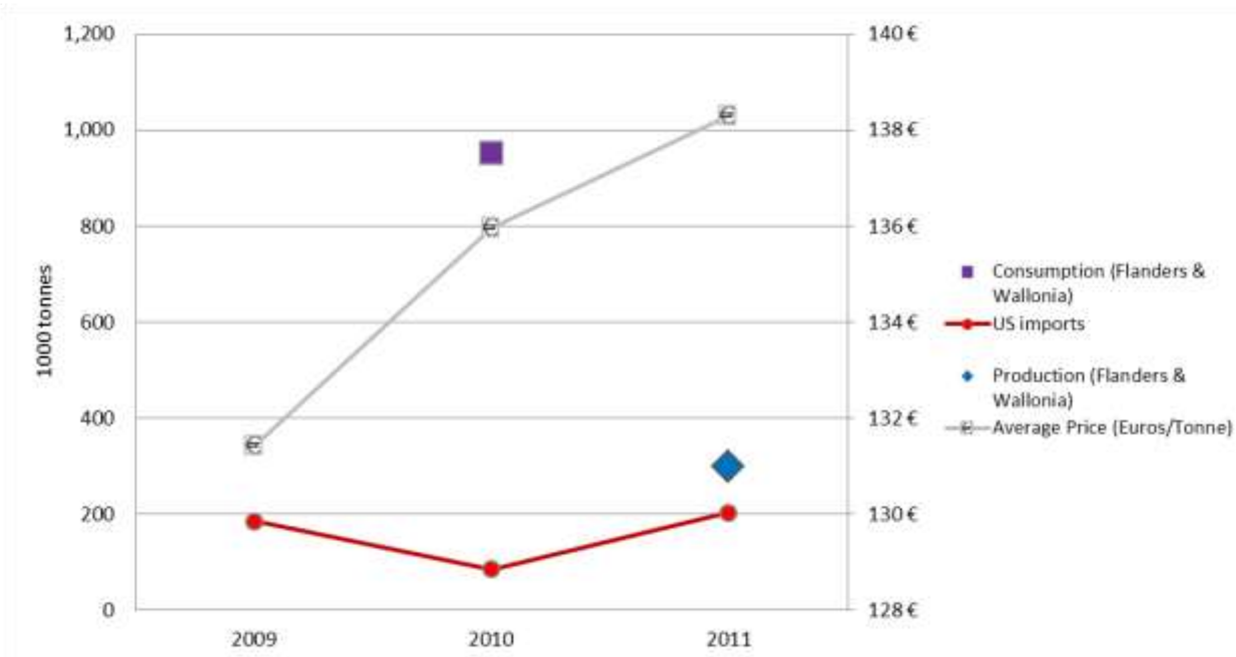
[40] Extracted from Eurostat; Global Wood Pellet Industry Market and Trade Study. IEA Bioenergy. 2011. Maurizio Cocchi et al.
[41] Energy Report 2011, p. 28.
[42] Energy Report 2011, p. 28.
[43] ECN, "Country Report the Netherlands", October 18, 2011. Available at http://www.ieatask33.org/app/webroot/files/file/2011/Netherlands.pdf
[44] ECN, "Dutch 16% renewable energy target requires additional offshore wind farms and additional deployment of biomass in coal-fired plants", November 1, 2012.

implementation of supplier obligations under which electricity suppliers must source a portion of their power supply from renewable sources.[45]

2.1.3 – Belgium Policy and Demand

Belgium incentivizes power generation from biomass through a Green Certificate Scheme (GEC), and Green Certificate schemes exist both on a national as well as a regional basis. Biomass is eligible for certificates under each of the regions, although the number of certificates per unit production varies based on factors including size and technology.[46] The minimum payment to be received by the producers is set by each region and ranges from approximately 65-90 euros/certificate.[47] Each region has pre-determined quotas of renewable energy production through at least 2020 to be achieved through the Green Certificate Scheme. Each region has a methodology to determine the number of certificates awarded to renewable energy producers based on technology, plant size, or carbon offset.

Figure 9 - Belgium pellet production, consumption, US imports, and price (2009-2011) [48]



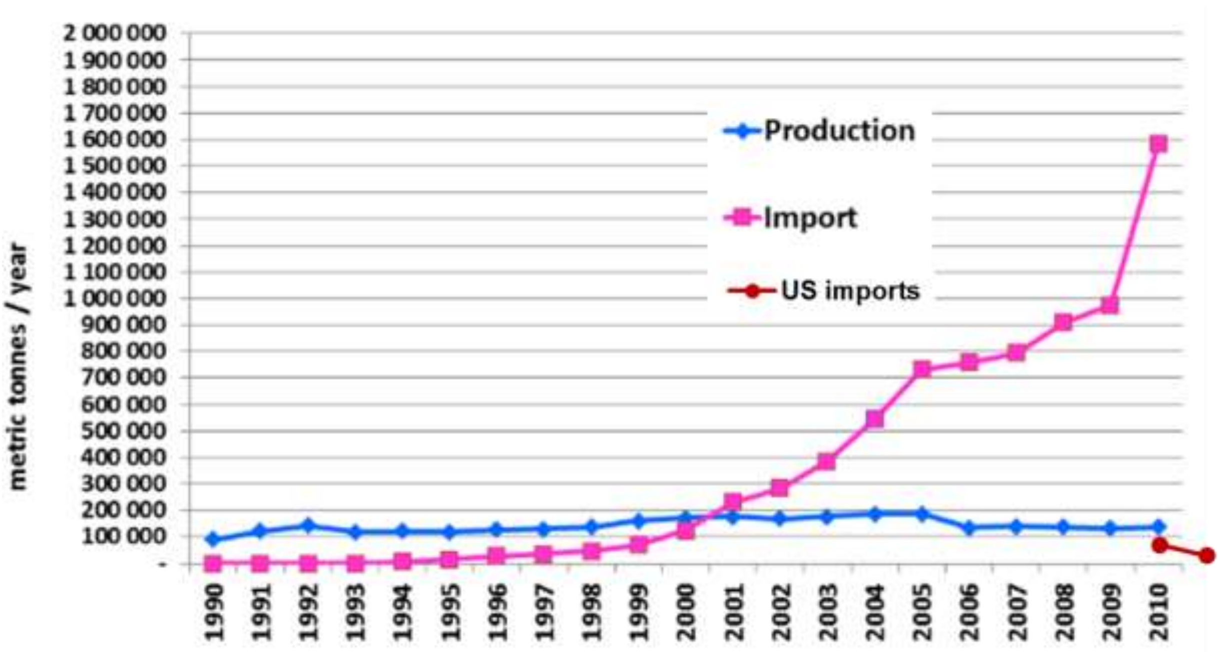
[45] Energy Report 2011, p. 28.
[46] http://www.res-legal.eu/search-by-country/belgium/tools-list/c/belgium/s/res-e/t/promotion/sum/108/lpid/107/
[47] http://www.res-legal.eu/search-by-country/belgium/tools-list/c/belgium/s/res-e/t/promotion/sum/108/lpid/107/
[48] Extracted from Eurostat; Global Wood Pellet Industry Market and Trade Study. IEA Bioenergy. 2011. Maurizio Cocchi et al.

Belgium is divided into three Regions, two of which, Flanders and Wallonia, are in turn subdivided into provinces; the third Region, Brussels, is atonymous[49]. Because of deep historical, linguistic, and political divides, most data is reported by region (Figure 9). Total consumption of wood pellets for Wallonia and Flanders in 2010 is 953,000 tonnes. Whereas estimated production for 2011 is 300,000 tonnes. Although, production capacity increased substantially between 2005 and 2009 the domestic pellet production in Belgium is not able to satisfy this huge demand. Imports are mostly from Canada, US and Germany. US exports to Belgium in 2010 were nearly 9% of total Belgian consumption.

2.1.4 – Denmark Policy and Demand

Denmark utilizes a feed-in premium to incentivize power generation from biomass. The Promotion of Renewable Energy Act (2009) established a feed-in premium for renewable energy generation, and this premium varies based on technology, size, and date of installation.

Figure 10 - Denmark Production and Imports (1990-2010)[50]



[49] Approximately 80% of wood pellet consumption in Belgium is industrial while the rest is residential, given that Brussels is the capital and is relatively small compared to Flanders and Wallonia, major industrial use of wood pellets is most likely concentrated in Flanders and Wallonia. Therefore, even if some residential customers are consuming or consumed wood pellets in the past (2010) total quantity should be relatively insignificant compared to whole consumption in Belgium.

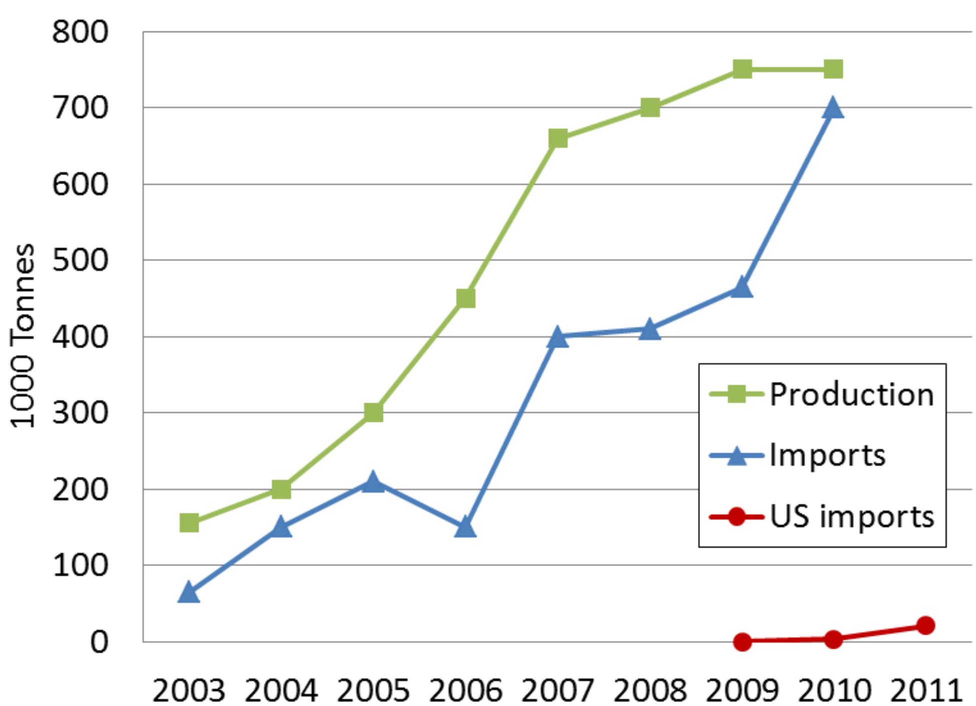
[50] Extracted from Eurostat; Global Wood Pellet Industry Market and Trade Study. IEA Bioenergy. 2011. Maurizio Cocchi et al.

Some premiums may be reduced when electricity prices are high such that the total compensation received by the producer does not exceed a pre-determined maximum. Power generation from biomass combustion is awarded a premium of .15 DKK /KWh, applicable to both dedicated and co-firing facilities.[51] Denmark expects that this incentive will increase use of biomass, and the incentive has no specified end-date.[52] Similar to The Netherlands, Danish consumption has risen steadily since ~2000, but production has not changed significantly (Figure 10). As a result, Denmark imports the bulk of it pellets, though the US comprised well below 1% of that consumption in 2010 and 2011.

2.1.5 Italian Demand

The increase in Italian production has kept pace with imports from 2003 to 2010 (Figure 11). Italy imports a small tonnage of wood pellets, but it appears to be on the rise given the possible trend from 2009-2011.

Figure 11 - Italian Pellet Production and Imports (2003-2011)[53]



[51] http://www.iea.org/dbtw-wpd/Textbase/pm/?mode=re&id=4425&action=detail

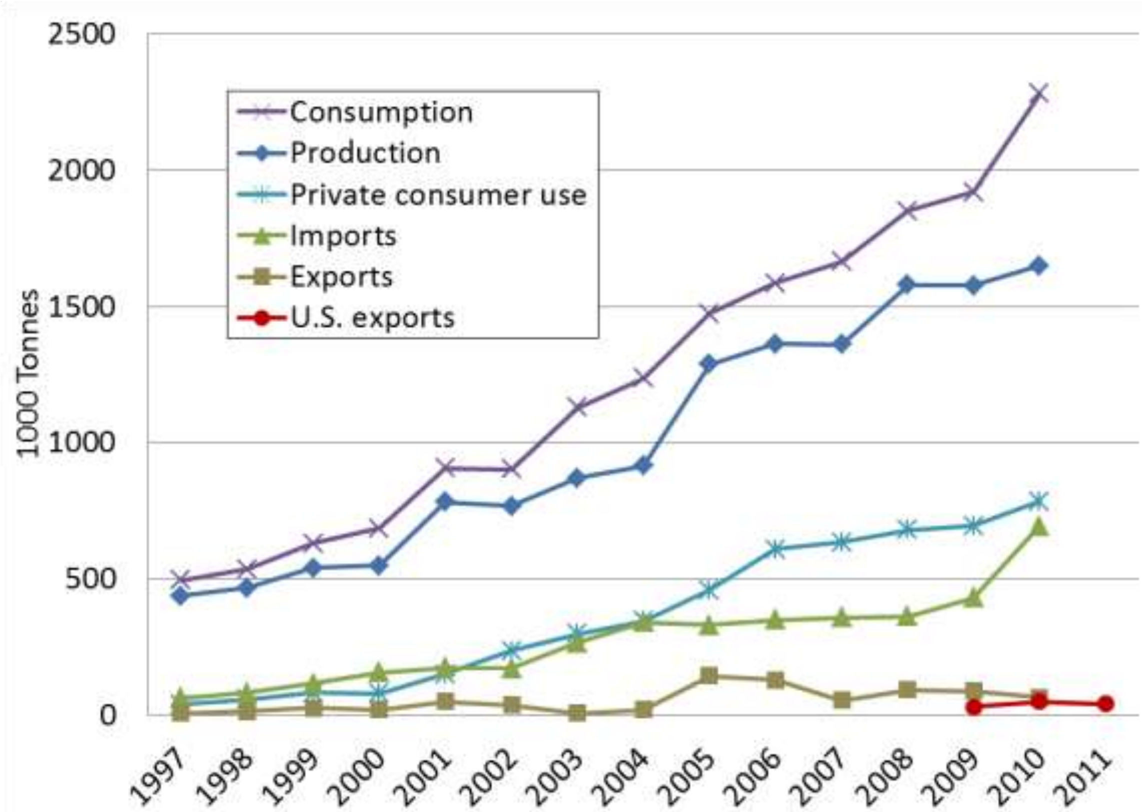
[52] Denmark National Renewable Energy Action Plan, p. 75.

[53] Extracted from Eurostat; Global Wood Pellet Industry Market and Trade Study. IEA Bioenergy. 2011. Maurizio Cocchi et al.

2.1.6 Swedish Demand

Similarly to Italy, Swedish production has kept pace with consumption which has meant that imports have not risen as sharply as in The Netherlands, UK, and Belgium, all of which have limited forest resources (Figure 12).

Figure 12 - Swedish Pellet Production, Consumption, and Trade (1997-2011)[54]



[54] Global Wood Pellet Industry Market and Trade Study. IEA Bioenergy. 2011. Maurizio Cocchi et al.

