EASTERN HARDWOOD FOREST REGION WOODY BIOMASS ENERGY OPPORTUNITY

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Significant initiatives are underway within the US to both diversify the country's energy resource base and to address growing concern surrounding the role of fuel emissions in the context of global climate change. A multi-pathway approach is being pursued to engage these issues, and woody biomass derived energy represents a viable contributing avenue towards energy diversification and emissions reduction. The following report examines the woody biomass energy opportunity for the 35 states comprising the Eastern Hardwood Forest Region ("EHFR"), with the dual objectives of providing an educational overview of the market as it exists today, and offering a baseline reference resource for advanced, targeted feasibility studies within the wood fuel arena. An abbreviated summary of the opportunity is provided below.

MARKETPLACE OVERVIEW

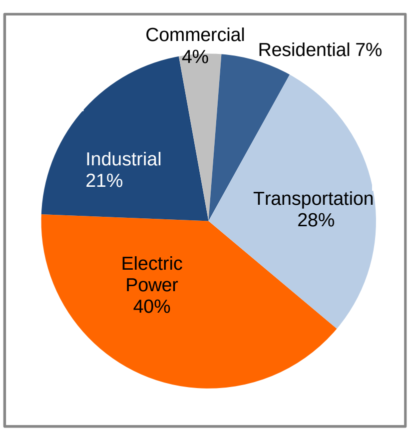
Wood fuel products compete within the broad domestic energy market. The following US energy market dynamics highlight sector parameters.

- The US consumes approximately 100 quadrillion btu's of energy on annual basis, representing approximately 22% of total world consumption. This consumption level has a retail market value of $1 trillion and represents 8.5% of US Gross Domestic Product (EIA, 2006a; BP, 2006a; EIA, 2007b).

- The energy market may be broadly segmented into the following five market sectors: Electric Power, Industrial, Commercial, Residential and Transportation. In addition, the following five primary fuel types are utilized within the US: Petroleum, Coal, Natural Gas, Nuclear Electric Power, and Renewable Energy (Figures 1 & 2).

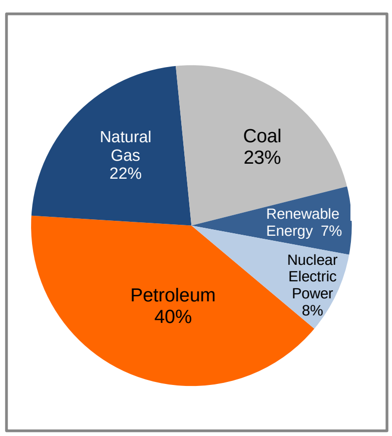
- Over the past three, five and ten years, aggregate domestic energy market consumption has increased at compound annual growth rates ("CAGR's") of 0.7%, 0.2% and 0.9%, respectively.

Figure 1: US Primary Energy Consumption by Sector (btu's)



Source: EIA, 2006a

Figure 2: US Primary Energy Consumption by Fuel Type (btu's)



Source: EIA. 2006b

EXECUTIVE SUMMARY

WOODY BIOMASS

The role of woody biomass within the energy sector today is relatively insignificant.

- The US consumes 2.2 quadrillion btu's of woody biomass energy on an annual basis, comprising slightly over 2% of total US energy consumption. Woody biomass represents approximately 70% of consumed biomass, which in turn represents 50% of the renewable energy category. (SRI estimates derived from EIA, 2005; EIA, 2006).

- At current prices, the wood fuel segment has an approximate market value of $6.5 billion.

- The market today consists of 4 primary commercialized product categories: Process Residuals, Wood Chips, Cordwood and Wood Pellets. Commercialized products are utilized by or sold into the Electric Power, Industrial, Commercial and Residential sectors (Figures 3 & 4).

- In addition, significant effort is underway to develop a next generation biofuels product set from integrated biorefineries with potential emerging products including bio-oil, syngas, cellulosic ethanol and Fischer Tropsch fuels. Beyond existing wood fuel markets, this product set would also establish a wood fuels presence in the Transportation sector.

- Over the past three, five and ten years, aggregate domestic wood fuel consumption has increased (decreased) at CAGR's of 1.9%, (1.5%), and (1.2%), respectively.

Figure 3: US Woody Biomass Consumption by Sector (btu's)

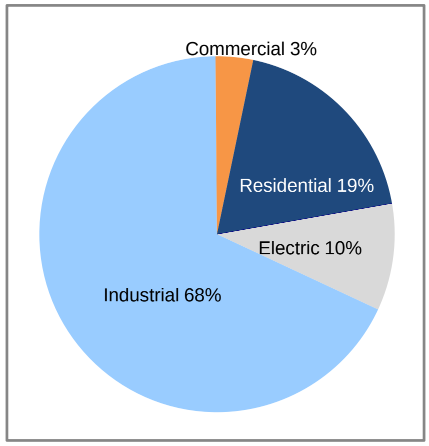
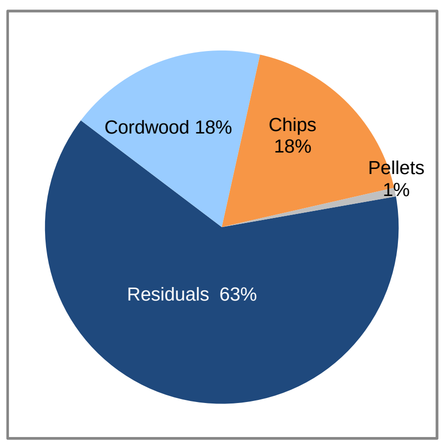


Figure 4: US Woody Biomass Consumption by Product (btu's)



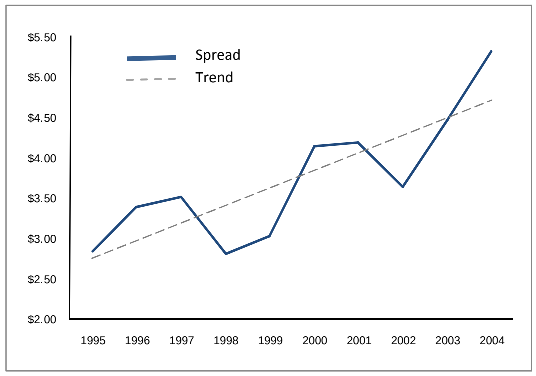
Source: SRI estimates derived from EIA, 2005; EIA, 2006; Lisle, 2006

EXECUTIVE SUMMARY

MARKET OPPORTUNITY

The woody biomass market opportunity is not a single vector to growth, but rather an aggregation of existing and emerging wood fuel products participating in multiple major energy market segments, competing against various primary fuel types. While the opportunity matrix is somewhat complex, in the case of wood fuels, the overall economic backdrop may be condensed into the following basic chart (Figure 5).

Figure 5: US Average Energy Price / Biomass Price Spread (Nominal $/Mbtu)



Source: SRI derived from EIA, 2004

Simply stated, within the US, the spread between the average price paid for all fuel types and the price paid for wood fuels is widening. While a variety of social, political and other factors will ultimately influence adoption thresholds and growth rates, all else being equal, woody biomass as an energy fuel source has become meaningfully more cost competitive over the past 10 years, and that trend is continuing today.

In the context of an increasing cost differential between biomass fuel costs and aggregate fuel costs, the following primary & secondary economic drivers have been identified as influencing adoption and market growth rates.

PRIMARY DRIVERS	SECONDARY DRIVERS
• Market Fuel Prices	• Market Size
• Policy & Incentives	• Local Market Conditions
• Feedstock Supply Dynamics	• Transportation Costs
• Technology & Infrastructure Investment	• Import/Export Markets
• Price Sensitivity of Demand	• Market Presence & Education

EXECUTIVE SUMMARY

MARKET GROWTH POTENTIAL

Under favorable market conditions, the EHFR has an estimated sustainable feedstock base available today to support consumption level growth in excess of 50% over existing levels. Forest products industry growth and changing practices are expected to support additional growth, for a total market size up to 100% greater than the current market. Finally, under high feedstock price scenarios it is possible that additional low-grade material currently utilized in other applications could become available to support further wood energy market expansion.

The EHFR woody biomass energy opportunity is an evolving landscape. It represents one of multiple component pathways towards achieving the dual macro objectives of domestic energy resource diversification and climate change mitigation. While the sheer size of the US energy market relative to the sustainable EHFR feedstock base will ultimately restrict the role of EHFR sourced woody biomass to a small percentage of the overall energy market, in the context of today's in-place wood fuels industry, the potential for significant growth off the existing base represents a meaningful market opportunity.

INTRODUCTION

INTRODUCTION

Within the United States energy industry, multiple economic, political and social variables are directionally converging to positively influence the market for domestically sourced alternative energy. As a result, a new demand paradigm is emerging and a potential unique window of opportunity exists for meaningful advancement of the domestic woody biomass energy market.

The following report will examine the opportunity to convert woody biomass within the Eastern Hardwood Forest Region ("EHFR") into wood fuels for energy applications. The analysis will explore the regional value creation chain, with an emphasis on identifying and assessing the key economic drivers of existing and emerging wood fuel products. Two primary objectives of this report are to provide an educational roadmap for understanding the market as it exists today, and to produce a baseline reference resource for further advanced, targeted feasibility studies in woody biomass energy applications.

The following introductory comments highlight primary macro variables driving the opportunity, as well as define the landscape, scope, informational framework and analytical structure of this report.

MACRO ENVIRONMENT

The broad US operating environment within which demand for wood fuel is derived is experiencing significant movement in favor of domestically sourced alternative energy. Trends in several important variables have meaningfully contributed to an increased interest in, and demand for, cost effective domestic energy sources. These variables include petroleum fuel costs, climate change conditions, energy related domestic security issues and investment capital flows.