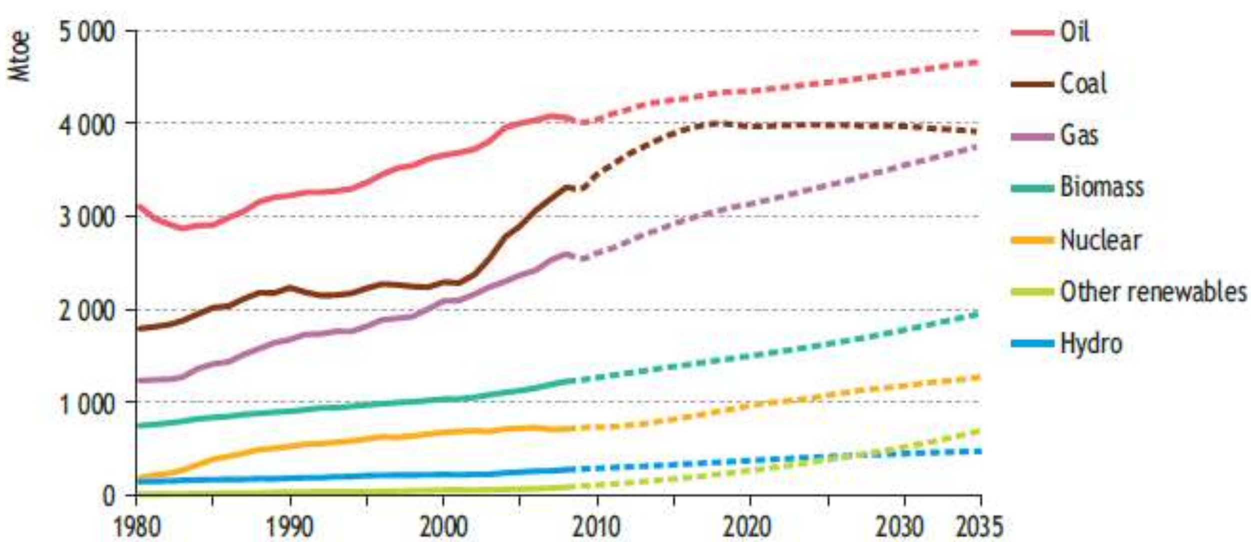
3. Future Biomass Demand

As a result of these policies, global consumption of wood pellets has more than doubled in the years 2006-2011. Growing demand also exists in Asian countries like China, Korea and Japan.

3.1 Future Global Energy Demand

The International Energy Agency (IEA) publishes annual World Energy Outlook report which includes projections and analysis on global energy use and demand. The IEA International Energy Agency uses three major scenarios: current policies, new policies, and 450. One can find further information on these scenarios on their reports. The "current policies" outlook is self-explanatory and includes all formally adopted and implemented policies. "New policies" is based on the future adoption of actual policies based on current policy commitments (plotted below in Figure 13). The "450 Scenario" is a theoretical prediction based on keeping atmospheric CO2 concentrations below 450ppm and restricting the average global temperature to a maximum of 2° C. Compared to 2008 levels, biomass consumption, which includes both liquid biofuels and wood pellets, is predicted to increase by at least 20% by 2020 and by greater than 40% by 2035.[24]

Figure 13 - World Primary Energy Demand[55]



As traditional uses of biomass (primarily wood fuel) continue to decline around the world, IEA predicts that the use of biomass-derived electricity, heat, and liquid biofuels will double or triple over the next twenty years. Global demand for wood pellets has risen consistently over

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[55] New policies scenario, World Energy Outlook 2010, Fig. 2.4, p84
http://www.worldenergyoutlook.org/media/weo2010.pdf

the last decade. Several studies projected demand for wood pellets depending on various factors.[56]

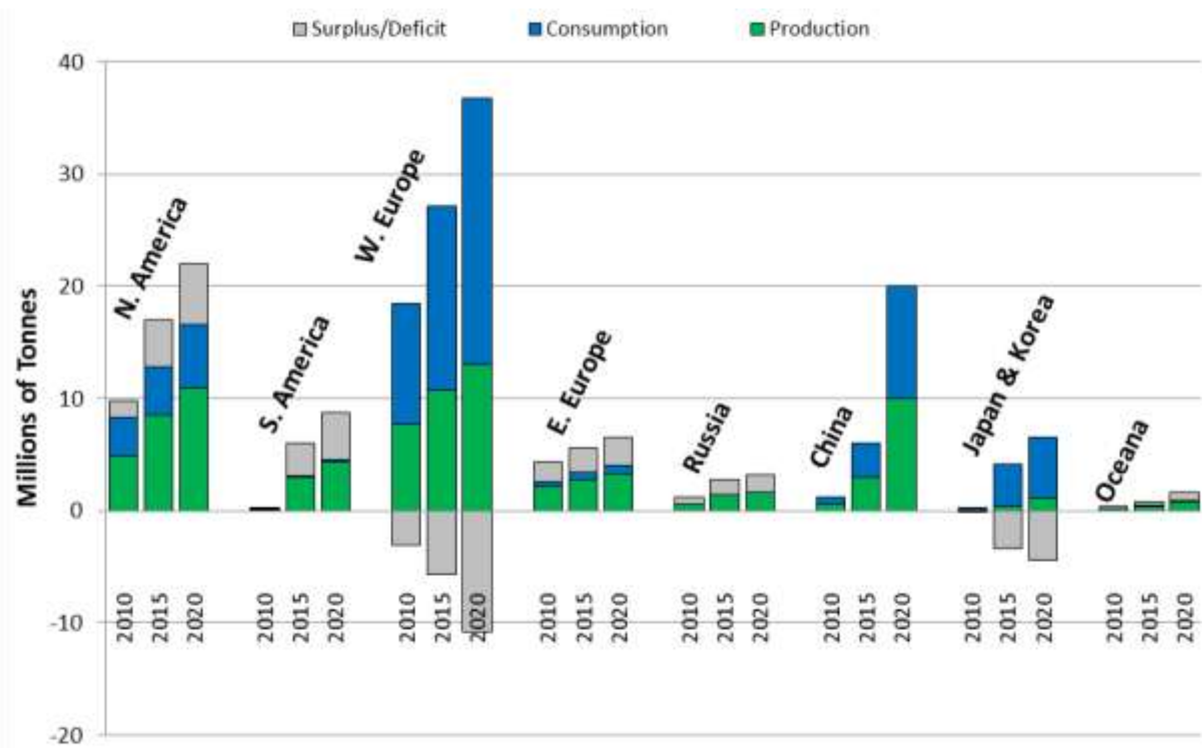
Generally, in these studies, demand is driven by EU renewable energy policies. To give an idea, Sikkema et al. estimate that the maximum technically obtainable wood pellet demand theoretically can reach up to 150 million tonnes by 2020, if 50% of all heating oil boilers are replaced by 2020, and assuming an EU-wide average co-firing rate of 10% in all coal power plants. IEA Bioenergy projects demand will be around 35 million tonnes in 2020 if 2011 consumption trends are extrapolated exponentially (as they have grown in the past).

3.2 Biomass Pellet Market Projections

3.2.1 European Market Projections

Historical production and trade data were presented in Section 2.2, above. In Figure 14, global production, consumption, surplus, and deficit projections out to 2020 are presented based on an analysis by Pöyry Management Consulting. Western Europe will remain as the largest wood pellet consumer, driven by increased share of biomass use in power generation.

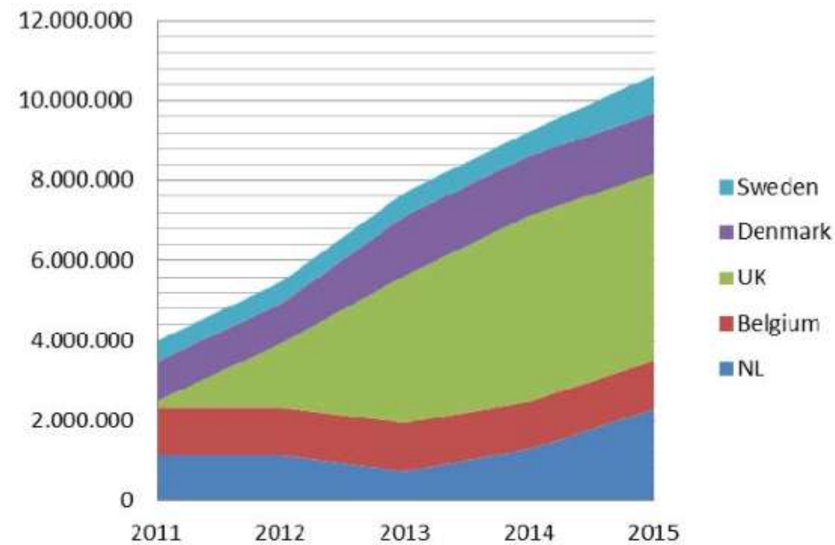
Figure 14 - Wood Pellet Production, Consumption, Surplus/Deficit (2010-2020)[57]



[56] Global Wood Pellet Industry Market and Trade Study. IEA Bioenergy. 2011. Maurizio Cocchi et al.
[57] Pöyry Management Consulting, http://www.poyry.co.uk/sites/www.poyry.co.uk/files/110.pdf

Although, total production cost of wood pellets may be lower or decrease in the future in other global locations, cost of transportation to Europe will remain as an issue for exporters. By 2008, the EU27 had made just over 50% progress towards their 2020 renewable energy consumption targets, while The Netherlands, UK, and Belgium had each made less than 25% progress.[58]

Figure 15 – Future Industrial Wood Pellet Demand in Northern Europe (tonnes)[59]



Although renewable energy resources include hydro energy, wind energy, biomass, geothermal energy, solar energy and others, opportunities to increase renewable energy consumption, in particular for base load power, are limited. In order to reach the 2020 renewable energy targets, EU countries will most likely increase biomass consumption in residential and commercial sectors as well. EU directives state that reducing greenhouse gas emissions and complying with the Kyoto Protocol are the main reasons for exploiting renewable sources; however, security of energy supply is listed important with other factors such as technological and regional development.[60,61] A more specific scenario devised by IEA Bioenergy Task 40

[58] Europe's Energy Portal, http://www.energy.eu/#renewable
[59] IEA Bioenergy. 2011. Maurizio Cocchi et al., Figure 5.2, page 141
[60] EUR-Lex http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32009L0028:EN:NOT
[61] First two parts of the directive "Directive 2009/28/EC": (1) The control of European energy consumption and the increased use of energy from renewable sources, together with energy savings and increased energy efficiency, constitute important parts of the package of measures needed to reduce greenhouse gas emissions and comply with the Kyoto Protocol to the United Nations Framework Convention on Climate Change, and with further Community and international greenhouse gas emission reduction commitments beyond 2012. Those factors also have an important part to play in promoting the security of energy supply, promoting technological development and innovation and providing opportunities for employment and regional development, especially in rural and isolated areas. (2) In particular, increasing technological improvements, incentives for the use and expansion of public transport, the use of energy efficiency technologies and the use of energy from renewable sources in

working group on the likely demand for industrial use of wood pellets in Northern Europe projects with 2011 expectations (including existing policies), total industrial demand is likely to increase from about 4 million tonnes in 2011 to a little over 10 million tonnes in 2015, Figure 15 below.

3.2.2 Chinese Market Projections

China is another location where substantial increase in wood pellet consumption is expected; however, in the near-term, feedstocks will primarily come from domestic resources with very limited effect on international biomass trade. China will meet its domestic demand with biomass pellets from domestic agricultural and processing residues such as rice husk[62]. China is not expected to become an important wood pellet producer due to a large raw material deficit.

3.2.3 Japanese Market Projections

Starting with past two oil crises in 1973 and 1979, Japan has been steadily promoting efforts to ensure a stable supply of imported resources while reducing the rate of dependency on external resources by increased use of nuclear energy. However, the Fukushima nuclear accident significantly increased opposition to nuclear power; this resulted in the Japan Energy and Environment Council considering reductions in dependency on nuclear energy. Table 5 represents Japanese government renewable energy objectives.

Table 5 - Japanese Renewable Electricity Targets (100 million kWh) [63]

	2010	2020	2030
Solar	38	352	666
Wind	43	169	663
Geothermal	26	75	219
Biomass, etc.	144	236	328
Ocean energy	0	0	30
Hydropower	809	1,012	1,095
Total	1,060	1,844	3,001

On September 19, 2012, a Japanese Cabinet Decision stated, "The Government of Japan will implement future policies on energy and the environment, taking into account 'the Innovative Strategy on Energy and the Environment' (the decision of the Energy and the Environment

transport are some of the most effective tools by which the Community can reduce its dependence on imported oil in the transport sector, in which the security of energy supply problem is most acute, and influence the fuel market for transport.

[62] Pöyry Management Consulting

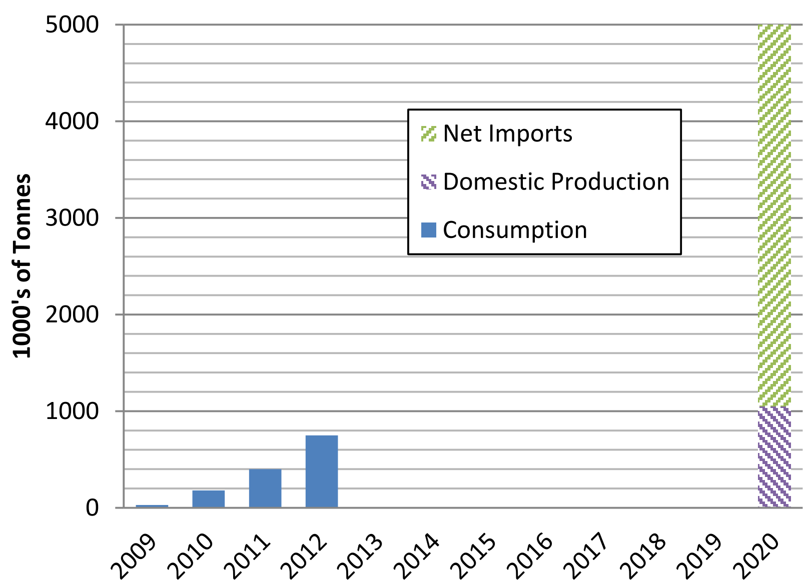
[63] Asia Biomass Office, http://www.asiabiomass.jp/english/topics/1212_03.html; Japan New Energy Foundation http://www.npu.go.jp/en/policy/policy06/index.html; http://www.env.go.jp/council/06earth/y060-111/ref05.pdf

Council on September 14th, 2012)". However, the information in Table 5, above, is not included in the original "the Innovative Strategy on Energy and the Environment" document. As such, current Japanese policy concerning biomass directives is unclear.

3.2.4 South Korean Market Projections

The South Korean Government has laid out a vision of "low carbon, green growth".[64] This vision intends sustainable economic growth by reducing energy and resource consumption besides minimizing CO2 emissions. The share of new and renewable energy in total primary energy is targeted to grow to 6.1% in 2020, and 11.5% in 2030 from 2.4% in 2007. While share of biomass was 6.0% of new and renewable energy in 2007, the country plans to raise it to 30.8% by 2030. Two percent of South Korea electrical power generation is mandated renewable with plans to increase to 10% in 2022.[65] It is unclear if South Korea has met its goal to begin construction on eight new pellet plants in 2010. Expectation of high demand and lack of sufficient local supplies may present an opportunity for wood pellet exporters (Figure 16). US wood pellet exports in 2009 were only a small fraction of total Korea imports.