INTRODUCTION

Petroleum Fuel Costs

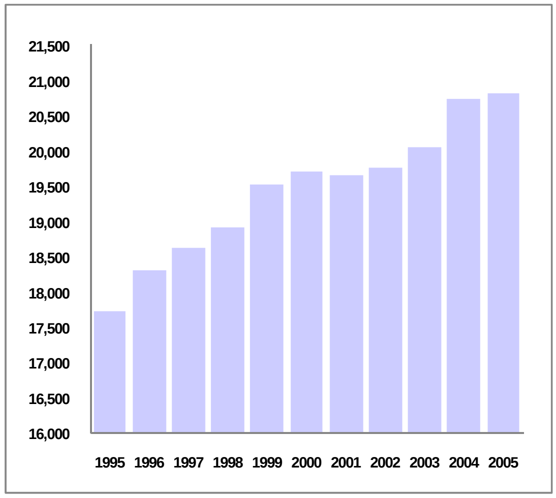
Petroleum represents the largest single energy source for the US and petroleum based products permeate the US marketplace. Over 20.8 million barrels of crude oil are consumed domestically on a daily basis, and usage has increased approximately 17% over the last 10 years, as relatively low crude prices have led to higher consumption levels for petroleum based products (Figure 6).

More recently, in response to increased global demand, crude prices have moved substantially higher. Over the five-year period ended 2005, crude oil prices have increased 86% from $30 to $56 per barrel. This increase comes on top of a rise in prices from $18 per barrel in 1995, and since 1995, crude oil prices have increased 207% (Figure 7).

The trend has continued further into 2006 and 2007, with prices trading in excess of $70 per barrel.

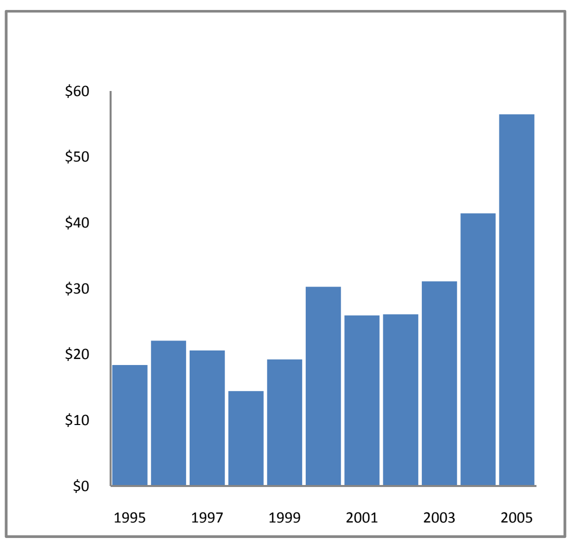
Over the short to intermediate term, demand for energy is relatively inelastic. As a result, despite higher energy prices consumers have maintained high usage levels, allocating an increasing proportion of capital resources to purchase energy, and reversing a longstanding domestic trend of declining energy costs in relationship to Gross Domestic

Figure 6: Thousands of Barrels per Day Supplied - US



Source: EIA, 2006c

Figure 7: Annual Average Crude Oil Price in $US per Barrel (WTI Spot Average)



Source: EIA, 2007a

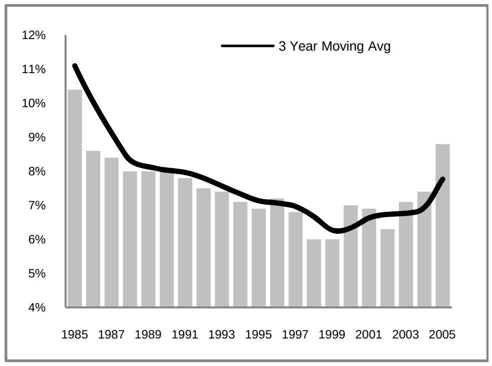
Since 1995, crude oil prices have increased 207%

INTRODUCTION

Product ("GDP") (Figure 8). Since 1999, annual energy expenditures have increased from 6% of GDP to nearly 9% in 2005.

One consequence of higher petroleum prices is improved cost competitiveness of alternative fuels in the marketplace. While early prices increases resulted in a transition from "cheap oil" to "less cheap oil", more recent continued increases have pushed price points to levels that have altered the pricing dynamics of the energy industry and created an environment where previously non-competitive alternative sources of energy can now compete more effectively on price.

Figure 8: US Annual Energy Expenditures as % of GDP



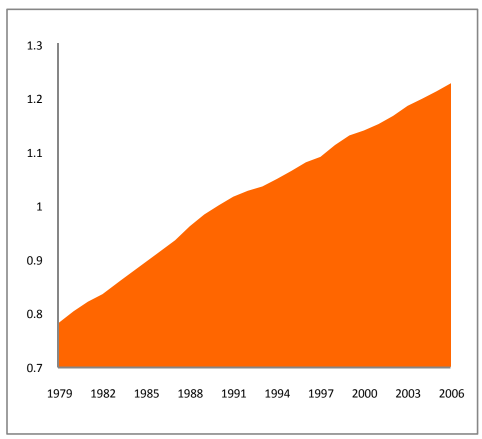
Source: EIA, 2007b

US energy expenditures have increased to nearly 9% of GDP

Climate Change Conditions

Increasing awareness of linkages between fossil fuel emissions and rising global temperatures has begun to play a material role in political, economic and social decision making both domestically and outside the US. The trend is clearly towards a growing consensus that global temperatures continue to rise, fossil fuel greenhouse gas emissions are meaningfully contributing to this rise, and higher temperatures are a negative outcome. A commonly cited index measuring global greenhouse gas concentrations, the NOAA AGGI, highlights the gas concentration trend in the atmosphere since 1979, with a 1990 benchmark year[1] (Figure 9).

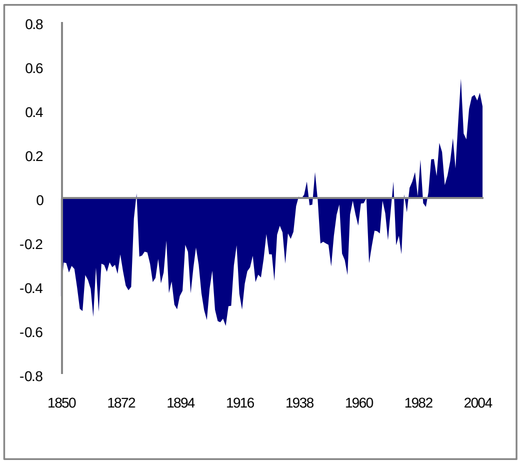
Figure 9: NOAA Annual Greenhouse Gas Index (AGGI) – Benchmark Year 1990



Source: Earth System Research Laboratory, Global Monitoring Division, 2006

[1] Global greenhouse gas concentrations are analyzed in terms of the changes in radiative forcing for the period beginning in 1979. An Annual Greenhouse Gas Index (AGGI) has been defined as the ratio of the total radiative forcing due to long-lived greenhouse gases for any year for which adequate global measurements exist to that which was present in 1990. The change in annual average total radiative forcing by all the long-lived greenhouse gases since the pre-industrial era (1750) is used to define the NOAA Annual Greenhouse Gas Index (AGGI)(Earth System Research Laboratory, 2006).

Figure 10: Global Temperatures Record, Global Air Temperatures Anomalies



Source: Jones, 2006

Correlating rising greenhouse gas concentrations is an upward trend in warmer global air temperature anomalies (Figure 10). This time series represents the combined global land and marine surface temperature record from 1850 to 2006. Only one year in the last twelve years was not one of the warmest on record.

Strengthening awareness and concern towards climate change issues favors alternative energy sources with lower greenhouse gas emissions profiles than traditional fossil fuels.

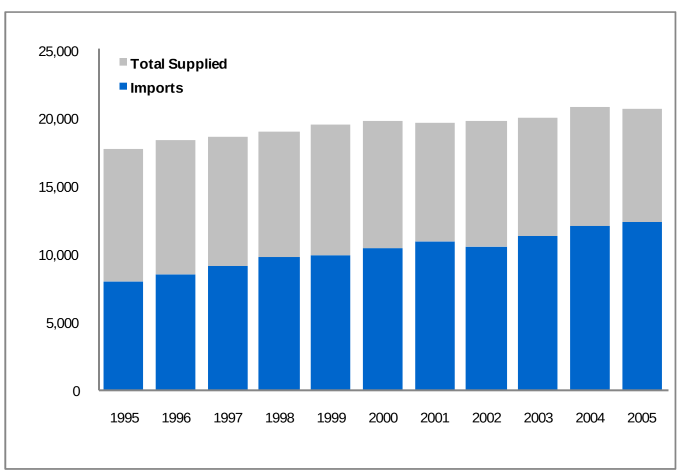
Only one year in the last 12 years was not one of the warmest on record since 1850

Domestic Energy Security

Compounding the issue of rising petroleum costs is the large and increasing percentage of oil that is imported into the country. Today, US crude imports account for over 60% of domestic oil consumption, up from 44% in 1995. Rising foreign oil imports increases US dependence on the external providers of this resource.

Further, from an energy security standpoint, this situation is exasperated by a relatively small and dwindling proven reserve base in the United States compared to the global reserve base, and regional concentration of reserves.