Figure 16 - Korea Forest Service Wood Pellet Consumption Forecast[66]

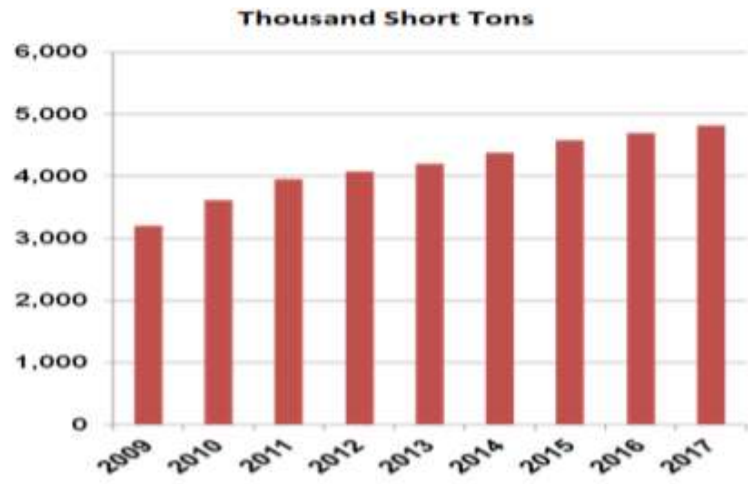


[64] http://www.asiabiomass.jp/english/topics/1107_04.html
[65] http://www.bloomberg.com/news/2011-12-21/s-korea-s-power-generators-pledge-to-raise-renewable-portfolios.html
[66] http://www.asiabiomass.jp/english/topics/1107_04.html; Joint Workshop: IEA Bioenergy T40 / ERIA, Tsukuba, Japan, 28-30 October 2009, Wood Pellet Production and Trade in South Korea http://www.bioenergytrade.org/downloads/tsukuba15hanwoodpelletproductionandtradeinsout.pdf

3.2.5 US Market Projections

In North America, most growth in wood pellet consumption will most likely be in the residential heating market as some consumers switch from heating oil to lower cost wood pellets, particularly where access to natural gas is restricted. [67]

Figure 17 - US Domestic Pellet Consumption (2009-2017) [68]



In general, however, affordable natural gas is likely to limit growth of wood pellet consumption in all sectors. The US EIA suggests that primary energy use in the residential sector will grow by an average of 0.2% per year until 2035.[69] While the EIA predicts a modest rise in consumption, there is a potential domestic market for wood pellets. Given the higher price/btu of heating oil compared to wood pellets, switching from heating oil boilers to wood pellets boilers may make sense for some of the 8 million US households that used heating oil in 2009, approximately 80% of which were located in the Northeast.[70] In 2010, approximately 3.3 billion gallons of heating oil were sold to residential consumers in the Northeast. Assuming comparable boiler efficiencies (around 78%) a metric tonne of wood pellet (16.5 GJ/metric tonne = 15.6 MBtu/metric ton) may replace approximately 113 gallons of (138.7 MBtu/gallon) fuel oil No. 2. [71] For example, if only 1% of US residential heating oil users switched to wood pellets, domestic consumption of wood pellets would increase approximately 292,000 tonnes.

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[67] US EIA, www.eia.gov/neic/experts/heatcalc.xls
[68] North American Wood Pellet Markets (RISI) http://pelletheat.org/wp-content/uploads/2010/01/Walker.pdf
[69] US Energy Information Administration, www.eia.gov/forecasts/aeo/pdf/0383(2012).pdf
[70] US EIA, http://www.eia.gov/energyexplained/index.cfm?page=heating_oil_use
[71] US EIA, www.eia.gov/neic/experts/heatcalc.xls

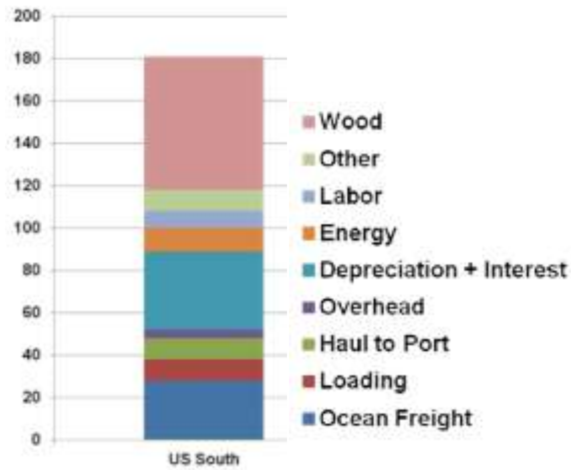
4. Wood Pellet Price

Our forecast for wood pellet prices examines four primary cost drivers as a method for predicting future prices. These cost drivers include transportation, feedstock cost, energy cost, and currency exchange. Of these, feedstock cost represents the most significant cost driver and most significant cost advantage for the Southeast relative to the rest of the US. The study forecasts three scenarios of pellet prices out to 2035. High pellet price projection is +38% by 2020 and +126% by 2035; medium pellet price projection is +19% by 2020 and +73% by 2035; and the low pellet price projection is +0% by 2020 and +15% by 2035.

4.1 Wood Pellet Price Drivers

Labor, packaging, and other costs for generating wood pellets are comparable across US regions; however, the wood feedstock and energy costs are most favorable in the South.[72] Abundance of wood supply, mild climate, and proximity to major US energy corridors contribute to lower costs.

Figure 18 - Wood Pellet Export Costs (2012 USD/ton) [73]



Wood pellet export cost drivers are critical for estimating prices. Since this study focuses on wood pellet manufacturing in North Carolina, we used approximate cost breakdown of export costs for a Southern pellet manufacturer as a basis of allocating costs. A few of the cost drivers were further subdivided and allocated in our price projection calculations. Due to high variability of small scale manufacturer costs and size of market opportunities, our analysis is focused on wood pellets manufacturing for export. Wood pellet exports from the southern US to EU are primarily sold in long-term contracts to heat and/or power plants for co-firing.

[72] North American Wood Pellet Markets (RISI) http://pelletheat.org/wp-content/uploads/2010/01/Walker.pdf
[73] North American Wood Pellet Markets (RISI) http://pelletheat.org/wp-content/uploads/2010/01/Walker.pdf

Because of the end-user type, we believe most contracts are done in CIF or FOB port prices destined to nearby ports to buyers. Therefore, middleman and distributor margins, road or rail transport in Europe, VAT, duties etc. are not included in our quantitative analysis unless otherwise stated. A more comprehensive pricing study can incorporate cost drivers for leading global wood pellet manufacturing locations and include multiple competitive factors such as transportations costs, tariffs, and government incentives among those locations to estimate price movements. However, difficulties in reliably gathering all relevant information with accurate future forecasts will limit additional benefits.

4.1.1 Transportation Cost

Transport costs from wood pellet manufacturing plant to ocean transport port will vary based on plant location, distance to port and means of transport (trucking, railroad, ship tonnage). One should also consider transport contract terms such as frequency, consistency etc., e.g., Table 6.

Table 6 - NC Transportation Costs [74]

Land Transport - Truck	
trk rate - grain, 2008, <= 25 mi ($/mi)	= $ 4.75
trk rate - grain, 2008, <= 100 mi ($/mi)	= $ 3.00
trk rate - grain, 2008, <= 200 mi ($/mi)	= $ 3.00
Source: USDA & USDOT, Study of Rural Transportation Issues, April 2010. (pg. 427, 429)	
Land Transport - Rail	
RR revenue - grain, yr2006, 20-500 mile trips ($/ton-mi)	0.045
RR revenue - grain, yr2006, 501-750 mile trips ($/ton-mi)	0.035
Source: USDA & USDOT, Study of Rural Transportation Issues, April 2010	

Baltic Exchange Dry Index (BDI) provides an assessment of the price of moving the major raw materials by sea. BDI takes into account major global shipping routes and covers Handysize, Supramax, Panamax, and Capesize dry bulk carriers carrying a range of commodities including coal, iron ore and grain. BDI is historically highly correlated with crude oil prices and inversely correlated with global shipping overcapacity. Current global dry cargo overcapacity causes

[74] NC Dept. of Transportation, www.sbeydo.com/maritime/Tech_memo/TM_DelivCostModel_FINAL.PDF. Additionally, one can check various price indices and historical data to get a better grasp of range and volatility of transport costs, e.g. US land transport trucking index: www.freightrateindex.com/index_files/page0015.htm; US Railroad Rates: 1985-2007: http://www.stb.dot.gov/stb/industry/1985-2007RailroadRateStudy.pdf; International Dry Bulk Cargo Ocean Transport Price Index: Baltic Dry Index: http://www.bloomberg.com/quote/BDIY:IND/chart

current freight prices to be lower than long-term averages. Freight prices are expected to level due to reduction in overcapacity and increase in the long-term.

4.1.2 Feedstock Cost

Cost of wood constitutes a substantial portion of wood pellet total manufacturing cost (Figure 18). Generally, small scale manufacturers of wood pellets use sawmill residues. However, increased demand for wood pellets particularly in EU in the last several years attracted investors to build larger scale pellet manufacturing plants which use round wood in higher percentages as a raw material. As stated earlier, supply of sawmill residues is limited and depends on overall market demand for lumber. Higher estimated global pellet demand and limited supply of sawmill residues will drive pellet manufacturers to use more low-cost (still more expensive than sawmill residues) round wood to respond. All these limited supply and higher demand projections give rise to higher wood raw material costs and wood prices in the Southeastern US will most likely continue their historical upward trend.

Figure 19 – North Carolina Southeast Region Wood Cost[75]

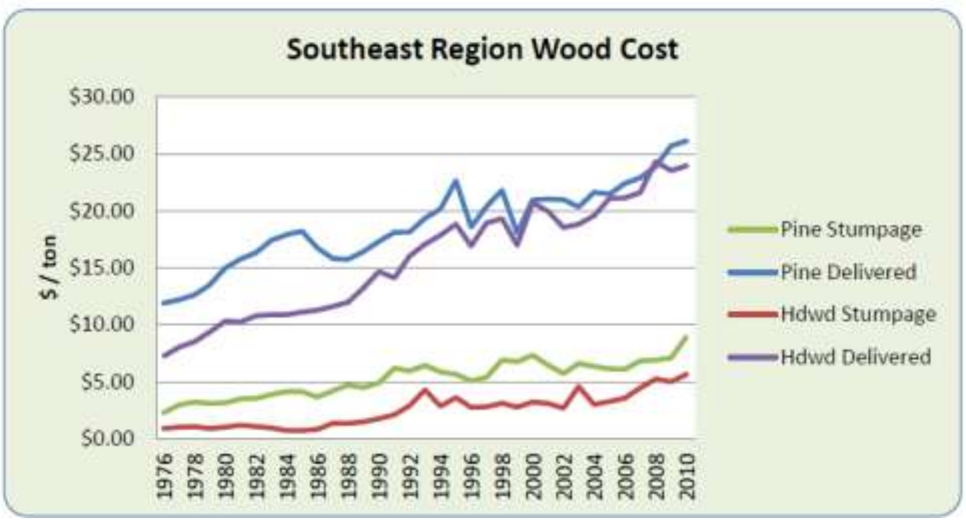


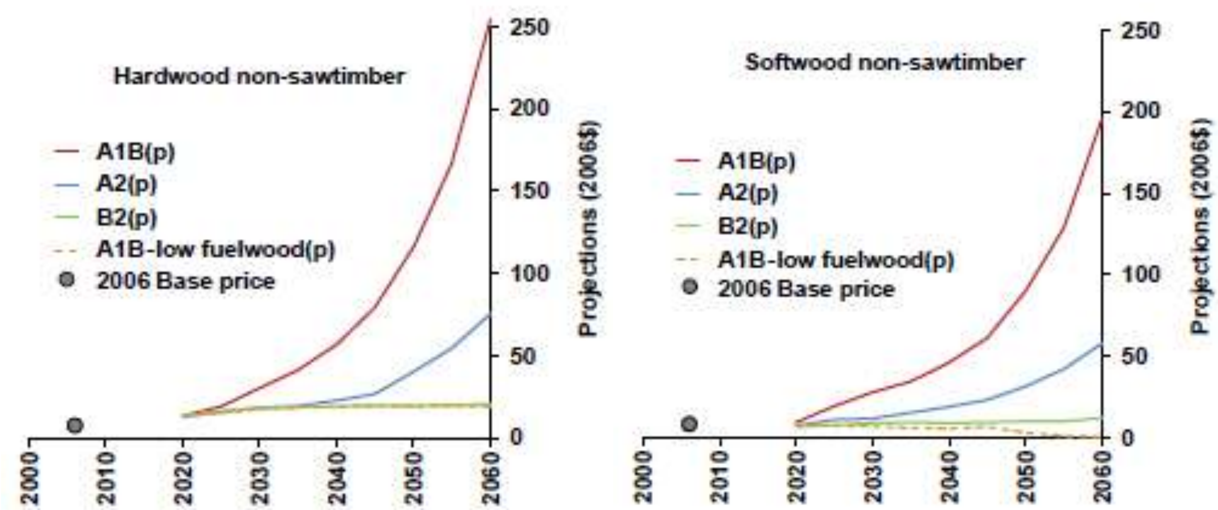
Figure 19 shows the historical trend for wood prices in the Southeast US. Both stumpage and delivered prices have increased over the past 30 years; however, the delivered price has increased faster reflecting increases in transportation costs. The USDA has developed a method to project forest product prices (Forest Products Module, USFPM)[76] which we use to

[75] Biofuels Center of North Carolina

[76] USFPM is a partial market equilibrium model of the US forest sector that operates within the Global Forest Products Model (GFPM). Wear, David N. 2011. US Forest Products Module: A Technical Document Supporting the Forest Service 2010 RPA Assessment. Research Paper FPL-RP-662. Madison, WI: US Department of Agriculture, Forest Service, Forest Products Laboratory. 61 p., http://www.fpl.fs.fed.us/documnts/fplrp/fpl_rp662.pdf

drive our wood pellet price projections. The price projections assume that long-term wood prices will change in proportion to USFPM/GFPM projections of real non-sawtimber stumpage prices for hardwoods and softwoods in the US South. In the USFPM model, supply responses were also scaled by projections of land-use changes based on different Resources Planning Act (RPA) storylines (A1B, A2, and B2 in Figure 20).[77] For each scenario, population and income forecasts drive forecasts of urbanization at the county level. As a result, supply functions for the US South depend on the population, income, and climate forecasts specified for the given storyline.

Figure 20 – Southern US Non-Sawtimber Stumpage Prices (2006 $/m3)[78]



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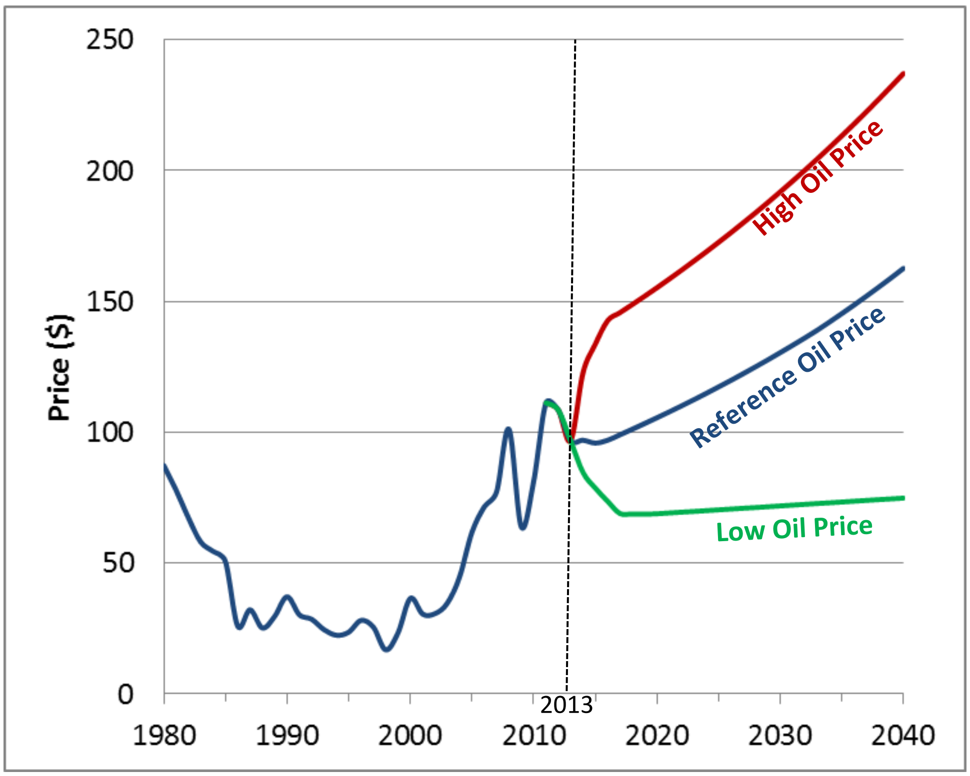
Scenario	A1B	A2	B2
General description	Globalization, economic convergence	Heterogenic regionalism, less trade	Localized solutions, slow change
Social development themes	Economic growth, new technologies, capacity building	Self-reliance, preservation of local identities	Sustainable development, diversified technology
Global real GDP growth, (2010–2060)	High (6.2×)	Medium (3.2×)	Medium (3.5×)
Global population growth, (2010–2060)	Medium (1.3×)	High (1.7×)	Medium (1.4×)
U.S. GDP growth, (2006–2060)	Medium (3.3×)	Low (2.6×)	Low (2.2×)
U.S. population growth, (2006–2060)	Medium (1.5×)	High (1.7×)	Medium (1.3×)
Global expansion of primary biomass energy production, (2000–2060)	High (5.9×)	Medium (3.1×)	Medium (3.2×)

78 **USFPM/GFPM** http://www.fpl.fs.fed.us/documnts/fplrp/fpl_rp662.pdf

4.1.3 Energy Cost

Crude oil is not only a leading benchmark for energy prices but also a determiner of competitiveness for many other fuels. Additionally, input costs for many industries and sectors are based on its price. Higher prices of crude oil may help wood pellets to become more competitive whereas increasing costs of pellet production and transportation. Energy, hauling and ocean transport cost changes are included in our wood pellet price projection model. Our model assumes crude oil price significantly contributes to costs of those inputs. US EIA's low, reference, and high oil prices (Figure 21) are part of our Low, Medium, and High pellet price projections, respectively (Figure 23).