Figure 11: US Annual Net Petroleum Imports / Total Supplied Barrels



Source: EIA, 2006d

US crude imports account for over 60% of domestic oil consumption

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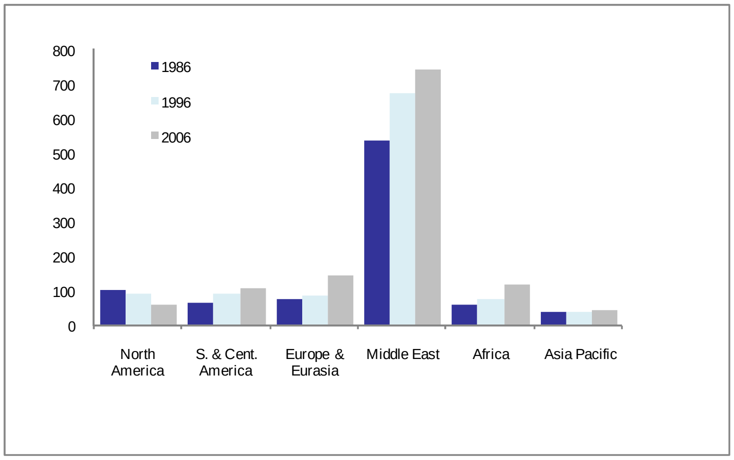
Figures 12 and 13 highlight the global distribution of proven oil reserves and changes in that distribution over the last 20 years[2]. Proved reserves in the Middle East region materially exceed all other regional reserve levels. It is worth noting, however, that significant unproved reserves do exist in North America in an area known as the Canadian

Figure 12: Global Proved Oil Reserves over Time 1986-2006 (billions of barrels)

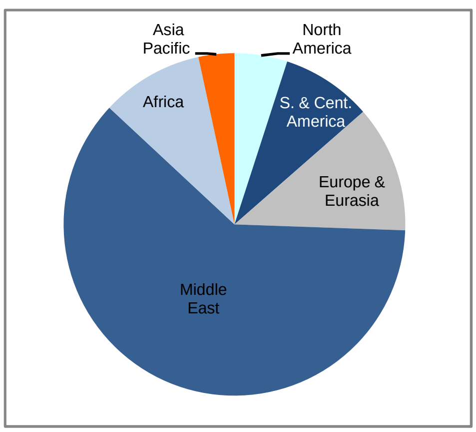


Source: BP Global, 2007a

Oil Sands (approximately 175 billion barrels). At current oil price levels, this region is being actively developed and is expected to yield significant additional supply over the years to come.

Excluding the oil sands, proved reserves within North America represent 5% of global proved supply, and this reserve level has steadily declined over the past 20 years on both an absolute and percentage basis of worldwide supply.

Figure 13: Global Proved Oil Reserves 2006 by Region



Source: BP Global, 2007a

Proved oil reserves within North America represent 5% of global proved supply

[2] Figures include official proved reserve estimate of 10.2 billion barrels for the Canadian oil sands. Unofficial estimates suggest approximately 175 billion barrels of oil sands reserves exist, second only to Saudi Arabia.

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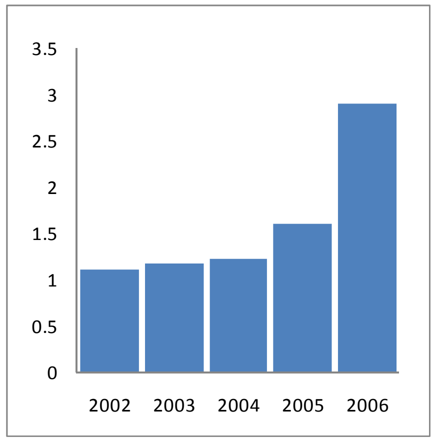
Investment Capital Flows

Capital investment in renewable energy has increased significantly over the past several years. Federal and state government initiatives are supporting improving market conditions, encouraging an acceleration of private capital deployment into the sector. Figure 14 highlights the increase in venture capital funding into the clean technology area over the past five years. From 2005 to 2006, North America venture capital spending increased 78% to $2.9 billion. Within the clean technology category, 2006 investment in biofuels increased sevenfold to $740 million from $110 million in 2005.

Figure 14: Annual Cleantech Investment North America ($ billions)



Source: Cleantech Network, 2007

Incremental capital resources dedicated to advancing alternative energy products and technologies will help build markets, create economies of scale, lower production costs, and increase the overall competitiveness of these products within the macro energy arena.

North America Cleantech venture capital spending increased 78% from 2005 to 2006

Impact of Macro Trends

While not an inclusive list, these primary identified trends in the macro environment are helping to set the stage and define the playing field for the biomass energy opportunity. It is important to note, however, that the actual timing and velocity of biomass energy market growth will be heavily influenced by more localized factors. In the context of favorable macro trends, the extent to which certain product and market specific thresholds have been reached in order to produce accelerated growth, must also be explored. The woody biomass energy market is an aggregation of various sub-markets, each with a unique set of opportunity drivers and varying levels of sensitivity to the macro trends discussed above. The growth profile of the Eastern Hardwood Forest Region woody biomass energy opportunity will ultimately be determined by specific product and market activity within the context of a favorable macro environment.

INTRODUCTION

LANDSCAPE OVERVIEW

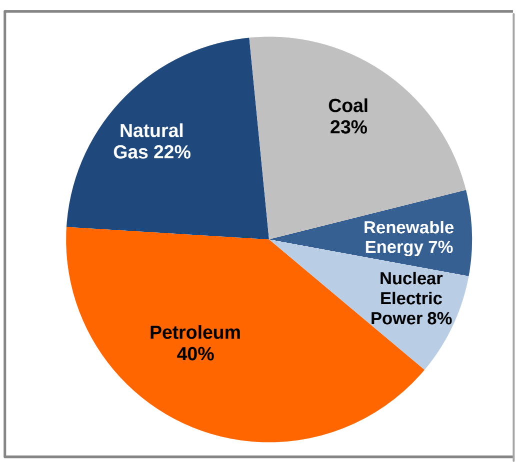
The wood fuel market occurs at the intersection of two primary US industries: Energy and Forest Products. Within the US, both industries are relatively mature and well established with a historically stable interrelationship. Woody biomass currently represents, on a btu basis, about 2.2% of annual US energy consumption (SRI estimate derived from EIA, 2005; EIA, 2006). Incremental demand will be heavily influenced by the ability of the forest products industry to deliver cost competitive feedstocks within the context of prevailing energy market conditions. Brief profiles of the two industries are provided below.

Domestic Energy Market

The US represents approximately 22% of global energy demand (BP, 2006a), and expends $1 trillion per year on energy. On a unit basis, the US consumes 100 quadrillion btu's of energy annually (EIA, 2006a). Approximately 40% of this energy is generated from petroleum based fuels, 23% from coal, 22% from natural gas, 8% from nuclear, and 7% from renewables (Figure 15). Within the renewables category, biomass represents 50% of the segment (Figure 16). Woody biomass comprises approximately 70% of the biomass category.

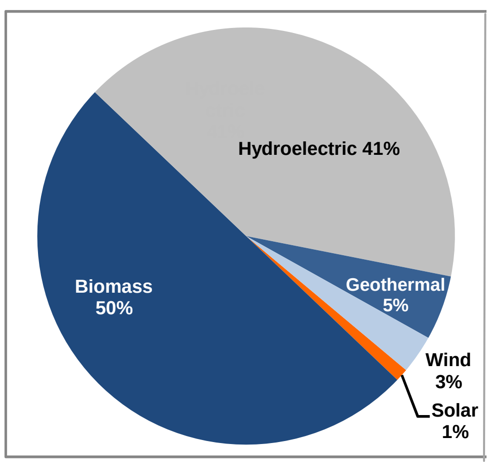
For the ten year period from 1995 to 2005, domestic energy consumption increased 9.8% or nearly 9 quadrillion btu's, resulting in a compound annual growth rate ("CAGR") of 0.94%. The DOE Energy Information Administration ("EIA"), projects consumption from 2005 to 2015 to grow another 12.2%, adding an additional 12 quadrillion btu annual demand, and resulting in an increased CAGR of 1.15% during this forecasted period (Figure 17).

Figure 15: US Energy Consumption by Energy Type



Source: EIA, 2006b

Figure 16: US Renewables Energy Consumption by Type



Source: EIA, 2005

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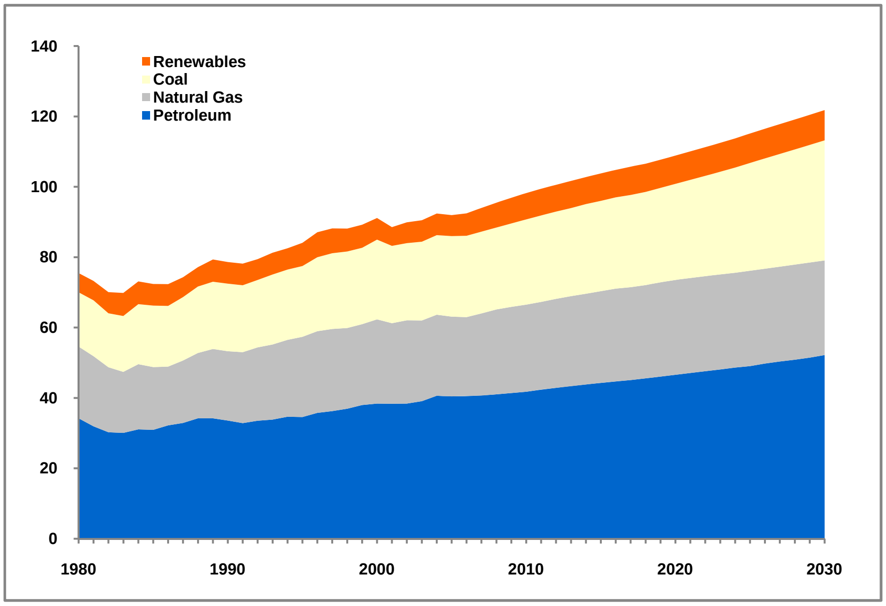
Figure 17: Historical & Projected US Energy Consumption (1980-2030 quadrillion btu's)



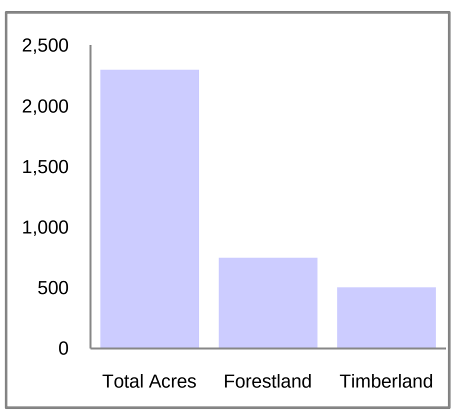
Source: EIA, 2005a

At current demand levels, energy prices have risen markedly. Additional forecasted consumption increases will place mounting pressure on supply, infrastructure and, most likely, energy prices.

Forest Products

The US land base consists of 2.3 billion acres. US forestlands cover 749 million acres or 33% of the total base. 504 million acres of forestlands are classified as higher productivity timberlands[3] (Figure 18).

Figure 18: US Land Composition (Acres - Millions)

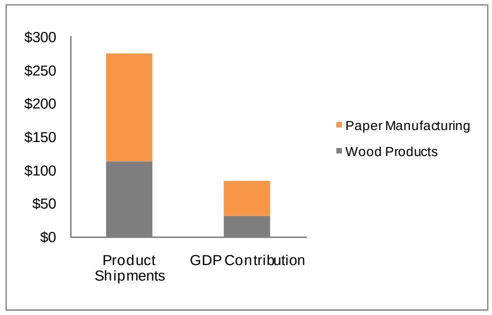


From this timberland and other sources, the US forest products industry produces $275 billion of

[3] Forestlands capable of producing greater than 20 cubic feet per year per acre and not legally constrained from timber production.

wood and paper products annually, and contributes $83.5 billion to GDP, representing slightly less than 1% of total annual gross domestic product (Figure 19).

Figure 19: US Forest Products Annual Value ($ billions)



Source: US Census Bureau, 2005 and 2006

When evaluating the US timberland base as a source of energy, it is worth considering how much energy exists today in the form of woody biomass. The USDA Forest Service estimates that approximately 24.6 billion dry tons of biomass exists on timberlands within the US (Smith et al, 2004a). Taking the informative, but completely unrealistic, assumption that all US timberland biomass is made available for energy use, this existing resource would provide approximately four years worth of US energy consumption[4]. This reference point highlights the relative size of the forest products resource base in the context of a much larger energy sector.

The estimated sustainable US woody biomass feedstock base can support a wood fuel energy market 2.5 times today's size

A more realistic assessment of annual woody biomass feedstock available for fuel applications is the sustainable level of various low-grade and "waste" materials that are by-products of forest products processing activities. These include logging residues, primary and secondary processor residues, fuelwood, urban wood waste, and fuel treatments. A commonly cited estimate of the sustainable level of forest derived resource is approximately 368 million dry tons annually (USDA, DOE, 2005). The energy content of this supply base represents approximately 6% of current annual US energy consumption, or 2.5 times the current wood fuel consumption level.

While availability of sustainable biomass feedstock ultimately limits the market share opportunity of the forest products sector within the much larger energy industry, the growth opportunity to more than double the existing woody biomass base is meaningful and represents a significant development opportunity before feedstock supply constraints begin to cap industry growth potential.

[4] Assumes 24.6 billion dry tons @ 17.2 mbtu per dry ton and annual energy consumption of 100 quadrillion btu's

INTRODUCTION

REPORT SCOPE

This report will provide an inclusive assessment of the woody biomass energy opportunity for the Eastern Hardwood Forest Region, evaluating the value creation chain beginning with woody biomass raw material in its various forms, and ending with delivered products and the markets they serve. The scope of this analysis, by design, is broad. This document is not intended to be a technical reference guide with local market precision, but rather an inclusive regional roadmap for understanding and further evaluating specific opportunities within this evolving market. The following four broad parameters have been established to further define the project scope.

Geographic Region

The geographic region available to provide feedstock for wood fuel applications is the 35 states comprising the Eastern Hardwood Forest Region. While the markets available for product distribution will not be constrained by this parameter, the raw material feedstock available for energy applications will be restricted to this region. Highlighted in Figure 20 are the states representing the EHFR.

Figure 20: Eastern Hardwood States

Source: Wood Education and Resource Center, 2007

Woody Biomass

For the purposes of this report, "woody biomass" will be defined as forest derived materials, and will not directly address conventional agricultural residues such as corn stover, grain straw, etc. It is worth noting that this delineation will likely blur over time as dedicated short-cycle energy crops emerge as a feedstock source and may include traditional forest materials grown and managed on agricultural lands in more of a standard agricultural regimen.

Fuel Products

The matrix of existing and emerging woody biomass based fuel product combinations is significant. This analysis will emphasize the commercialized products with the largest existing markets and the emerging products with the greatest market potential today. While, undoubtedly, niche products will continue to profitably exist and develop, the aggregate opportunity will be ultimately be defined by the largest successful product participants in the market.

INTRODUCTION

Energy Markets

Similar to the wide range of biomass derived fuel products, the range of potential market applications of these products is significant from both end market user segmentation and geographical standpoints. This report will emphasize the opportunity to distribute woody biomass fuels into major primary domestic energy market segments.

INFORMATIONAL & ANALYTICAL STRUCTURE

The woody biomass energy opportunity is best characterized as the aggregate performance of the multiple primary feedstock, product and end market channels. For the purposes of this report, segmentation of this opportunity will be broadly divided into four main areas of focus: woody biomass supply, wood fuel products, energy market demand, and integrated observations.

The economic analysis within this report will parallel the informational structure described above. Consistent with this structure, the analytical process will have three distinct categories. First, a feedstock analysis will classify and evaluate the raw materials available for further conversion or to be applied directly as biomass fuel. Second, conversion activities will be evaluated to outline cost and volume structure for the wood fuel product set. Finally, the energy sector will be evaluated and segmented into the primary markets within which the woody biomass fuel products will compete. The analytical process will identify the primary economic drivers of the opportunity and establish potential market opportunity scenarios based on reasonable estimates of these drivers.

Feedstock Supply

Procurement of raw feedstock is a primary consideration in any potential biomass to energy fuel opportunity. As will be highlighted later in this report, feedstock cost and availability varies widely across geographies, and is often the largest single cost component of a biomass derived fuel product. For these reasons, significant emphasis will be placed on identifying the primary feedstocks available for fuel, the characteristics of those feedstocks, the supply available, and the costs to procure for each of these feedstocks.

Woody biomass feedstock will be evaluated in the three broad categories of forest materials, wood processor residues and urban wood waste. These broad categories are further segmented as appropriate. The primary analytical output of the feedstock analysis is to establish feedstock cost structures and to address supply curves for raw feedstocks to be further processed into more refined fuels or applied directly to end markets for energy applications.

Feedstock Supply:

- ***Forest Materials***
- ***Processor Residues***
- ***Urban Wood Waste***

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Wood Fuels

The fuels section will explore the characteristics and manufacturing processes associated with the primary existing and emerging biomass fuel products. At the individual product level, this section will focus on fuel characteristics, market size, the conversion process, and the costs of production. The analysis will focus on the following five product sets: process residuals, wood chips, cordwood, wood pellets and emerging fuels.

Products:

- ***Process Residuals***
- ***Wood Chips***
- ***Cordwood***
- ***Wood Pellets***
- ***Emerging Fuels***

Energy Markets

End market demand will ultimately define the woody biomass energy opportunity. The primary market segments comprising the aggregate US energy market will be identified and described. Emphasis will be placed on defining broad market parameters, biomass fuel product positioning, and the competitive landscape.

Analysis of the energy industry will be segmented into five primary markets: residential energy, commercial energy, industrial energy, electric power and transportation. The opportunity to participate for each of the five wood fuel products described above will be evaluated in each primary energy market segments. It is important to note that energy market dynamics will play a key role in determining the woody biomass opportunity. Given the relatively insignificant market share of biomass based fuels in the broader energy markets, producers of these fuels will yield very little market power when it comes to selling prices. These producers will likely be price takers for the foreseeable future, and as a result, the market prices of the primary competing fossil fuels will heavily influence the profitability and growth profile of biomass based fuels.

Markets:

- ***Residential***
- ***Commercial***
- ***Industrial***
- ***Electric Power***
- ***Transportation***

Key Considerations

The final section of the report will highlight the key economic drivers and constraints of the aggregate opportunity. The combined procurement, conversion and market processes will be explored to identify the primary variables influencing the economic viability of the woody biomass energy markets. Drivers of both opportunity and risk will be assessed. Findings discussed in this section will be the outcomes obtained from the analytical process described below.

The analytical process will trace the primary contributing variables to the value-creation chain from feedstock procurement through end market distribution. All price points will be converted to a common unit of measurement (US $ per million btu's "Mbtu") in order to trace these components through the value chain. A "btu" (British Thermal Unit) is defined as the amount of heat required to raise one pound of water, one degree Fahrenheit. Additionally, where appropriate, point estimates of important variables will be supplemented with a corresponding range of values observed.