Figure 21 - Brent Crude Oil Prices (1980-2040)[79]



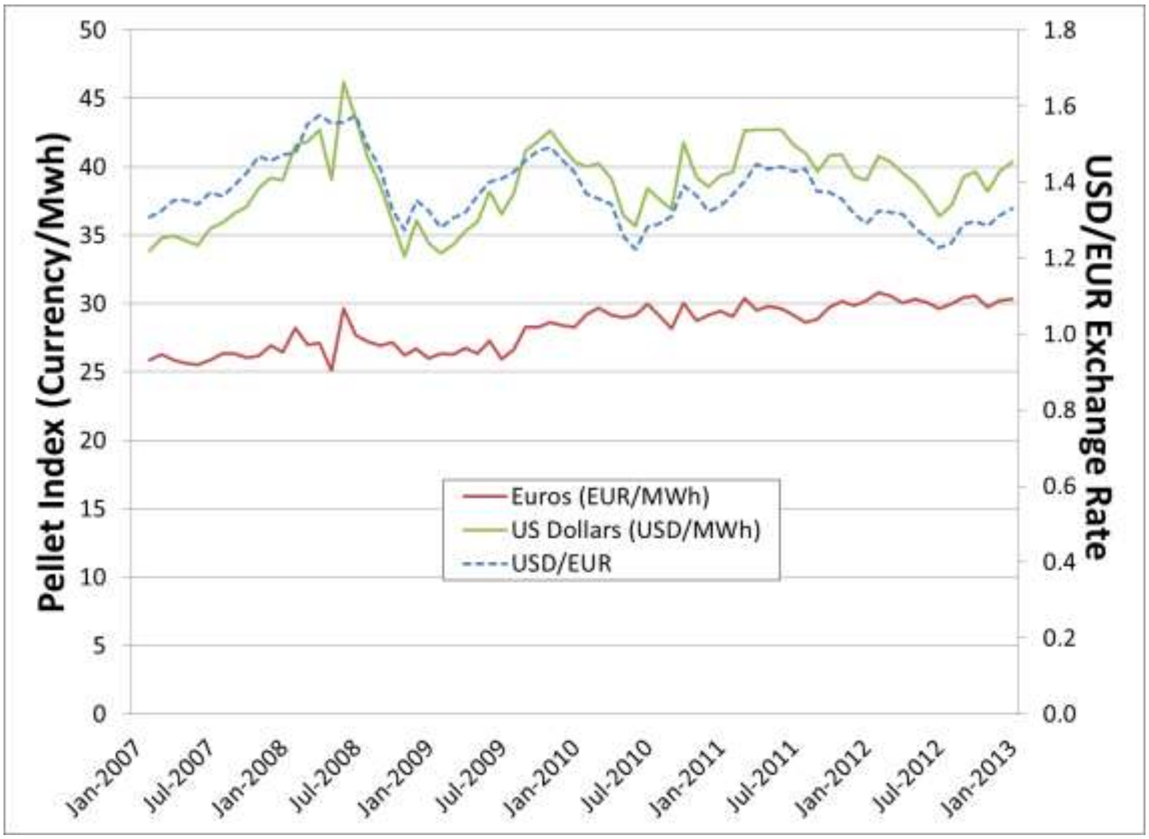
4.1.4 Currency Exchange Effect Cost

With increased global trade of wood pellets, pellet prices have begun to be observed more closely. One price index is FOEX - PIX Pellet Nordic Industrial Index[80] which became available

[79] US Annual Energy Outlook Projection 2013, http://www.eia.gov/forecasts/aeo/er/excel/overview.fig05.data.xls
[80] PIX Pellet Nordic Industrial Index Specification: Prices for wood pellets with diameter of 6-10 mm, max ash content of 3%, moisture content below 10% and net calorific value ≥ 16,5 GJ/t. Prices are reported in Euro/MWh or Euro/ton. Prices in Euro/ton are transformed into Euro/MWh using the coefficient of 4.8 unless otherwise informed by the price reporter. Terms of delivery: CIF Baltic Sea port or North Sea Port (for sea transport) and DDU (for truck or rail transport). Net prices without any taxes. Prices are latest actual monthly delivery prices

after February 2007. FOEX PIX Pellet Nordic prices are reported in euros in Figure 22. Since leading geographic pellet supplier for Northern Europe is North America we analyzed historical prices in both Euros and USD. In the figure above prices in euros (EUR) show an upward historical trend with relative stability. In contrast prices in USD are highly volatile and closely track USD/EUR exchange rate.

Figure 22 - European Pellet Price/MWh and USD/EURO[80]



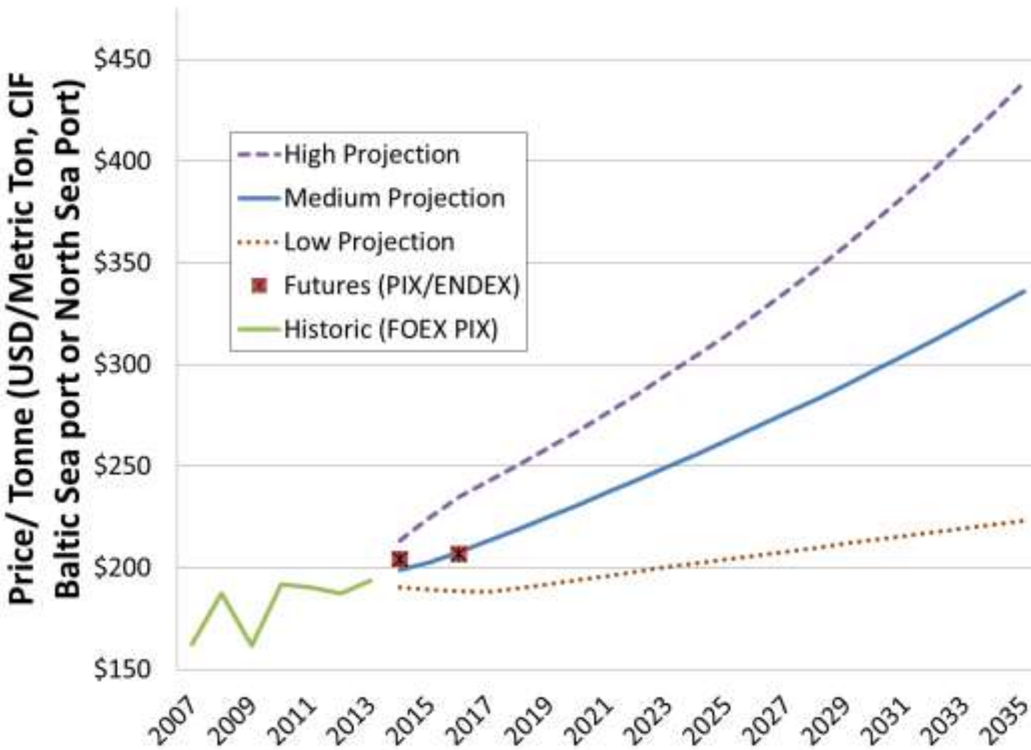
We believe willingness to pay for pellets by European industrial customers are tied to CO2 emission allowances. If large scale long-terms contracts between European buyers and North American pellet producers are signed in euros, North American producers are vulnerable to currency exchange rate changes due to the discrepancy of paying in USD but selling in EUR. Although, financial tools such as currency exchange rate contracts can mitigate some of the risks, long-term risks including the ones at investment stage may not be fully eliminated.

4.2 Wood Pellet Price Forecast

We used a cost driver model for predicting future prices for wood pellets shown in Figure 23 along with historical prices and future prices (February 2013). We estimate wood pellet prices will increase in accordance with increasing costs in production inputs and higher expected global demand. The variation *between* the three scenarios is derived from a tripling of non-sawtimber prices within 20 years and US EIA's high oil price forecast (High Projection); a doubling of non-sawtimber prices and US EIA's reference oil price forecast (Medium Projection); and no change in non-sawtimber prices with US EIA's low oil price forecast (Low Projection).

Approximate cost breakdown of export costs for a US South pellet manufacturer is used as a basis of allocating cost drivers. A few cost drivers further subdivided and allocated to relevant others. Finally, we assumed cost of wood/biomass, crude oil price, Producer Price Index, Employment Cost Index and interest rates will drive future prices based on their relative weights.

Figure 23 – Wood Pellet Price (2007-2035) [81]



[81] US Forest Service http://www.fpl.fs.fed.us/documnts/fplrp/fpl_rp662.pdf; US Annual Energy Outlook Projection, 2013 Early Release; Producer Price Index and Employment Cost Index projections we used coefficients determined by performing linear regression analysis on US Bureau of Labor Statistics data; interest rate projections we used US Department of the Treasury yield curve data. Further details, calculations and assumptions are provided in our spreadsheet model.

5. North Carolina's Market Share

The Southeastern United States presents a cost advantage in the wood pellet market for both feedstock and transportation costs. More specifically, North Carolina has significant forest resources and proximity to major ports that enable this advantage. Section 5. North Carolina's Market Share reviews forest removals and matches them against current pellet production facilities as a method of evaluating the continued ability of supply to meet demand projections.

We also examine the North Carolina existing and planned plants to understand specific supply constraint possibilities in the state and conclude that at a 50-mile radius, projected sustainable supply is almost twice the demand, indicating that there is further room for sustainable growth. Finally we review the impact of price on the sustainability of supply. At higher prices, projections show a shift from secondary sources of feedstock to primary sources, which in turn will have a greater impact on forest removals. We conclude that Eastern NC has enough sustainable forest capacity to supply at least five commercial wood pellet facilities.

5.1 Pellet Demand on NC Wood Resources

Three dedicated wood pellet producing plants have been announced by Enviva for Ahoskie, Northampton, and Southampton (VA) Counties.[82] The Ahoskie plant is now operating and Enviva shipped its first exports on 31 December 2012. The other two plants are now in development. We include the Southampton, Virginia plant because its supply catchment area includes portions of North Carolina. The proposed International WoodFuels pellet production plant in Sims in Wilson County is included in our calculations. In addition, we consider a potential pellet production facility for Lumberton which was used as an illustrative case study by the recent North Carolina Maritime study.[83]

Table 7 provides an overview of the forest removals needed to supply the three planned Enviva facilities and the two additional facilities, given the potential capacities. Collectively, the three announced plants are envisioned to produce 1.35 million dry tonnes of output annually. That output would require an estimated 2.1 million tonnes of input to the pelletization process. That, in turn, would require an estimated 151 million cubic feet of clean lumber, which is equivalent to an estimated 226 million cubic feet of forest output. Including the two additional plants raises total output to 2.0 million dry tonnes, the required annual input to 3.1 million wet

[82] http://www.envivabiomass.com/

[83] NC Maritime Strategy, Final Report, Prepared for the North Carolina Department of Transportation by AECOM in association with URS June 26, 2012 (http://www.sbeydo.com/maritime/Report/NC_Maritime_final_report_2012-06-26.pdf).

tonnes, and the needed clean lumber to 223 million cubic feet, which is equivalent to an estimated 335 million cubic feet of forest output.

Table 7 - NC Pellet Plant Capacity, Required Feedstock, and Available Feedstock Supply

	Pellet Capacity (tonnes/day)	Pellet Capacity (tonnes/yr)	Required feedstock (wet tonnes)	Required clean lumber (1000 ft3)	Required forest output (1000 ft3)	Wood Supply, 50 Mile Radius (1000 ft3)	Wood Supply, 70 Mile Radius (1000 ft3)
Northampton (Enviva)	1,429	500,000	785,000	55,826	83,739		
Ahoskie (Enviva)	1,000	350,000	549,500	39,078	58,617		
Southampton (Enviva)	1,429	500,000	785,000	55,826	83,739		
Enviva Sub-total	3,857	1,350,000	2,119,500	150,730	226,094	463,541	693,882
Wilson County (Sims)	857	300,000	471,000	33,495	50,243		
Lumberton (hypothetical)	1,000	350,000	549,500	39,078	58,617		
Total	**5,714**	**2,000,000**	**3,140,000**	**223,303**	**334,955**	**766,640**	**1,257,446**

We calculated the estimated total sustainable supply of forest resources within selected radii of the three plants, regardless of price. The results, summarized in the last two columns of Table 7, suggest that projected output is likely physically sustainable. As noted above, the 2007 TPO database has been used by other studies in estimating sustainable supply levels. At a 50-mile radius, projected sustainable supply is almost twice the demand. Extending the supply radius suggests that available supply may be nearly three times as large as demand. In this case, however, demand will be a substantial proportion of available supply. That implies that wood would need to be diverted from other uses and that substantial price distortion will ensue.

The Enviva plants are located within close proximity of each other (Figure 24). The tight clustering of facilities may help create transportation efficiencies for land transport to the Chesapeake port facility. A rail line to Wilmington passes directly through Lumberton so rail service could be possible. The Wilson plant, roughly equidistant from these ports, has not yet announced its shipping plans.