PROCUREMENT

PROCUREMENT

Availability and management of raw feedstock is a primary consideration in the evaluation of wood fuels. Feedstock is typically a major cost component in the biomass fuel production process, and consequently, significantly influences process economics. Beyond cost relevance, the basic consideration that feedstock represents the primary raw material required to produce biomass fuels, makes the availability of an uninterrupted supply a critical variable in production. As a result, expected supply parameters and confidence in those parameters will meaningfully impact industry development. This portion of the report will provide an overview of primary feedstock procurement considerations within the EHFR, explore the primary materials classifications used to segment the woody biomass feedstock market and evaluate a potential supply curve for these materials.

OVERVIEW

While the term "feedstock" has been introduced as a generic raw material from which woody biomass fuels are derived, in actuality the composition of and market for this material is anything but homogenous. Feedstock material represents a diverse set of procurement conditions, physical characteristics, and economic drivers. To further identify and explore these factors, an introductory discussion of procurement landscape dynamics, material specifications and analytical considerations is provided below.

Landscape Dynamics

Several overriding variables define the process and economics of procuring woody biomass as raw feedstock. These variables include the supply of cost-competitive low-grade wood available on a sustainable basis, the competitive environment, policies and incentives, resource ownership, operating environment, and social issues.

AGGREGATE LOW-GRADE WOOD SUPPLY

The introduction of this report highlighted an estimated 368 million dry tons of annual woody biomass available within the US for energy applications, representing a feedstock base to support a more than doubling of the current US wood energy market size. In order to put this national supply level into context of the EHFR, a closer examination of the national supply estimate is warranted. Of the 368 million ton annual supply, 279 million tons are currently available today without additional industry growth or changing practices. Of the 279 million tons available today, 142 million tons are currently utilized for existing energy applications. An additional 89 million tons are anticipated to be available in the future as a result of industry growth and changing practices (USDA, DOE, 2005).

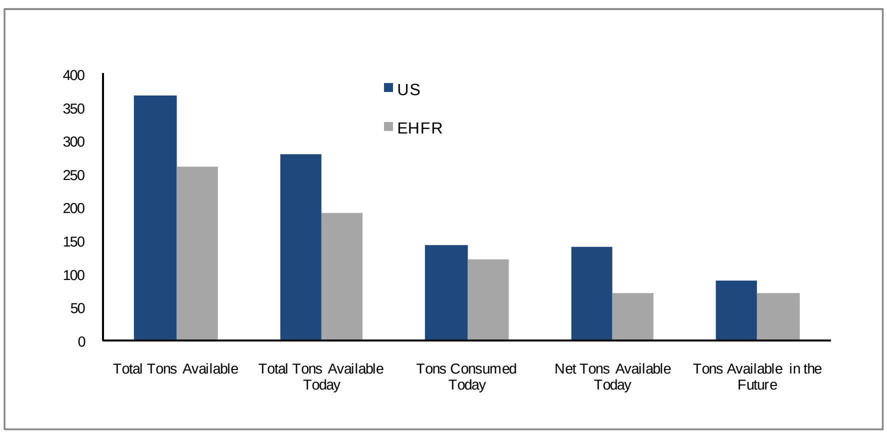
Within this framework, an estimated 260 million tons (71%) of the 368 million tons of projected annual US supply is or would be located within the geographic boundaries of the EHFR. Approximately 190 million EHFR tons are estimated to be available today, and 120 million tons of this amount are currently utilized for existing energy applications. An estimated 70 million tons available today are currently unutilized. In the context of the projected 89 million incremental tons to be available from industry growth and changing practices, an estimated 70 million tons of this amount would be derived from the EHFR, for a total incremental EHFR availability of approximately 140 million tons (Figure 21).

Overall, this assessment suggests that enough biomass feedstock is available today within the EHFR to support growth in excess of 50% over current consumption levels. With projected industry growth and changing practices, the supply level increases to a level supporting a doubling of current consumption.

EHFR biomass feedstock supports greater than 50% industry growth today and a doubling in the future

It is interesting to note that while the EHFR encompasses an estimated 71% of existing and future US feedstock supply, today the region represents approximately 85% of US current woody biomass consumption. Both positive and negative conclusions may be drawn from this observation. To the negative, the region faces higher relative demand for feedstock and potentially greater competition for a limited resource. To the positive, higher current consumption levels reflect relatively greater in-place infrastructure and investment by forest products and biomass energy consumers, which provides a larger footprint off of which industry growth may be achieved.

Figure 21: Estimated Annual Woody Biomass Feedstock Supply (Dry Tons - Millions)



Source: SRI estimates derived from USDA, DOE, 2005; Walsh et al, 2000; Graham et al, 1999

PROCUREMENT

COMPETITION

As might be expected, the competitive landscape plays an important role in determining the price and level of EHFR feedstock available for energy applications. Several contributing factors are highlighted below.

- Non-energy based demand for woody biomass feedstocks. Of the approximately 90 million dry tons of primary wood processing mill residues generated annually, about 55% of this material is currently utilized for higher value non-energy based products such as mulch, bedding, charcoal, pulp or composite wood products (Walsh et al, 2000).

- EHFR woody biomass fuel feedstocks may compete against different regions with similar available feedstock products. For example, the Western region of the US has a large amount of fuel treatment material potentially available for consumption. This available material under the right economic conditions could encourage new market entrants to locate outside the EHFR wood basket.

- Availability of other forms of biomass, such as agricultural residues, may decrease demand for woody biomass feedstock.

- Additionally, cost and availability of traditional non-biomass fuels will heavily influence the demand for and competitive positioning of EHFR woody biomass.

POLICY & INCENTIVES

Favorable government policy and a corresponding set of attractive incentives have the potential to significantly positively impact both the absolute growth trajectory of the woody biomass energy market and the velocity of that trajectory. Historically, at the procurement level, educational programs, research and development initiatives, as well as cost sharing and other financial assistance programs, have all supported low-grade woody biomass feedstock markets.

More recently, with increased emphasis at the government level on expanding the domestic renewable energy base, additional incentives are arising with the potential to further support industry development. Specifically, several legislative initiatives at the federal (Energy Policy Act 2005 and Farm Bill 2007) and state levels (State of Texas H.B. 1090) have emerged that provide funds to support low-grade woody biomass utilization efforts, and in some cases, effectively subsidize biomass feedstock procurement costs to varying degrees for renewable energy applications. Additional policies and incentives surrounding issues such as load hauling limits and fuel treatment (fire suppression) activities would also have the potential to improve feedstock procurement economics.

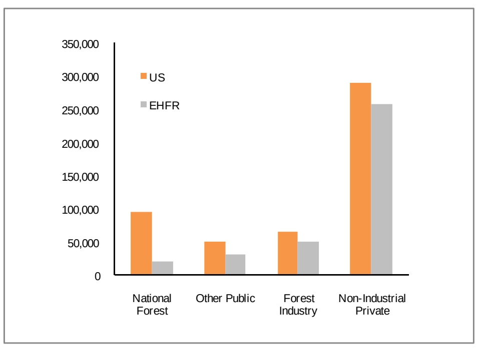
PROCUREMENT

RESOURCE OWNERSHIP

Four primary categories of timberland ownership exist in the US today. These are National, Other Public, Forest Industry and Non-Industrial Private. The distinction between public and private owners is particularly relevant because opportunities and restrictions towards biomass removal vary meaningfully by ownership type. Today, approximately 92% of growing stock removals within the US come from privately owned timberlands versus 8% of removals from publicly owned lands. Of the 504 million acres of timberland in the US, approximately 71% of this land is privately owned. Within the EHFR, 85% of timberland is privately owned. Figures 22 & 23 highlight the relative ownership profiles of US and EHFR timberland.

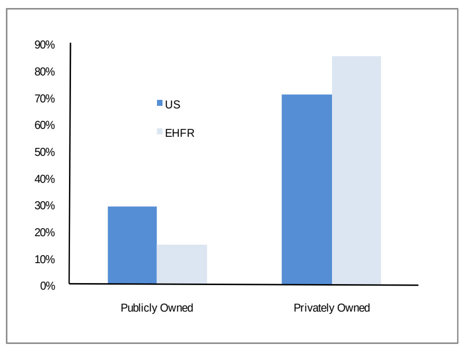
85% of EHFR timberland is privately owned

Figure 22: Timberland Ownership Profiles (000's acres)



Source: Smith et al, 2004b

Figure 23: US & EHFR Timberland Ownership, Public vs. Private



Source: Smith et al, 2004b

OPERATING ENVIRONMENT

When considering the procurement process within the EHFR, climate and geography play a role. For example, while wildfire is a large concern in the Western US, the EHFR has a relatively smaller issue with fire, so fuel treatment derived biomass opportunities are more limited. Forest floor and road conditions can vary significantly across the region. Topography plays an important role in accessibility of material. These general operating conditions account for significant variability in the regional and local biomass removal cost structures.

SOCIAL CONSIDERATIONS

Finally, social issues, while often difficult to quantify, can have a meaningful impact on availability of supply. These considerations may have both a positive and negative impact on feedstock costs. Markets may be subject to strong habitat protection and conservation initiatives that constrain available supply. Alternatively, markets may be located in development friendly corridors, which have the potential to provide a significant source of supply, albeit somewhat temporary and one-time in nature. In any event, the role of local communities' attitudes towards biomass procurement activities is a relevant consideration.

Material Specifications

Feedstock is typically classified based upon the source of the material (forest, processor, waste). While this is a useful and consistent method of segmentation, other important characteristics also distinguish these materials in wood energy applications, and are therefore worth highlighting. Form & consistency, species, moisture content and contamination fall into this category.