Figure 24 - Major NC Pellet Plants and Ports

(hypothetical plants in italics)

These calculations do not indicate whether such production levels are economically viable. Figure 25 illustrates the relationship between price and supply with our estimation of sustainable supply of woody biomass in 2020 at selected roadside prices.[84] When prices reach $60 per dry tonne, sawlogs (conventional pine or hardwood) begins being diverted from other uses to biomass. Past a certain price, waste products disappear as a source of supply because

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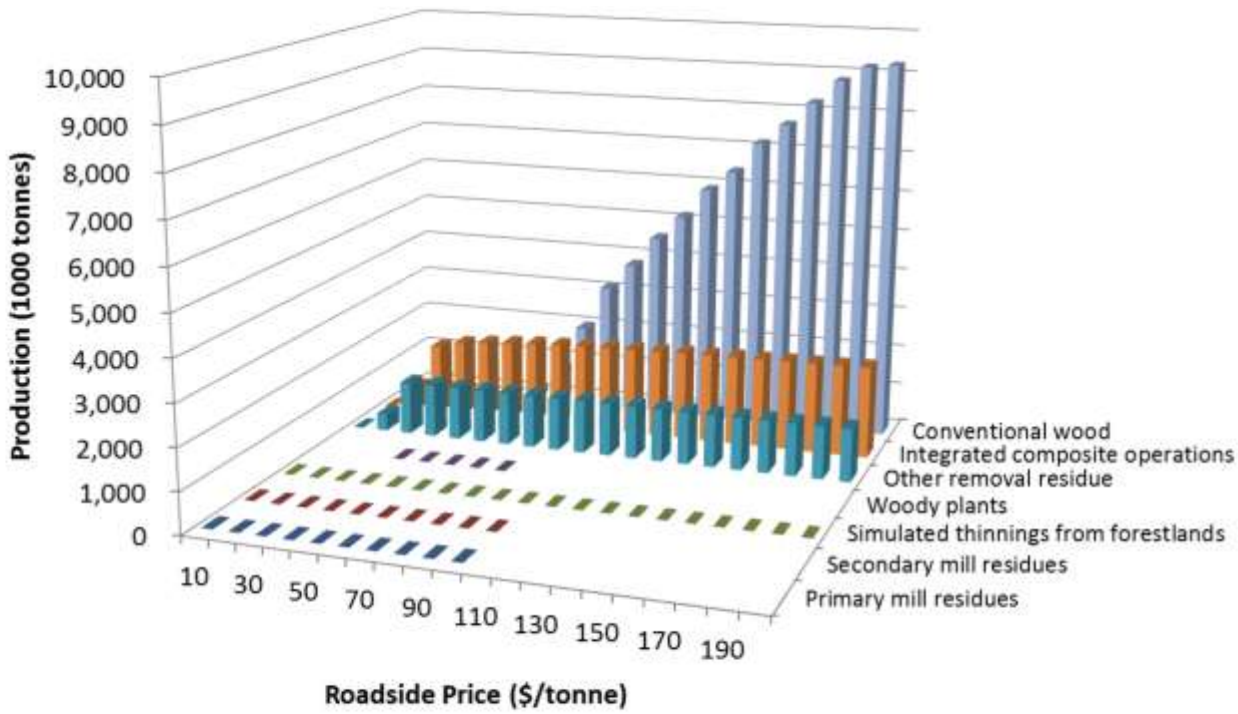
[84] Calculations based on data from US Department of Energy. US Billion-Ton Update: Biomass Supply for a Bioenergy and Bioproducts Industry. R.D. Perlack and B.J. Stokes (Leads), ORNL/TM-2011/224. Oak Ridge National Laboratory, Oak Ridge, TN. 2011. 227p. (http://www1.eere.energy.gov/biomass/pdfs/billion_ton_update.pdf).

so much of the forest harvest would be sent straight to pellet production. At lower prices, waste products predominate as a source of feedstock supply.

Figure 25 - Estimated NC Woody Biomass Supply-Mix[84]



None of these calculations indicate whether production levels are economically viable for a pellet plant or environmentally responsible once full impacts are considered. These estimates are significantly higher than those projected by the NC Maritime Strategy Study and would require a substantial reorientation on the part of the North Carolina wood products sector.

5.2 NC Transportation Infrastructure

Road, rail, and port infrastructure should not be a constraint to the expansion of the wood pellet sector. At present, no dedicated port facilities exists in North Carolina but there is sufficient land available to establish one at both the Morehead City and Wilmington ports. At this point, it is uncertain whether dedicated port facilities are economically viable, however. In our calculations of basic outward logistics needs, we assumed all plants were working at full capacity over 350 days per year and all output was exported. Parameters were adapted from the North Carolina Maritime Strategy Study but terminal costs were not included. Table 8 summarizes the outward trucking, rail, and ocean transport needs of the examined and hypothetical facilities at full capacity.

Table 8 - Outward-Bound Pellet Logistics Options[85]

Pellet Plant	Pellet Capacity (tonnes/d)	Miles from port	Truck to Port		Train to Port		Ocean Ship to EU	
			Trips/d	Cost ($/d)	Cars/d	Cost ($/d)	30,000-Tonne/yr	50,000-Tonne/yr
Northampton (Enviva)	1,429	100	71.4	$ 23,786	20.41	$ 11,143	16.7	10
Ahoskie (Enviva)	1,000	70	50.0	$ 11,655	14.29	$ 5,460	11.7	7
Southampton (Enviva)	1,429	50	71.4	$ 11,893	20.41	$ 5,571	16.7	10
Enviva Sub-total	3,857		192.9	$ 47,334	55.10	$ 22,174	45	27
Wilson County (Sims)	857	121	42.9	$ 17,268	12.24	$ 8,090	10	6
Lumberton	1,000	75	50.0	$ 12,488	14.29	$ 5,850	11.7	7
Total	**5,714**		**285.7**	**$ 77,090**	**81.63**	**$ 36,114**	**66.7**	**40**

The total number of truck trips required is significant - nearly 250 trips daily - but probably not sufficient to cause congestion on North Carolina or Virginia highways. The number of hourly departures from the individual plants averages between 2 and 3. An approximate daily trucking cost was calculated using one of the higher per-mile estimates in the Maritime Strategy study for short distance drayage. Collectively, the plants could spend over $70,000 per day on trucking their product to port, although long-term contracts could reduce costs somewhat. We calculated the number of rail cars needed daily to ship the output onward (12 to 20, depending upon the size of the plant). Assuming a 20 m.p.h. average speed and the relatively rapid loading and unloading of hopper cars, it should be possible for trains to each of these facilities to make a daily turn. Collectively, the examined plants could be spending somewhat less than $50,000 daily, should they be able to secure rail service.

The final column of Table 8 reports an estimate of the number of annual ocean shipments needed to transport the product to Europe. The inaugural Enviva shipment was 28,000 tonnes. We have calculated the number of annual shipments needed at 30,000, 50,000, and 60,000 tonnes. The literature suggests that 50,000 to 60,000 tonnes is the preferred shipment size for bulk cargos across the North Atlantic. There are tradeoffs but the larger sized ships are

[85] Assumptions: 100% pellet production capacity; 350 operational days per year; 20 tonne (44,000 lbs) trucking capacity; 24 hour operations; 70 tonne rail capacity; rail distances arbitrarily increased 30% to account for indirect routings; assumed all plants have direct rail access to port

generally more fuel efficient, reducing costs and carbon impact. Because Enviva has announced the intention of shipments every week and a half, we assumed shipments of 30,000 tonnes. Given an assumed transit time between Norfolk or Wilmington and Northwestern Europe of 10 days and a full day loading and unloading time at each end, three dedicated vessels with 30,000 tonne capacities should be able to handle the Enviva shipments with a safety cushion.[86] Backhaul loads could lengthen ship turnaround times, increasing the number of vessels needed but potentially reducing shipping costs. Seasonal variations in the demand for wood pellets or in the difficulty of shipping across the Atlantic would increase the needed ship capacity.

Other regions may achieve lower US land-side logistics costs. The Tennessee-Tombigbee Waterway may eventually support a corridor of wood pellet production which may enjoy lower US-side transportation and storage costs than all other potential sites. Should adequate rail arrangements be made, wood pellet plants in southern Georgia may enjoy lower land-side transportation costs. Wood pellet plants feeding Charleston SC could also face advantages given the geography of transportation and forestry.

5.3 Biomass Pellets or Biofuels Feedstock?

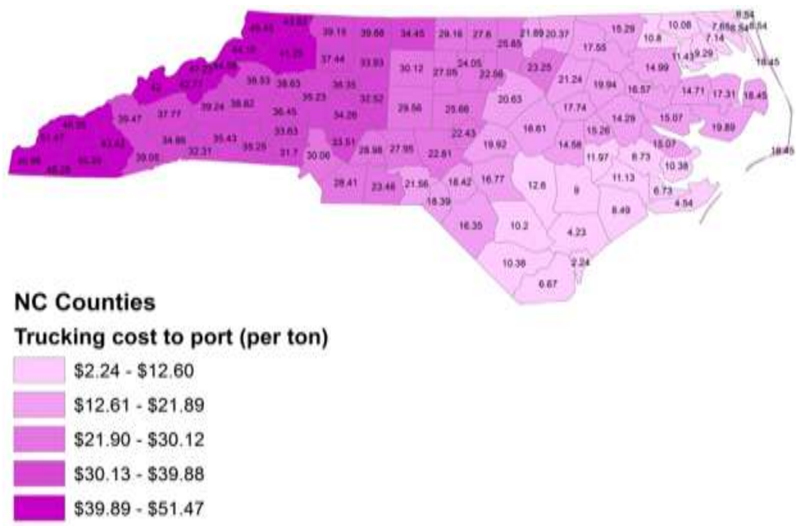
Recently, the paper sector consumed as much as 42% of the softwood and hardwood timber production in the southeast, with production concentrated in southeastern Georgia, northeastern Florida, southern Alabama, and Mississippi.[87] Over the past decade or so, paper manufacturing capacity has been declining in the Southeast as a result of the increasing use of recycled materials in paper production and long-term trends in the paper market which suggest a permanent lower per capita level of paper consumption. With demand already down 15 million tons in 2009 compared to 2000, a further 50 percent reduction in production by 2020 is to be expected.[88] From 41 kg per capita, paper consumption is expected to eventually stabilize at the European level of 25 kg per capita. Southeastern lumber and panel production, although cyclically impacted, do not appear to be structurally affected. The trends in paper production imply that the forests, which supplied the paper industry, are now available for new uses, such as biofuels or wood pellets.

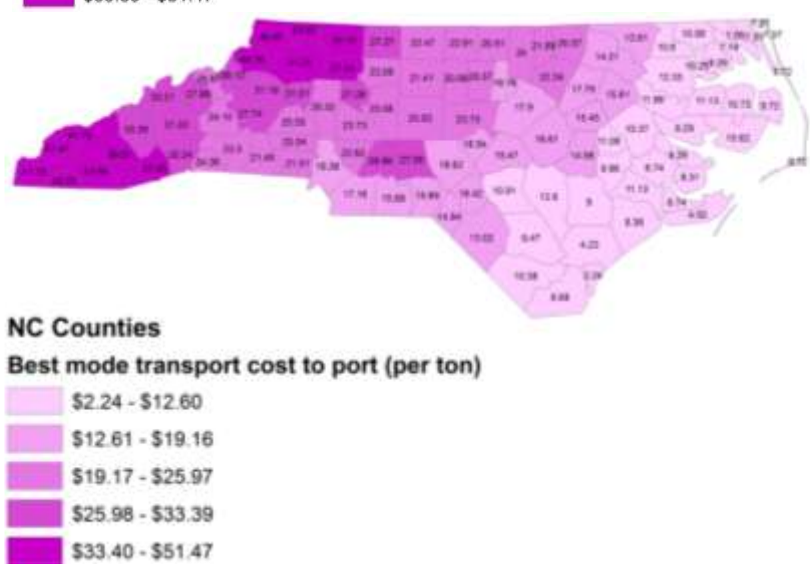
The market for wood-based biomass may be geographically limited because of transportation costs, however. An analysis of kraft liner board production suggests that compared to the U.S. West, Canada, and Europe, the Southeastern US may be competitive, but Brazil and Chile are

[86] Hapag-Lloyd's container service between Norfolk and Antwerp is published as 9 days. Bulk goods ships generally sail at a somewhat slower pace.
[87] www.srs.fs.usda.gov/econ/pubs/southernmarkets/sothern-markets-11.htm
[88] Richard B. Philips, "Prospects for Pulp and Paper – Global Dynamics of the Pulp and Paper Industry 2010.

lower cost producers. That is, Southeast producers are viable for the markets where a transportation cost advantage due to proximity to market outweighs the production cost disadvantage.[89] Although the analysis was performed for another industry, the results imply that the U.S. Southeast would likely face long-term competition for wood pellet export markets from the same sources. Although the analysis reviewed concentrated on inter-market transportation costs, intra-market transportation costs are also important. Figure 26 maps the wood pellet transportation costs to the most advantageous port.

Figure 26 - Cost of Transportation to Port





Because actual rail transport costs are often higher than potential costs and because shipper access to existing rail remains contingent, we show both costs by trucking and by the best

[89] www.srs.fs.usda.gov/econ/pubs/southernmarkets/sothern-markets-11.htm

(least-cost) mode of transport. A simple analysis abstracting several cost drivers was performed. Mecklenburg and Durham Counties stand out as Western outposts of low (less than $20 per ton) transport costs to port. Low costs (less than $20 per ton) are largely confined to East of I-95. In both cases, loading and unloading costs are ignored and the mix between pre- and post-pelletization costs (both of which would increase total inland shipping costs) are ignored. The implication of the costs illustrated is that in order to be competitive with Eastern forests for wood pellet feedstock, central and western North Carolina locations would need to offer a large price advantage to compensate for the higher transportation costs; however, wood prices are marginally higher in the west compared to the east.[90] Therefore, wood resources west of I-95 may be the optimal woody inputs for North Carolina biofuel production.

Fuelwood, much of which is removed as a by-product of harvesting softwoods, is a potential input to pellet and biofuel production. Its advantage is its low cost of acquisition. Fuelwood production in North Carolina is a significant proportion of wood product production and a noticable proportion of all forest removals (which include logging residues and other removals). At moderate levels of demand, in combination with a robust demand for pulp, fuelwood serves as a viable source of liquid biofuel feedstock. The rise in demand for wood pellets combined with the declining paper demand implies that fuelwood now has nearly as much value as pulpwood, with a differential due to differences in pre-processing costs. Fuelwood in the higher transport cost areas of the state will also be impacted by the high costs of transport to port but may continue to be a viable source of biofuels for domestic consumption.

[90] NC Biomass Resources Study, Biofuels Center of North Carolina, 2012

6. Concerns for long-term NC wood pellet market

The strong growth for the pellet industry is not met without risks. Just as policy and abundance of supply have been strong drivers for the industry; reverse or opposing trends in policy or supply constraints could threaten this growth. This section examines seven potential threats to this end.

6.1 Regulatory Risks of the Production of Wood Pellets for Export

Aside from increases in the cost of shipping and a potential renewal of domestic housing demand for wood, three regulatory issues could impact the viability of the wood pellet export industry. First, it is unclear whether present European Union accounting rules "count" the carbon costs of production and shipping as they occur outside the EU. Second, because most discussions of the wood pellet industry may base their assessments on the use of mill waste products, the full GHG and environmental impacts of dedicated pellet production may not be considered. Because mill waste products are not only already harvested and removed from the forest for reasons independent of energy production, there is no need to include the impact of harvesting and removal in the accounting of cost or carbon impact. Manufacturing wood pellets as a primary, rather than secondary or by-product, changes that. Third, the dedicated production of pellets entails land use changes which also have impacts on carbon production.