FORM & CONSISTENCY

From sawdust to black liquor to whole logs, the initial physical form of raw feedstock varies greatly. While each of these products is derived from woody biomass, form of material has implications on the usefulness of the material for fuel applications, the level of additional processing and handling required to utilize the feedstock, and ultimately, the cost of utilizing the material. For example, while black liquor is an attractive primary low-cost source of heat and power for industrial pulp and paper companies, it has little application in the residential heating market.

Often equally important, is the consistency of the physical product in whatever form it is provided. A consistent product will generally require less additional processing and cause fewer process problems, and therefore has additional economic value.

SPECIES

Wood feedstocks are often broadly segmented as hardwood or softwood. A common misperception related to these classifications is that softwoods have lower energy content than hardwoods, and thus are a less desirable feedstock. It is true that softwoods tend to be less dense than hardwoods and therefore when volume is used to measure energy content (as it typically is in the residential firewood market), the energy content of softwood will generally be lower on a volume unit basis. However, when weight is used as the measure of material, softwoods are comparable to hardwoods. In other words, the energy content per pound of material between softwood and hardwood species is similar and both can be attractive sources of feedstock.

PROCUREMENT

MOISTURE CONTENT

Moisture content is another distinguishing characteristic of biomass feedstock. Moisture levels of "green" feedstock can exceed 50%. The negative implications of higher moisture content include greater transportation cost (hauling water) and lower energy efficiency of the feedstock (energy is consumed as water is heated and evaporated during the fuel consumption process). Positive attributes of higher moisture content include fuel stability as it relates to undesired combustion, and in some cases, ease of processing the material. In any event, when evaluating feedstock cost based on material weight, moisture content is an important consideration.

CONTAMINATION

Similar to the issues around feedstock physical characteristics, contamination levels impact the suitability of certain biomass streams for energy applications. Typically, urban waste streams consisting of construction and demolition ("C&D") and municipal solid waste ("MSW") are the feedstock sources that have the greatest contamination levels. Contaminants can include paints, stains, chemicals and minerals and these "dirty" streams are generally not well suited for biomass energy purposes.

Analytical Considerations

In order to assess the major cost drivers within the feedstock procurement process, it is helpful to consider the primary cost elements associated with procuring raw feedstock, the variability of these costs, and the sensitivity of these costs to changes in demand. This final point is particularly relevant in the case of an expanding woody biomass fuel industry and will be addressed in detail in the upcoming "Supply Curve" section of this report.

PRIMARY COST ELEMENTS

Feedstock procurement costs may be broadly segmented into the following three primary buckets: the price paid for the raw material itself, the costs associated with collecting and handling the material, and the costs associated with transporting the material from the source to a secondary facility for further processing or consumption.

Raw Material Costs

At today's market prices, the uncollected/undelivered value of low-grade woody biomass feedstock is limited. In many cases, this material is simply the remaining waste stream of other higher value added processes and has little incremental worth as a stand alone raw material. Typically, the majority of the price paid by purchasers of biomass feedstock represents the costs of collection and transportation rather than the value of the material itself.

Today, the majority of biomass feedstock cost comes from collection and transportation rather than the value of the material itself

However, it is important to note, that today a major portion of the wood processor waste stream is utilized by the industrial forest products companies that generate residuals through their operations. These processors have high electrical and thermal needs that can be met by converting their on-site waste streams to energy. In this case, the material is effectively already collected and delivered to the user, and thus has value to the manufacturers. While this material could potentially be available to other external users, the value of the biomass is really the energy savings generated from utilizing the material internally and would likely make the resource cost-prohibitive to most external interests.

Another consideration related to uncollected/undelivered material values is that while increases in fossil fuel prices will improve the macro operating environment for woody biomass as a competitive feedstock, price increases in the material cost component may be somewhat restricted due to exposure of the collection and transportation components to fossil fuel prices. Higher overall prices paid for biomass feedstock as it becomes more competitive, will be partially offset by higher collection and transportation costs. Ultimately, the value of the raw material is capped by what the market is willing to pay for the feedstock minus the cost of collecting and delivering the material. In most cases, a reasonable range for uncollected/undelivered feedstock is < $0.10 per Mbtu at the low end for wood waste and residues, up to $1.50 per Mbtu for low-grade logs, where moderate stumpage fees are paid[5].

Collection Costs

Material collection costs can vary significantly based on feedstock type and site conditions. In the case of primary industrial processors utilizing their own residual waste streams on-site, collection costs are minimal. On the other hand, collecting forest residues may involve harvesting, densification, skidding/forwarding, and chipping to prepare the material for transportation to a secondary facility. Collection costs may range anywhere from <$0.10 per Mbtu to over $3.50 per Mbtu depending on the collection scenario[6].

Transportation Costs

Hauling costs also play an important role in the economics of woody biomass procurement. Material is typically transported by truck, sometimes rail, and as might be expected, costs increase with distance traveled.

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[5] SRI estimate derived the following primary sources: US Department of Conservation, 2007; The Journal of Southern Timber Market News, 2007; and from field conversations.

[6] SRI estimate derived from the following primary sources: USDA, Forest Operations Research Unit, Southern Research Station, 2004; Lumberjack Resource Conservation and Development Council, Inc., 2005; Biomass Energy Resource Center, Sherman, 2007; and from field conversations.

PROCUREMENT

An additional transportation issue relates to the relatively lower energy density of the biomass material compared to alternative fuel sources. The consequence of this is a competitive disadvantage of woody biomass in the marketplace, as it costs more to transport an Mbtu of biomass than an Mbtu of coal, for example. This density issue increases the importance of logistical planning to minimize haul distances, particularly for transporting green feedstocks, where 50% of the haul weight can be water.

Transportation costs may range from nil for material already on-site to $1.25 per Mbtu for typical distances of less than 100 miles. Longer hauling distances may incur greater transportation costs[7].

COST VARIABILITY

Although feedstock is generally classified into several broad categories of materials, the pricing of these materials does not represent the implied commodity nature of the products. Within each major feedstock classification, significant variably in cost exists on an intraregional, regional and US basis. This variability can be a function of localized supply/demand situations, accessibility of material, geographic proximity to markets, development activities, fuel treatment efforts, and other factors. This report emphasizes a somewhat stabilized regional perspective of estimated feedstocks costs. In the context of this regional average, it is important to consider the accompanying discussion surrounding the range of variability representing this average, to appreciate the opportunity and risks surrounding feedstock procurement costs.

FEEDSTOCK COST & SUPPLY CURVE ESTIMATES

The following "Primary Materials" and "Supply Curve" segments of this report provide estimates of cost and availability for the major woody biomass feedstock categories. These data points rely heavily on information provided from the following two primary sources: Walsh, Marie, et al. "Biomass Feedstock Availability in the United States: 1999 State Level Analysis", 2000; and Perlack, Robert, et al. "Biomass as Feedstocks for a Bioenergy and Bioproducts Industry: The Technical Feasibility of a Billion-Ton Annual Supply", 2005. Additional secondary sources are noted as appropriate, and price data presented are current SRI estimates derived from these sources.

[7] SRI estimate derived from the following primary sources: Lumberjack Resource Conservation and Development Council, Inc., 2005.; USDA Operations Research Unit, Southern Research Station , 2004; Graham et al, 1995.; Northern Woodlands Magazine, 2007; and from field conversations.

PROCUREMENT

PRIMARY MATERIALS

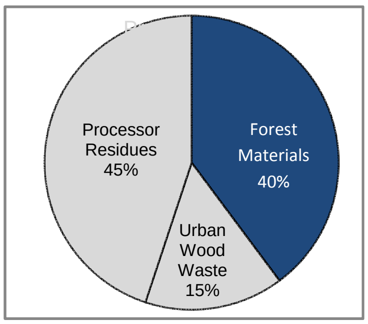
Woody biomass feedstocks are often classified into the major categories of forest materials, processor residues and urban wood wastes, reflecting the primary, secondary and tertiary source bases of this material. A description and assessment of each category is provided below.

Forest Materials

Approximately 73 million dry tons of forest materials are estimated to be available today within the EHFR

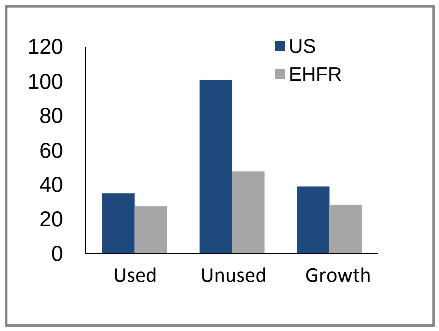
Forest materials may be broadly defined as feedstock collected directly from forestland. These materials consist of forest residues from forest management and land clearing operations, as well as low-grade whole logs. Within this category, collection costs tend to vary significantly based upon location of material within the forest, terrain, collection equipment deployed, potential higher value-added applications, and proximity of feedstock to its delivered location. The following section will examine the characteristics, supply, and procurement costs for each of the primary categories of forest based feedstock.

Figure 24: EHFR Woody Biomass Annual Supply - Forest Materials % of Total



Source: SRI estimate derived from USDA, DOE, 2005; Walsh et al, 2000

Figure 25: Annual Supply Composition - Forest Materials (Dry Tons Millions)



Source: SRI estimate derived from USDA, DOE, 2005; Walsh et al, 2000

FOREST RESIDUES

Forest residues are the byproducts of forest management activities and land conversion operations, and represent an often otherwise unutilized source of raw material. Residues may be produced from clearing, logging, thinning and fuel treatment activities. Several collection methods exist for the removal of forest residues. These residues can be integrated into existing logging operations where they are simultaneously processed along with higher value timber, or the residues may be left behind for future removal as a separate activity. It is generally more cost effective to integrate the activities, particularly when there are opportunities to reduce skidding/yarding costs. Another interesting collection method being evaluated today is forest residue bundling, where forest biomass is collected and wrapped into cut-to-length bundles which may then be handled with conventional log-handling equipment. In general, forest residues represent a significant source of woody biomass feedstock to the extent they can be cost effectively processed.