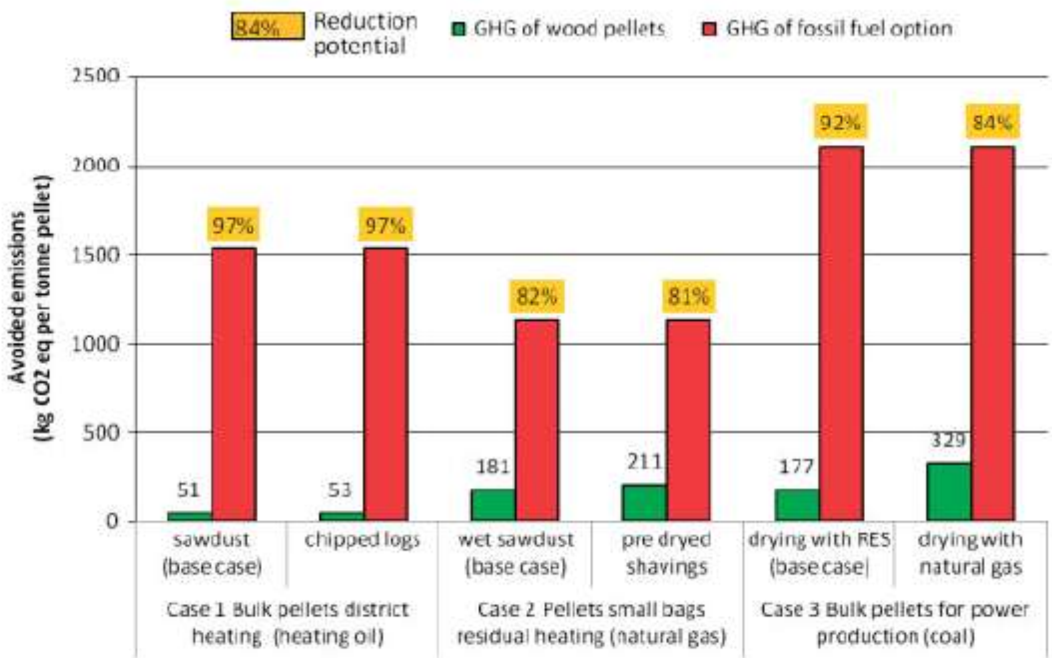
Under IPCC 2006 guidelines, the removal of forest biomass is regarded as an emission from the country where the harvesting of trees has taken place, whereas the use of biofuels is not treated as an emission in the country of combustion.[91] Moreover, European Union accounting rules credit the users of biofuels, rather than the producer, creating an interest in importing pellets for heating and power production which may not be fully justified by the underlying carbon generation. According to Sikkema et al., using residues (like shavings or sawdust) as feedstock is defined as CO2 neutral in the EU's RES Directive (2009/28/EC) and according to an advice prior to that Directive, the same is valid for the use of logs for pellets when supplied to small-scale heating plants. However, they point out that this convention is controversial and that other sources include the extra GHG impacts from the forest steps, independent of which kind of biomass is used. A complete accounting of the process, particularly for the use of saw logs, raises the estimate of carbon produced (91).

Such considerations, while important, do not consider the full impacts of using wood pellets for energy production. Transportation, drying, and plant operations all contribute to the GHG

[91] Sikkema, Richard et al. (2010) "The international logistics of wood pellets for heating and power production in Europe: Costs, energy-input and greenhouse gas balances of pellet consumption in Italy, Sweden, and the Netherlands," Biofuels, Bioproducts, and Biorefining 4: 132-152, p.150.

emissions associated with delivered wood pellets (~54% of GHG from transportation alone).[92] Figure 27 provides a comparison of the GHG impact of various types of wood energy resources delivered to Europe (e.g. the Enviva plants are producing bulk wood pellets for electricity generation) compared to the oil, natural gas, and coal that they replace.

Figure 27 – Lifecycle GHG Emissions from Pellet Consumption [92]



From the graph, the benefits of using biomass energy are clear. However, the base assumption that the process of burning biomass is GHG neutral, while burning fossil fuels is additive, is inaccurate. Trees sequester large amounts of carbon.[93] When wood is harvested for use as a building material, much of the carbon remains sequestered. However, when wood is burned, the carbon is released, creating a carbon "debt." As replanted forests grow, the debt is paid off and the use of wood pellets begins paying a carbon "dividend." Just as economic investments have a payback period, so do carbon investments. Replacing coal-fired electric plants with wood pellets results in a three percent net increase in carbon footprint because sufficient forest has not yet grown back—the actual payback period may be as long as 21 years.[94] After 40 years, using wood biomass to replace oil-fired combined heat and power plants only yields a

[92] Adapted from Sikkema et al. 2010
[93] Much of the discussion in this section is based on Manomet Center for Conservation Sciences. 2010. Massachusetts Biomass Sustainability and Carbon Policy Study: Report to the Commonwealth of Massachusetts Department of Energy Resources. Walker, T. (Ed.). Contributors: Cardellichio, P., Colnes, A., Gunn, J., Kittler, B., Perschel, R., Recchia, C., Saah, D., and Walker, T. Natural Capital Initiative Report NCI-2010-03. Brunswick, Maine.
[94] The Royal Society for the Protection of Birds http://www.rspb.org.uk/Images/biomass_report_tcm9-326672.pdf

25% reduction in greenhouse gases net of forest sequestration. Though the practice is highly unlikely, replacing a gas-fired electrical generation plant would result actually in a 100 percent increase in greenhouse gasses released. These considerations have led some to wonder whether biomass is dirtier than coal.[95] Accordingly, the use of imported biomass by Europe has been likened to "baling more while we poke more holes in the boat."[96]

A portion of the regulatory confusion stems from categorizing the burning of biofuels as an energy impact but the harvesting of biomass as a land use impact. Because the latter are less-well tracked and regulated, the use of woody biomass for energy generation appears more environmentally favorable than a more complete accounting would find.[97] Including the impacts of harvesting creates a significant delay in net benefit.[98]

The net impact is that the use of US wood pellets to substitute for coal in the generation of European electricity does not result in a strong greenhouse gas benefit, at least on the decadal timescale. Dedicated wood pellet production for export is subject to a substantial, possibly unwarranted, regulatory benefit and a correspondingly large regulatory risk. That risk is tempered by the European dependence on biomass. Excluding hydropower, biomass is by far the largest source of renewable energy. Given the stated objectives of increasing the use of renewable fuels, European governments will have little incentive to alter regulations. The main threat to the North Carolina wood pellet export industry may be competing sources of biomass which have more favorable overall carbon reduction profiles.

6.2 Competing Uses

The increase in European demand coincided with a decrease in demand from the US housing industry. The depressed domestic demand has augmented the interest in the export demand. Furthermore, a report to the Massachusetts Department of Energy Resources estimates the energy required to manufacture and transport pellets for domestic US use is less than 2% of the energy content of the pellets.[99]

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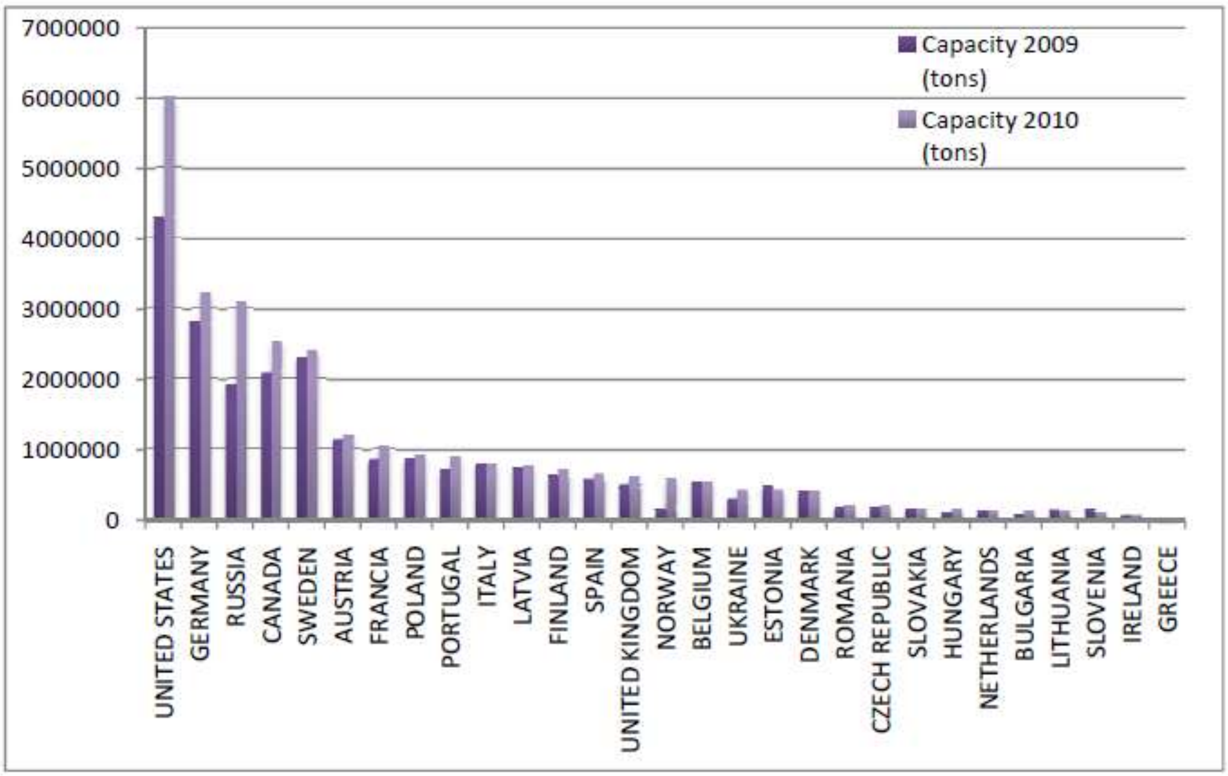
95 http://www.rspb.org.uk/Images/biomass_report_tcm9-326672.pdf
96 http://www.epoverviews.com/oca/greene.pdf
97 Tim Searchinger (2012) "Sound Principles and an important inconsistency in the 2012 UK bioenergy strategy," September 20, http://www.rspb.org.uk/Images/Searchinger_comments_on_bioenergy_strategy_SEPT_2012_tcm9-329780.pdf.
98 Jon McKechnie, Steve Colombo, Jiaxin Chen, Warren Mabee, and Heather L. MacLean (2011) "Forest Bioenergy or Forest Carbon? Assessing Trade-Offs in Greenhouse Gas Mitigation with Wood-Based Fuels," Environmental Science and Technology 45 (2): 789-795.
99 Manomet Center for Conservation Science. 2010. Biomass sustainability and Carbon Policy Study: Report to the Commonwealth of Massachusetts Department of Energy Resources.

6.3 Pellet Plant Capacity & Utilization

Increase in global demand for wood pellets - namely the EU - is driving an increase in wood pellet production capacity for the three primary global exporters: the US, Canada, and Russia. Figure 28 below depicts the 22% growth in wood pellet production capacity by country between 2009 and 2010, with 2010 capacity at over 28 million tonnes. [100]

Figure 28 - Wood Pellet Production Capacity by Country



Production facilities are producing at surprisingly low capacity utilization rates: 33%, 69% and 52% for US, Canada, and Russia, respectively in 2010. One suspected reason for this is the reduction in the availability of traditional sawmill residues, due both to the housing crisis during the latter part of the decade and the growth of the pellet industry itself. However, an increase in use of traditional sawmills may make stand-alone pellet manufacturers less competitive. Moreover, Russia's installed capacity may increase substantially with the construction of the 1 million tonne plant, Vyborgskaya Cellulose, located in northwest Russia, near the border with

[100] www.bioenergytrade.org/downloads/t40-global-wood-pellet-market-study_final.pdf. Global Wood Pellet Industry Market and Trade Study. IEA Bioenergy. 2011. Maurizio Cocchi et al.

Finland[101]. Ramp up of this plant may increase the number of Russian imports to Europe and may pose a long-term threat to North American production.

Pelletizing wood is a step towards commoditization but other feedstocks can also be pelletized. Aside from the woody residues and round wood considered in this report, woody energy crops, municipal solid waste, and wet and dry herbaceous residues and energy crops can also be pelletized for eased transport.[102] Doing so could tap potential North Carolina biofuel resources as wood pellets are now being used to manufacture "green" gasoline on a pilot project basis.[103]

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[101] The Development of the pellet production and trade in Russia 2012. Dr. Olga Rakitova, The National Bioenergy Union

[102] J. Richard Hess, Christopher T. Wright, Kevin L. Kenney, and Erin M. Searcy (2009) Uniform-Format Solid Feedstock Supply System: A Commodity-Scale Design to Produce an Infrastructure-Compatible Bulk Solid from Lignocellulosic Biomass, Idaho National Laboratory, INL/EXT-09-15423, April.

[103] "Green Gasoline from wood Pilot Biorefinery Demonstration Project," US Department of energy, Energy Efficiency and Renewable Energy, Haldor Topsoe Inc. Pilot Project.

7. Appendices

7.1 Appendix 1 - Over Land Transportation Costs of NC Forests

With a commoditized product such as wood pellets, market share depends upon the aggregate level of demand and landed (delivered) price. Landed price is a function of production cost and transportation cost. Variations in production cost depend, in large part, upon variations in the quantity and quality of feedstocks. Variations in transportation cost for export goods depend, with some wrinkles, upon distance from an ocean port and the distance between the port of export and the importing port. As noted above, Southeastern US has recently overtaken Canada as the largest source of European wood pellet imports. The increase in market share has been attributed to the lower total logistics costs, with the inland portion of the journey being perhaps the largest component of the price difference.[104] Like Mississippi, Georgia, and Louisiana, North Carolina has significant forest resources. As the wood pellet export industry reaches maturity, regions within the Southeast with large, contiguous tracts of high suitability forest may increase in competitiveness and market share.[105]

Figure 29 maps the total forest removals in 2007 and the location of pellet plant capacity in 2009. The data on forest removals stem from the latest available detailed data on forest output.[106] These data are collected by the US Department of Agriculture, Forest Service Division and have served as foundational data by studies of sustainable forest potential for energy and other end uses.[107] Concentrations of forest output in the Northwest, Upper Midwest, New England, and the Southeast are visible. The shorter shipping distances to Asia suggest that, should substantial demand for US wood pellets develop in Asia, the Northwest would likely emerge as the source of choice. Within the Southeast, which is emerging as the source of choice for European customers, North Carolina competes with other states, including those mentioned above.

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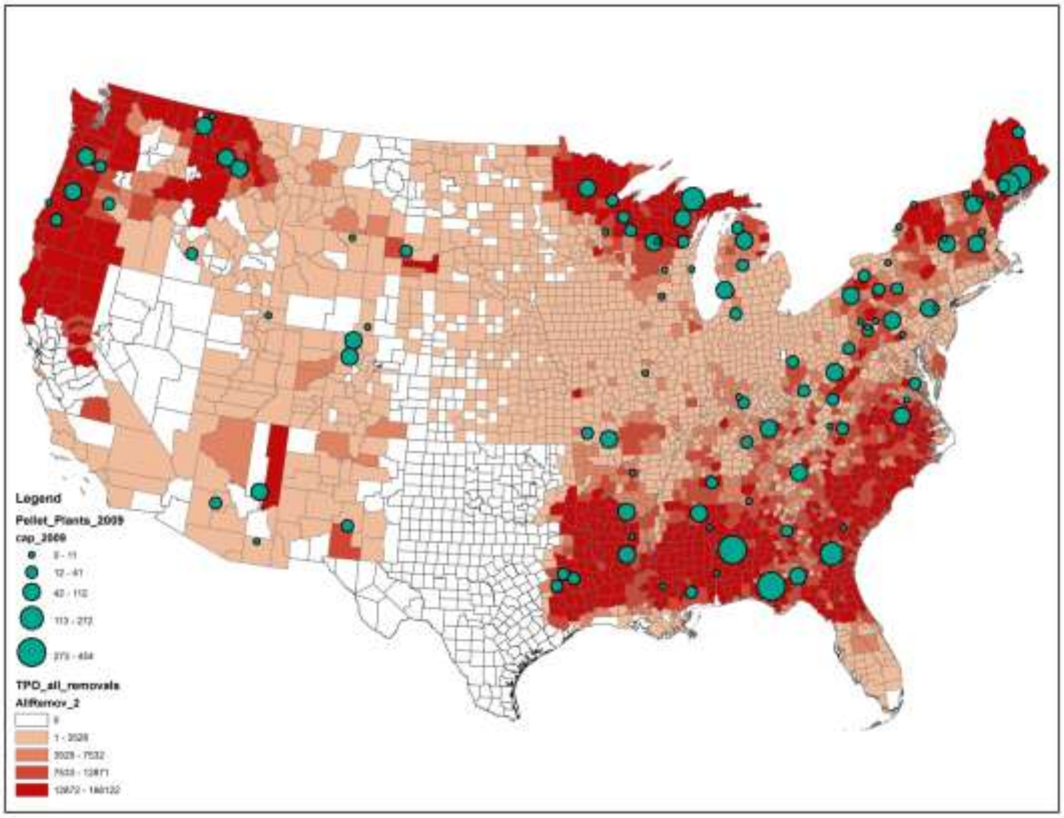
[104] Wood Pellets: Becoming a Primary Product, Issues in the Forest, August 2011.

[105] Timothy M. Young, James H. Perdue, and Xia Huang (2012) Spatially-Defined Opportunity Zones for Cellulosic Biomass Supply Integrated with the BioSAT Model

[106] US Department of Agriculture, Forest Service. 2007. Timber Product Output (TPO) Reports. Knoxville, TN: US Department of Agriculture, Forest Service, Southern Research Station. http://srsfia2.fs.fed.us/php/tpo_2009/tpo_rpa_int1.php. [Date accessed: Month da, year].

[107] US Department of Energy. 2011. US Billion-Ton Update: Biomass Supply for a Bioenergy and Bioproducts Industry. R.D. Perlack and B.J. Stokes (Leads), ORNL/TM-2011/224. Oak Ridge National Laboratory, Oak Ridge, TN. 227p. (http://www1.eere.energy.gov/biomass/pdfs/billion_ton_update.pdf).

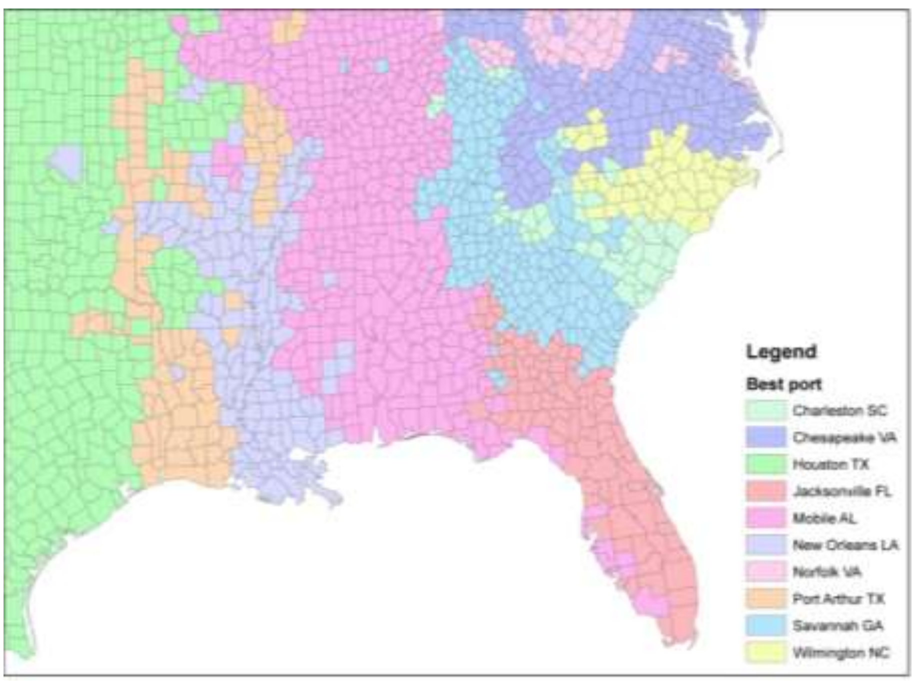
Figure 29 - All Forest Removals 2007; Pellet Plant Capacity 2009



Only a small proportion of the total removals were devoted to wood pellet manufacture. Moreover, much of the pellet production which existed in 2009 relied on primary (sawmill) and secondary (e.g., furniture manufacture) waste. Accordingly, most wood pellet production capacity was in relatively small facilities which were operated in conjunction with primary facilities. Over the last several years, larger wood pellet facilities, oriented towards manufacturing pellets directly from forest harvests have begun to emerge. These can also be seen in Figure 29. The production of many of the smaller plants is bagged and used for regional home heating needs. The wood pellet export sector is still in its infancy; therefore, the location of the larger facilities may be driven as much by the accidents of early market detection as by a search for the optimal location.

Figure 30 and Figure 31 show two components of domestic transportation costs which could affect the level and geographic distribution of wood pellet production in 2020. Port catchment areas are shown because the quantity of production in each catchment area helps determine the potential capacity of a needed port facility and therefore the potential economies of scale. These can be critical in minimizing the transport costs which have a significant impact of delivered price. Morehead City NC port is excluded from this analysis because the Enviva plants in Eastern NC and southeastern VA are already committed to the Chesapeake VA port. The optimal transportation mode also has an impact on inland delivery costs. In principle rail and waterway are less expensive modes of transport than truck. The size of a port hinterland which can be served by rail can determine the viability of rail service. A large hinterland along a rail line may make it feasible to establish "milk run" service, collecting cars loaded with export materials in one direction and returning the empty cars on the return trip. Such service might also be possible along specific waterways. In practice, railroads are oriented towards high volume, long distance service. North Carolina shippers often struggle to secure rail service. These factors help determine the relative costs of transporting pellets to ports, illustrated in Figure 32 for each county in the Southeast (the cheaper it is to transport material to a port, the lighter the county is shaded).[108]

Figure 30 - Port Catchment Areas in Southeastern US



[108] Port catchment areas, optimal transportation mode, and inland transportation costs were determined on the basis of data generated by CTA Transportation Networks (http://cta.ornl.gov/transnet/). Transportation "impedance" values which tap costs but are not directly tied to dollar values are graphed.

Figure 31 - Best Transportation Modes in Southeastern US

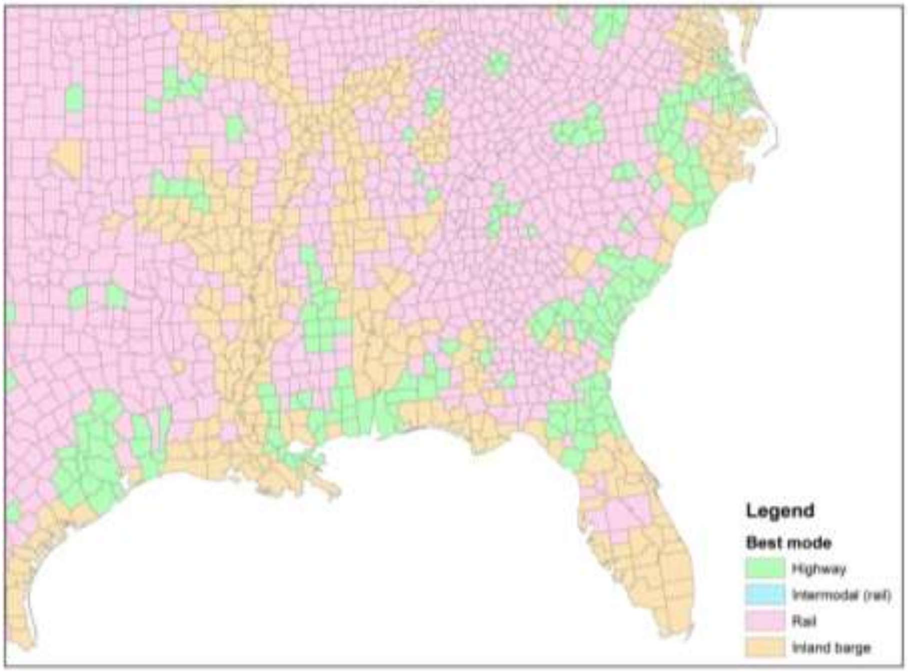


Figure 32 - Cost Impedance to Port in Southeastern US

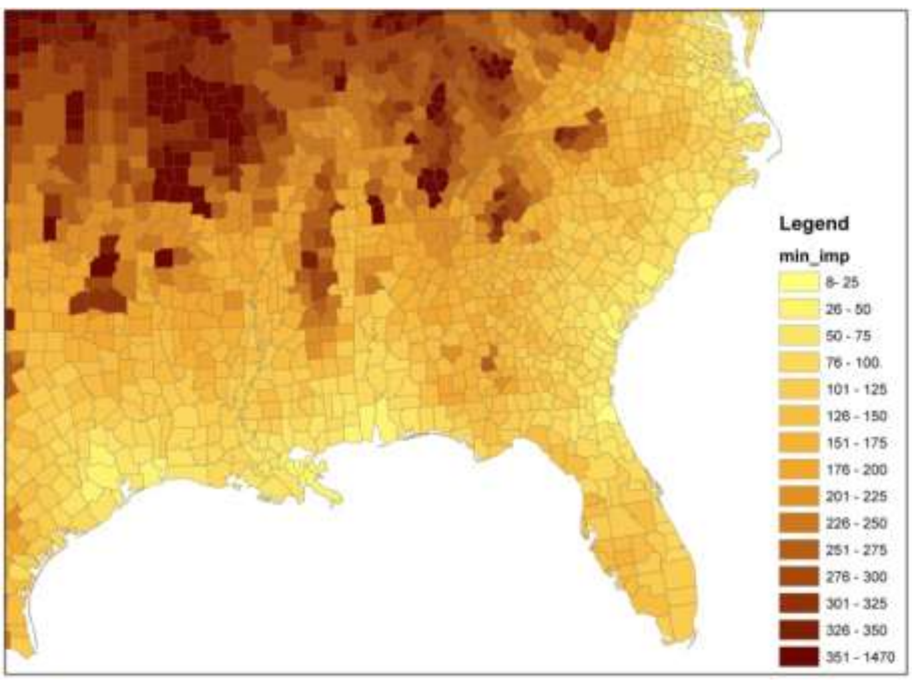
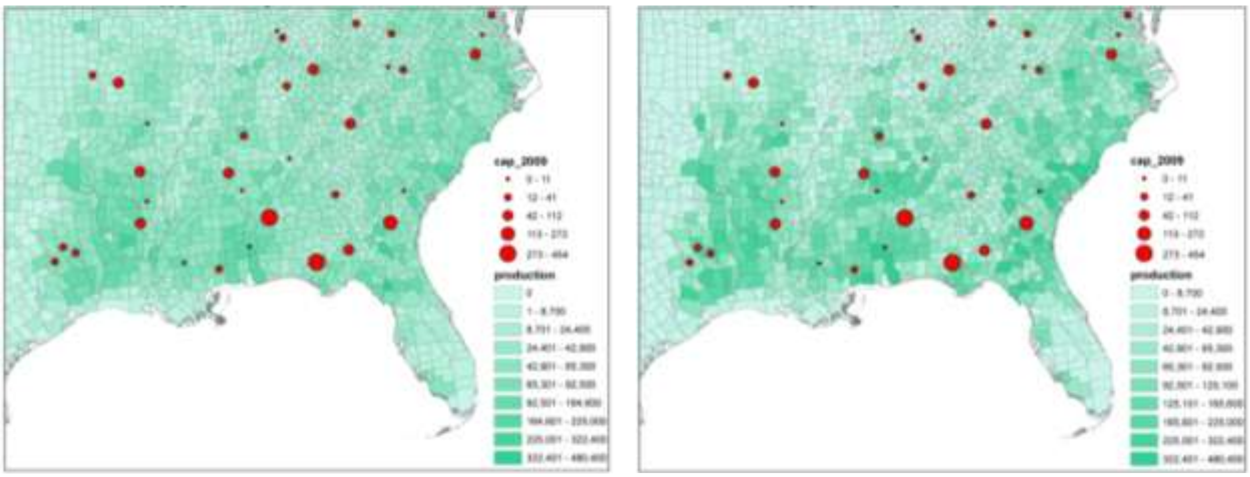


Figure 33 illustrates the estimated supply of forest biomass in 2020 at $70 and $100 per roadside tonne. These price levels approximately correspond to the range of delivered prices of wood pellets to Baltic ports discussed above. The assessments are drawn from the same Timber Product Output shown above and estimates of local supply curves over time at selected prices.[109] The lowest, $70, estimate corresponds closely with today's prices and the low range projection and the highest, $100, estimate corresponds to high projection (Figure 23). The increase in number of darker shaded counties indicates that more forest will come into production as the paid price increases.

Figure 33 – Southeast US Forest Biomass Supply in 2020

$70 per roadside ton $100 per roadside ton



Market share will likely shift over time as delivered prices rise and as transportation costs vary. At all prices, transportation costs contribute significantly to total delivered cost but will weigh more heavily on the production sites lacking low-cost connections to appropriately equipped ocean ports as illustrated. Because of its higher sensitivity to fuel costs, those areas relying on truck transport to deliver pellets from the site of production to the port of export will likely be relatively disadvantaged if diesel prices increase over time. Perhaps more importantly, as the price offered for wood pellets increases, producers in different regions are differentially induced to generate supply. Some of that shift is tied to changes in the composition of raw material used at various price points. Appendix 2 summarizes simple estimates of stat shares of production at selected prices in 2020. Two points standout. First, as offered price increases, the Southeast's share of national production increases from approximately 55 percent of national production at today's prices to 67 percent at the high range of the price projections. Second, Georgia's share of Southeastern production increases as the offered price goes up but the regional share for most states, including North Carolina, holds about steady. This does imply both growing production and national share.

[109] U.S. Department of Energy. 2011. U.S. Billion-Ton Update: Biomass Supply for a Bioenergy and Bioproducts Industry. R.D. Perlack and B.J. Stokes (Leads), ORNL/TM-2011/224. Oak Ridge National Laboratory, Oak Ridge, TN. 227p. (http://www1.eere.energy.gov/biomass/pdfs/billion_ton_update.pdf).

7.2 Appendix 2 - Estimated Forest Biomass Production at Selected 2020 Prices for Southeastern US

Production in U.S. tons

Price point	U.S. total	Southeastern total*	Georgia	North Carolina	Mississippi	Alabama	Arkansas	South Carolina	Texas	Louisiana	Florida	Virginia
60	65,232,500	34,969,700	4,006,200	3,507,400	3,526,100	2,699,000	2,554,700	2,114,800	2,419,000	2,898,100	1,689,700	2,688,100
70	77,503,000	42,562,000	5,200,300	4,213,000	4,170,200	3,306,200	3,224,400	2,596,300	3,402,000	3,278,600	2,525,100	2,971,600
80	100,214,800	53,752,700	7,215,500	5,439,200	5,117,600	4,688,200	4,183,200	3,608,500	3,808,500	3,960,300	3,407,400	3,585,700
90	98,006,300	64,166,600	9,231,400	6,603,400	6,191,400	5,865,000	5,149,100	4,665,300	4,656,900	4,513,600	4,230,200	3,926,800
100	109,877,000	73,311,900	10,531,400	7,277,200	7,253,100	7,578,300	5,759,600	5,325,800	5,465,000	5,204,700	4,703,200	4,551,900
110	119,599,300	81,048,000	11,771,700	8,038,300	7,939,000	8,832,200	6,394,000	5,911,100	6,039,300	6,095,300	5,227,100	5,065,600

Share of production

	(of U.S. total)	(of Southestern U.S. total)									
Price point	Southeastern total*	Georgia	North Carolina	Mississippi	Alabama	Arkansas	South Carolina	Texas	Louisiana	Florida	Virginia
60	0.5361	0.1146	0.1003	0.1008	0.0772	0.0731	0.0605	0.0692	0.0829	0.0483	0.0769
70	0.5492	0.1222	0.0990	0.0980	0.0777	0.0758	0.0610	0.0799	0.0770	0.0593	0.0698
80	0.5364	0.1342	0.1012	0.0952	0.0872	0.0778	0.0671	0.0709	0.0737	0.0634	0.0667
90	0.6547	0.1439	0.1029	0.0965	0.0914	0.0802	0.0727	0.0726	0.0703	0.0659	0.0612
100	0.6672	0.1437	0.0993	0.0989	0.1034	0.0786	0.0726	0.0745	0.0710	0.0642	0.0621
110	0.6777	0.1452	0.0992	0.0980	0.1090	0.0789	0.0729	0.0745	0.0752	0.0645	0.0625