Sustainable Annual Supply

The estimated sustainable annual supply of logging/thinning residues in the US available today is 41 million dry tons. Approximately 33 million dry tons of this material is located within the EHFR. Very little of this material is being utilized today. Within the US, an additional 23 million dry tons is expected to be available in the future from industry growth and changing practices. A reasonable estimate of the future amount to be located within the EHFR would be 17 million dry tons.

The estimated sustainable annual supply of fuel treatment residues available in the US is 60 million dry tons. Nearly all of this material is available today, however the majority of this amount is located outside of the EHFR. Approximately 14 million dry tons of this material is estimated to be located within the EHFR.

Cost to Procure

It is estimated that the majority of EHFR forest residues may be procured today for $2.40 to $4.00 per Mbtu with an estimated weighted average cost of $2.95 per Mbtu.

LOW-GRADE LOGS

Both low-grade fuelwood and pulpwood logs are harvested under conventional logging methods to satisfy the needs of the pulp and paper products industry, and residential home heating customers. This material is readily available, but typically commands a stumpage payment upon harvest and therefore often represents the highest cost source of low-grade woody biomass.

Sustainable Annual Supply

Annual consumption of fuelwood in the US today is estimated at 35 million dry tons. Approximately 25 million dry tons of this material is located within the EHFR. All of this material is being utilized today. Within the US, an additional 16 million dry tons is expected to be available in the future from industry growth and changing practices. A reasonable estimate of the future amount to be located within the EHFR would be 11 million dry tons.

While not included in this analysis, over 50 million dry tons of pulpwood is harvested within the US each year at stumpage prices comparable to or moderately higher than the upper end of the fuelwood price range. It is possible under a high price feedstock scenario, that a portion of this material could be utilized for energy applications.

PROCUREMENT

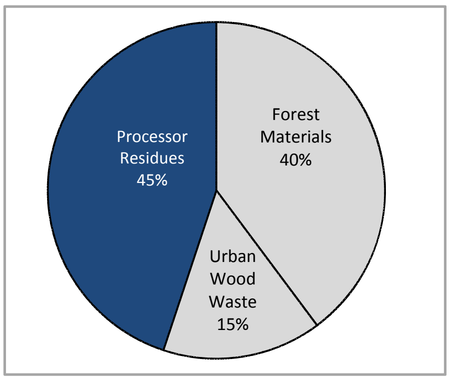
Cost to Procure

The estimated costs to procure fuelwood range from $1.60 to $5.60 per Mbtu with an estimated weighted average cost per Mbtu of $3.83.

Wood Processor Residues

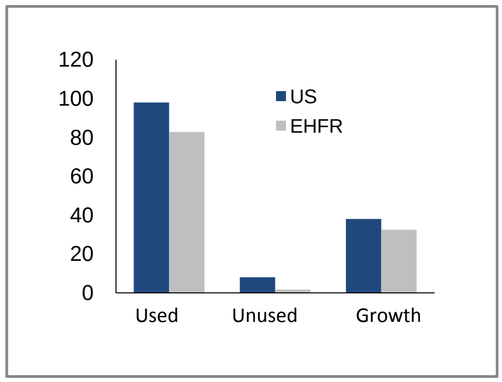
Two main tiers of wood processor residues exist. Primary processors consist of sawmills,

Figure 26: EHFR Woody Biomass Annual Supply – Wood Processor Residues % of Total



Source: SRI estimate derived from USDA, DOE, 2005; Walsh et al, 2000

Figure 27: Annual Supply Composition – Wood Processor Residues (Dry Tons, Millions)



Source: SRI estimate derived from USDA, DOE, 2005; Walsh et al, 2000

and pulp & paper manufacturers, while secondary processors consist of wood product manufacturers. Processor "waste" is generally not wasted at all. In fact, as Figure 27 highlights, very little wood processor residue is available today. The processors themselves are efficient users of their residues, either for internal process heat and power or for higher value uses, such as mulch, bedding, charcoal, pulp or composite wood products. In addition, the residues that are utilized by the processors for heat and power applications may not be available at reasonable prices to external users because the real cost of these residues to the processor is often the cost of the fossil fuel that is being displaced by the wood fuel products.

Approximately 84 million dry tons of wood processor residues are estimated to be available today within the EHFR

PRIMARY PROCESSORS

The primary processors, sawmills and pulp & paper producers, generate four primary residue types. These include fines, course residues, bark and black liquor residues. Fines are typically sawdust and other small particle material too small for chipping. These residues are used primarily for fuel, bedding and fiber products. Coarse residues are mainly slabs, chunks, edges and veneer cores that are chipped for use in pulp & paper, engineered products and other applications. Bark is typically used as mulch and fuel. Black liquor is used to generate heat, steam and electricity as part of the paper manufacturing process.

Sustainable Annual Supply

The estimated annual supply of primary processor residues in the US available today is 100 million dry tons. Approximately 79 million dry tons of this material is located within the EHFR. Substantially all of this material is being utilized today. Within the US, an additional 38 million dry tons is expected to be available in the future from industry growth and changing practices. A reasonable estimate of the future amount to be located within the EHFR would be 33 million dry tons.

Not included in this amount is an additional estimated 49 million dry tons produced annually that is diverted to the other higher value uses. Similar to pulpwood, it is possible under a high price feedstock scenario, that a portion of this material could be utilized for energy applications.

Cost to Utilize

The estimated costs to utilize primary processor residues range from $1.60 to $2.40 per Mbtu with an estimated weighted average cost per Mbtu of $2.09.

SECONDARY PROCESSORS

Secondary processors utilize products produced by primary processors and typically produce coarse and fine residues. These materials have the similar applications as those produced by primary processors.

Sustainable Annual Supply

The estimated annual supply of secondary processor residues in the US available today is 6 million dry tons. Approximately 5 million dry tons of this material is located within the EHFR. Most of this material is estimated to be available.

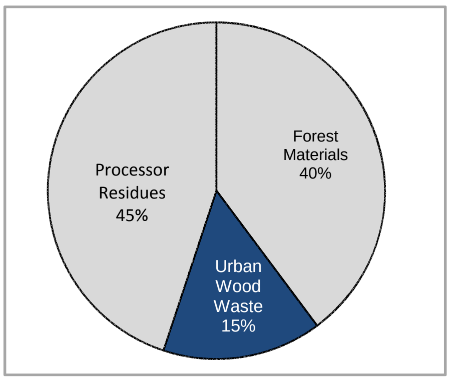
Cost to Utilize

The estimated costs to utilize secondary processor residues range from $0.80 to $2.40 per Mbtu with an estimated weighted average cost per Mbtu of $1.73.

Urban Wood Wastes

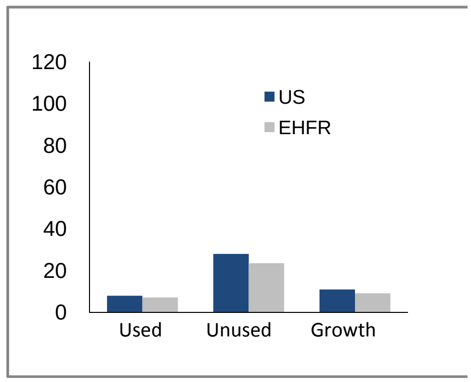
Municipal solid waste (MSW) and construction and demolition debris (C/D) comprise the urban wood waste segment. MSW includes containers, packaging, yard trimmings, durable and non-durable goods. Construction and demolition debris is generated from two distinct waste streams. Construction debris tends to be much cleaner with fewer contaminants than demolition debris which may contain paints, insulation, fasteners and other non-suitable materials.

Figure 28: EHFR Woody Biomass Annual Supply – Urban Wood Wastes % of Total



Source: SRI estimate derived from USDA, DOE, 2005; Walsh et al, 2000

Figure 29: Annual Supply Composition – Urban Wood Wastes (Dry Tons, Millions)



Source: SRI estimate derived from USDA, DOE, 2005; Walsh et al, 2000

Approximately 31 million dry tons of urban wood waste residues are estimated to be available today within the EHFR

Sustainable Annual Supply

The estimated annual supply of urban wood waste in the US today is 36 million dry tons. Approximately 31 million dry tons of this material is located within the EHFR. Approximately 20% of this material is being utilized today. Within the US, an additional 11 million dry tons is expected to be available in the future from industry growth and changing practices. A reasonable estimate of the future amount to be located within the EHFR would be 9 million dry tons.

Cost to Procure

The estimated costs to procure urban wood wastes range from $1.60 to $2.40 per Mbtu with an estimated weighted average cost per Mbtu of $1.92.