* Also includesKentucky, Missouri, Tennessee, and West Virginia

7.3 Appendix 3 - Wood Pellet Companies

Company	Plant	State	Feedstock	Capacity	Status
Equustock Wood Fibers LLC	Equustock - Jasper	AL	Hardwood Softwood	40,000	OPERATIONAL
Lee Energy Solutions	Lee Energy Solutions	AL	Hardwood	110,000	OPERATIONAL
Nature's Earth Pellet Energy LLC.	Nature's Earth Pellets	AL	Hardwood Softwood	100,000	OPERATIONAL
Westervelt Renewable Energy LLC	Westervelt Renewable Energy	AL	Softwood	309,000	CONSTRUCTION
Zilkha Biomass Fuels LLC	Selma Plant	AL	Hardwood Softwood	303,100	PROPOSED
Superior Pellet Fuels LLC	Superior Pellet Fuels LLC	AK	Hardwood	12,000	OPERATIONAL
Fiber Energy Products AR, LLC	Fiber Energy Products AR, LLC	AR	Hardwood	11,000	OPERATIONAL
Nex Gen Biomass	Nex Gen Biomass	AR	Softwood	496,00	PROPOSED
Mallard Creek Inc.	Mallard Creek Inc.	CA	Softwood	30,000-60,000	OPERATIONAL
Confluence Energy	Confluence Energy	CO	Softwood	100,000	OPERATIONAL
Rocky Mountain Pellet Co. Inc.	Rocky Mountain Pellet Co. Inc.	CO	Softwood	40,000-65,000	OPERATIONAL
Green Circle Bio Energy Inc	Green Circle Bio Energy Inc	FL	Hardwood softwood	560,000	OPERATIONAL
First Georgia BioEnergy	First Georgia BioEnergy	GA	Softwood	374,785	PROPOSED
Fram Renewable Fuels LLC	Appling County Pellets LLC	GA	Hardwood softwood	220,460	OPERATIONAL

Fulghum Fibres Inc	Fulghum Fibres Inc	GA	Hardwood softwood	200,000	CONSTRUCTION
Georgia Biomass	Georgia Biomass	GA	Undisclosed	827,000	OPERATIONAL
SEGA Biofuels LLC	SEGA Biofuels LLC	GA	Softwood	100,000	PROPOSED
Varn Wood Products	Varn Wood Products	GA	Softwood	80,000	CONSTRUCTION
Woodlands Resources	Woodlands Resources	GA	Hardwood softwood	165,300	PROPOSED
Jensen Lumber Co.	Jensen Lumber Co.	ID	Softwood	15,000	OPERATIONAL
Lignetics	Lignetics of Idaho Inc	ID	Hardwood	Undisclosed	OPERATIONAL
North Idaho Energy Logs	North Idaho Energy Logs	ID	Softwood	60,000	OPERATIONAL
Olympus Pellets	Olympus Pellets- Hauser	ID	Softwood	40,000	
Qb Corp.	Lemhi Valley Pellets	ID	Softwood	1,000	OPERATIONAL
Rocky Canyon Pellet Co.	Rocky Canyon Pellet Co.	ID	Hardwood softwood	10,000	OPERATIONAL
American Pellet Supply LLC	APS-Indiana	IN	Hardwood softwood	300,000	OPERATIONAL
Koetter & Smith Inc.	Koetter & Smith Inc.	IN	Hardwood	Undisclosed	OPERATIONAL
Southern Indiana Hardwoods	Southern Indiana Hardwoods	IN	Hardwood	10,000	OPERATIONAL
Anderson Wood Products Co.	Anderson Hardwood Pellets	KY	Hardwood	25,000	OPERATIONAL
Highland Biofuels LLC	Highland Biofuels LLC	KY	Hardwood	100,000	PROPOSED
Somerset Pellet Fuel	Somerset Pellet Fuel	KY	Hardwood	Undisclosed	OPERATIONAL
Southern Kentucky Pellet Mill Inc.	Southern Kentucky Pellet Mill Inc.	KY	Hardwood	12,000	OPERATIONAL

Corinth Wood Pellets LLC	Corinth Wood Pellets LLC	ME	Hardwood softwood	75,000	OPERATIONAL
F.E. Wood & Sons - Natural Energy	F.E. Wood & Sons - Natural Energy	ME	Hardwood softwood	343,920	PROPOSED
Geneva Wood Fuels LLC	Geneva Wood Fuels	ME	Hardwood	90,000	OPERATIONAL
Maine Woods Pellet Co.	Maine Woods Pellet Co.	ME	Hardwood softwood	10,000	OPERATIONAL
Northeast Pellets LLC	Northeast Pellets LLC	ME	Hardwood softwood	40,000	OPERATIONAL
Fiber By-Products Corp.	Fiber By-Products	MI	Hardwood	60,000	OPERATIONAL
American Pellet Co.	American Pellet Co.	MI	Hardwood softwood	12,000	OPERATIONAL
B D Schutte Farms	Wolverine Harwood Pellets	MI	Hardwood	750	OPERATIONAL
Equustock Wood Fibers LLC	Equustock - Clare	MI	Hardwood softwood	80,000	OPERATIONAL
Kirtland Products LLC	Kirtland Products LLC	MI	Hardwood softwood	35,000	OPERATIONAL
Michigan Timber	Michigan Timber	MI	Softwood	18,000	OPERATIONAL
Michigan Wood Fuels	Michigan Wood Fuels	MI	Hardwood	48,000	OPERATIONAL
Vulcan Wood Products	Vulcan Wood Products	MI	Hardwood softwood	9,000	OPERATIONAL
Wood Pellet Coop	Wood Pellet Coop	MN	Hardwood	Undisclosed	OPERATIONAL
Enviva LP	Enviva Pellets Amory	MS	Hardwood softwood	150,000	OPERATIONAL
Enviva LP	Enviva Pellets Wiggins	MS	Hardwood softwood	551,000	PROPOSED

Ozark Hardwood Products	Ozark Hardwood Products	MO	Hardwood	40,000	OPERATIONAL
Eureka Pellet Mills Inc.	Eureka Pellet Mills	MT	Softwood	Undisclosed	OPERATIONAL
Eureka Pellet Mills Inc.	Eureka Pellet Mills	MT	Softwood	Undisclosed	OPERATIONAL
Horizon Biofuels Inc.	Horizon Biofuels Inc.	NE	Hardwood softwood	12,000	OPERATIONAL
New England Wood Pellet LLC	Jaffrey Manufacturing Facility	NH	Hardwood softwood	84,000	OPERATIONAL
Equustock Wood Fibers LLC	Equustock - Raton	NM	Hardwood softwood	50,000	OPERATIONAL
Mt. Taylor Machine	Mt. Taylor Machine	NM	Hardwood softwood	7,000	OPERATIONAL
Instantheat Wood Pellets Inc.	Instant Heat Wood Pellets Inc.	NY	Hardwood	50,000	OPERATIONAL
Associated Harvest Inc.	Associated Harvest Inc.	NY	Hardwood	8,000	OPERATIONAL
BioMaxx Inc.	Dry Creek Products	NY	Hardwood	100,000	OPERATIONAL
Curran Renewable Energy	Curran Renewable Energy	NY	Hardwood softwood	100,000	OPERATIONAL
Enviro Energy	Enviro Energy	NY	Ag	1,800	OPERATIONAL
Essex Pallet & Pellet	Essex Pallet & Pellet	NY	Hardwood softwood	36,000	OPERATIONAL
Hearthside Wood Pellets	Hearthside Wood Pellets	NY	Hardwood	600	OPERATIONAL
New England Wood Pellet LLC	Schuyler Manufacturing Facility	NY	Hardwood softwood	84,000	OPERATIONAL

New England Wood Pellet LLC	Deposit Manufacturing Facility	NY	Hardwood softwood	84,000	OPERATIONAL
Enviva LP	Enviva Pellets Northampton	NC	Hardwood softwood	402,000	OPERATIONAL
Enviva LP	Enviva Pellets Ahoskie	NC	Hardwood softwood	99,000	OPERATIONAL
Nature's Earth Pellet Energy LLC.	Nature's Earth Pellets NC	NC	Softwood	75,000	OPERATIONAL
Riverside Pellets LLC	Riverside Pellets LLC	NC	Hardwood softwood	50,000	PROPOSED
American Wood Fibers	American Wood Fibers - Circleville	OH	Hardwood softwood	50,000	OPERATIONAL
Bear Mountain Forest Products	Bear Mountain Forest Products - Cascade Locks	OR	Softwood	100,000	OPERATIONAL
Bear Mountain Forest Products	Bear Mountain Forest Products- Brownsville	OR	Softwood	30,000	OPERATIONAL
Blue Mountain Lumber Products	Blue Mountain Lumber Products	OR	Softwood	20,000	OPERATIONAL
Frank Pellets	Frank Pellets	OR	Softwood	21,000	OPERATIONAL
Ochoco Lumber Company	Malheur Pellet Mill	OR	Softwood	18,000	OPERATIONAL
Pacific Pellet LLC	Pacific Pellet LLC	OR	Hardwood	40,000	OPERATIONAL
Roseburg Forest Products	Dillard Composite Specialties	OR	Softwood	40,000	OPERATIONAL
West Oregon Wood Products Inc.	West Oregon Wood Products Inc.	OR	Softwood	50,000	OPERATIONAL

West Oregon Wood Products Inc.	West Oregon Wood Products Inc.	OR	Softwood	30,000	OPERATIONAL
Woodgrain Millwork Inc.	Woodgrain Millwork Inc.	OR	Softwood	Undisclosed	OPERATIONAL
Alexander Energy Inc	Alexander Energy Inc	PA	Hardwood	8,500	OPERATIONAL
Allegheny Pellet Corp.	Allegheny Pellet Corp.	PA	Hardwood	Undisclosed	OPERATIONAL
Barefoot Pellet Company	Barefoot Pellet Company	PA	Hardwood	45,000	OPERATIONAL
BioMaxx Inc.	PA Pellets	PA	Softwood	50,000	OPERATIONAL
BioMaxx Inc.	Nazareth Pellets	PA	Softwood	50,000	OPERATIONAL
Energex Inc.	Energex Pellet Fuel Inc.	PA	Hardwood	60,000	OPERATIONAL
Great American Pellets	Great American Pellets	PA	Hardwood	30,000	OPERATIONAL
Greene Team Pellet Fuel Co.	Greene Team Pellet Fuel Co.	PA	Hardwood	50,000	OPERATIONAL
Log Hard Premium Pellets Inc.	Log Hard Premium Pellets Inc.	PA	Hardwood	25,000	OPERATIONAL
Pellheat Inc.	Pellheat Inc.	PA	Hardwood	5,000	OPERATIONAL
Penn Wood Products Inc.	Penn Wood Products Inc.	PA	Hardwood	5,000	OPERATIONAL
Tri State Biofuels	Tri State Biofuels	PA	Softwood	50,000	OPERATIONAL
Wood Pellets C&C Smith Lumber	Wood Pellets C&C Smith Lumber	PA	Hardwood	30,000	OPERATIONAL
Inferno Wood Pellet	Inferno Wood Pellet Co.	RI	Hardwood softwood	Undisclosed	OPERATIONAL

Deadwood Biofuels LLC	Deadwood Biofuels LLC	SD	Softwood	71,000	OPERATIONAL
Heartland Pellet	Heartland Pellet	SD	Softwood	45,000	OPERATIONAL
Ace Pellet Co. LLC	Ace Pellet Co. LLC	TN	Hardwood	4,000	OPERATIONAL
Hassell & Hughes Lumber Co.	Hassell & Hughes Lumber Co.	TN	Hardwood	30,000	OPERATIONAL
Henry County Hardwoods Inc.	Henry County Hardwoods Inc.	TN	Hardwood	40,000	OPERATIONAL
Equustock Wood Fibers LLC	Equustock - Nacadoges	TX	Hardwood softwood	36,000	OPERATIONAL
German Pellets GmbH	German Pellets Texas	TX	Hardwood softwood	551155	PROPOSED
Patterson Wood Products Inc.	Patterson Wood Products Inc.	TX	Softwood	40,000	OPERATIONAL
Zilkha Biomass Fuels LLC	Crockett Plant	TX	Hardwood softwood	44,000	OPERATIONAL
Arbor Pellet LLC	Arbor Pellet LLC	UT	Hardwood softwood	20,000	OPERATIONAL
Beaver Wood Energy	Beaver Wood Energy	VT	Hardwood softwood	110,000	PROPOSED
Vermont Wood Pellet Co. LLC	Vermont Wood Pellet Co. LLC	VT	Softwood	14,000	OPERATIONAL
Equustock Wood Fibers LLC	Equustock - Troy	VA	Hardwood softwood	36,000	OPERATIONAL
American Wood Fibers	American Wood Fibers - Marion	VA	Hardwood softwood	75,000	OPERATIONAL

Ensign-Bickford Renewable Energies Inc.	Biomass Energy LLC	VA	Hardwood softwood	110,000	OPERATIONAL
Enviva LP	Enviva Pellets Southampton	VA	Hardwood softwood	551,000	PROPOSED
Equustock Wood Fibers LLC	Equustock - Chester	VA	Hardwood softwood	5,000	OPERATIONAL
Franklin Pellets	Franklin Pellets	VA	Hardwood softwood	500,000	PROPOSED
Lignetics	Lignetics of Virgina Inc.	VA	Softwood	Undisclosed	OPERATIONAL
O'Malley Wood Pellets	O'Malley Wood Pellets	VA	Hardwood	85,000	OPERATIONAL
Potomac Supply Corp.	Potomac Supply Corp.	VA	Softwood	Undisclosed	OPERATIONAL
Turman Hardwood Pellets	Turman Hardwood Pellets	VA	Hardwood	25,000	OPERATIONAL
Manke Lumber Co.	Manke Lumber Co.	WA	Hardwood	38,000	OPERATIONAL
Olympus Pellets	Olympus Pellets - Omak	WA	Softwood	40,000	OPERATIONAL
Olympus Pellets	Olympus Pellets - Shelton	WA	Softwood	40,000	?
Appalachian Wood Pellets	Appalachian Wood Pellets	WV	Hardwood	Undisclosed	OPERATIONAL
Hamer Pellet Fuel	Hamer Pellet Fuel Mt. Hope	WV	Hardwood	50,000	?
Hamer Pellet Fuel	Hamer Pellet Fuel Elkins	WV	Hardwood	60,000	OPERATIONAL
Lignetics	Lignetics of West Virginia Inc.	WV	Hardwood	Undisclosed	OPERATIONAL

American Wood Fibers	American Wood Fibers - Wisconsin	WI	Hardwood softwood	25,000	OPERATIONAL
Fiber Recovery Inc.	Fiber Recovery Inc.	WI	Hardwood	12,000	OPERATIONAL
Great Lakes Renewable Energy Inc.	Great Lakes Renewable Energy Inc.	WI	Hardwood softwood	82,000	OPERATIONAL
Green Friendly Pellets LLC	Green Friendly Pellets LLC	WI	Hardwood	17,000	OPERATIONAL
Greenwood Fuels	Greenwood Fuels	WI	Paper Waste	140,000	OPERATIONAL
Indeck Energy Services Inc.	Indeck Energy Ladysmith Biofuel Center LLC	WI	Hardwood	90,000	OPERATIONAL
Marth Peshtigo Pellet Co.	Marth Wood Shavings Supply	WI	Hardwood	31,000	OPERATIONAL
Marth Peshtigo Pellet Co.	Marth Peshtigo Pellet Co.	WI	Hardwood	25,000	OPERATIONAL
Pellet America Corp.	Pellet America Corp.	WI	Paper Wste	50,000	OPERATIONAL
Risley Pellet Solutions LLC	Risley Pellet Solutions LLC	WI	Hardwood	42,000	?
Bearlodge Forest Products Inc.	Bearlodge Forest Products Inc.	WY	Softwood	5,000	OPERATIONAL
South & Jones Timber	South & Jones Timber	WY	Softwood	7,000	OPERATIONAL