PROCUREMENT

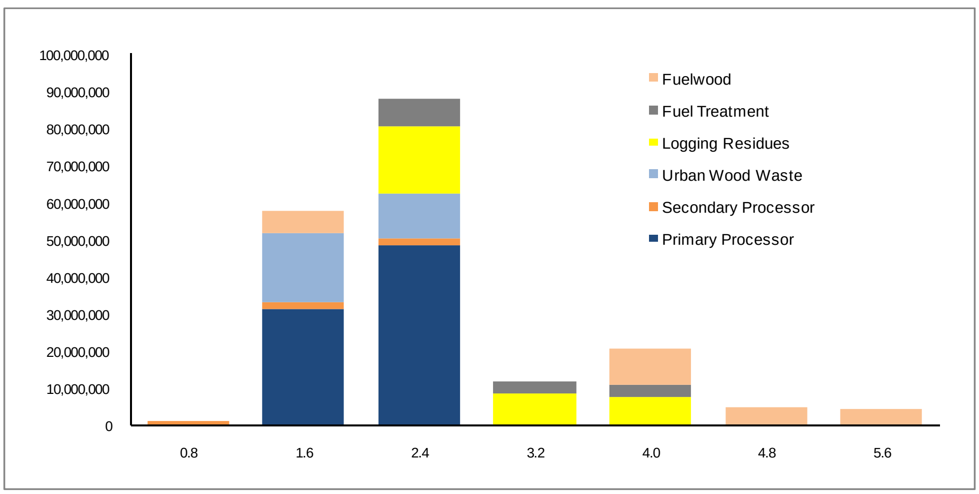
SUPPLY CURVES

In the context of an expanding woody biomass energy market, feedstock resource supply curves become an important consideration. Increased demand levels can potentially have positive or negative impacts on feedstock prices. In some cases, demand growth may allow for biomass suppliers to achieve greater economies of scale and operational efficiency, thereby lowering procurement costs and feedstock prices. A more common scenario results in higher prices with increased demand, as purchasers compete for a limited resource and costs of procuring incremental supply move higher.

EHFR Supply Curve

Based upon feedstock volume and price estimates highlighted in the previous comments, it is possible to construct an EHFR woody biomass feedstock supply curve. Provided in Figure 30 are the estimated primary feedstock volumes available at various price points.

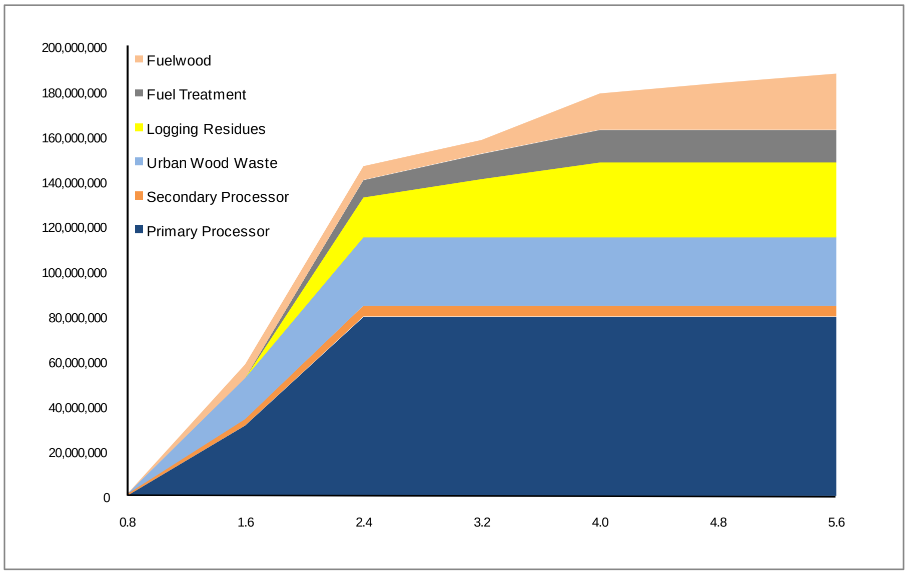
Figure 30: EHFR Supply Curve Components (Tons available @ $/Mbtu)



Source: SRI estimate derived from USDA, DOE, 2005; Walsh et al, 2000

Aggregating this data generates the following EHFR regional feedstock supply curve (Figure 31).

Figure 31: EHFR Feedstock Supply Curve (Dry Tons @ $/MBTU)



Source: SRI estimate derived from USDA, DOE, 2005; Walsh et al, 2000

Curve Implications

The primary objective of this supply curve analysis is to distill a projected order of magnitude adjustment of feedstock prices at the regional level, in response to increased demand. In other words, the goal is to determine if industry growth is feasible from a regional feedstock supply perspective or if increased demand would create prohibitively high feedstock costs.

A 30% increase in demand would result in a 7% average feedstock cost increase

TODAY'S CURVE

Based on the supply curve generated, feedstock costs for the EHFR at today's consumption level of 120 million dry tons per year average approximately $2.00 per Mbtu. A 15% increase in regional feedstock demand would result in a 3% average increase in feedstock costs; a 30% increase in demand would result in a 7% average cost increase, and a 50% increase in demand would result in a 19% average cost increase.

Given the wide variability in feedstock costs within the region, this aggregate profile appears manageable in the context of moderate feedstock demand increases.

ADDITIONAL POTENTIAL SUPPLY SOURCES

The supply curve produced above reflects estimated identified feedstock levels available today without industry growth, changing practices or utilization of existing low-grade products currently applied to higher value uses.

Beyond the amounts included under this curve are several additional potential sources of feedstock that might be available if demand and pricing warrants. As mentioned earlier, within the US on annual basis approximately 49 million dry tons of primary processor residues are currently utilized for other product purposes, 50 million dry tons of pulpwood are harvested, and an additional 88 million dry tons of material from all sources is anticipated to be available for energy applications due to future industry growth and changing practices. Off of current EHFR woody biomass energy consumption base of 120 million dry tons per year and 70 million dry tons of additional material available today within the EHFR, these additional potential feedstock supply sources could contribute to meaningful additional supply beyond the curve estimates.

Analysis Limitations

It is important to note that price and volume estimates provided above are based on reasonable assumptions derived from preexisting data. This analysis is not intended to represent highly precise estimates of price or volume, or to be used as a substitute for targeted feasibility assessments. Instead, the purpose of these estimates is to generate the building blocks necessary to achieve a reasonable regional perspective of supply curve dynamics in order to provide general feedstock price and supply parameters.

In addition, the supply curve itself represents an estimated scenario at the aggregate regional level. As has been noted earlier in this report, feedstock costs can vary meaningfully across the EHFR region based on localized factors, and consequently local wood basket supply curves may differ materially from the regional perspective provided.

PRODUCTS

PRODUCTS

Woody biomass feedstock may be utilized "as is" or further processed into products meeting specific end market requirements. Today, basic process residuals comprise the largest product segment, representing consumption of primary and secondary manufacturer waste utilized for heat, steam and industrial electricity generation. Looking forward, significant emphasis is centered around advances in technologies which will allow for the production of economically viable woody biomass derived liquid fuels in markets historically reserved primarily for petroleum products. While volume production of these emerging fuels does represent real potential for woody biomass to participate in previously untapped markets, the current environment also supports growth opportunities across the existing spectrum of wood fuels. Traditional products serving the residential, commercial, industrial and electric power markets are also well-positioned for growth. The following section will examine this wood fuel product range, beginning with an overview of the product segment, and then examining both commercialized and emerging product categories.

OVERVIEW

At the most basic level, conversion of woody biomass into wood fuel may be chipping forest residues into wood chips for consumption at a power generation facility, or cutting and splitting cull wood into cordwood for residential heating applications. At the emerging fuel end of the spectrum, conversion represents a complex set of material processing capabilities that result in liquid biofuels achieving strict transportation market requirements. In all cases, during the conversion process, raw feedstocks are processed to varying degrees into fuel forms which have higher value-added uses in their respective end markets. The following comments will introduce the primary existing and emerging wood fuel products within the US today and highlight the broad landscape dynamics within which these products participate.

Basic process residuals comprise the largest wood fuel product segment

Product Types

Today, the domestic wood fuel market consists of four primary commercialized wood fuel product categories; process residuals, wood chips, cordwood and wood pellets. Process residuals represent approximately 63% of current domestic wood fuel consumption, while wood chips and cordwood each represent approximately 18% of the market, and wood pellets comprise approximately 1% of the market (Figure 32).

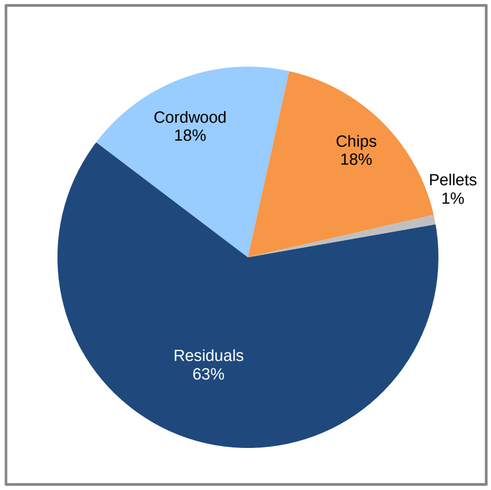
PRODUCTS

Primary emerging wood fuels include bio-oil, syngas, cellulosic ethanol, and Fischer Tropsch fuels. Each of these products is further explored in this report segment.

Landscape Dynamics

The major dynamics influencing the manufacture of wood fuels include the broad market economic factors of feedstock supply and end market demand curves, as well as product specific drivers including production costs, policy & incentives, regulatory environment, social issues and competition. At the regional level, each of these considerations influences product mix and market development opportunities.

Figure 32: Primary Woody Biomass Product Categories (btu's, 2005)



Source: SRI estimates derived from EIA, 2005 ; EIA, 2006; Lisle, 2006

MARKET ECONOMICS

Consistent with most manufacturing processes, the economic viability of wood fuel production processes are heavily influenced by raw material procurement costs and end market prices. Volatility in either of these factors can represent significant business risk and meaningfully impact operational profitability. Efforts to mitigate these risks through longer-term contractual arrangements with suppliers and customers can offer a lower risk profile to the extent that price volatility in these areas can be reduced.

PRODUCTION COSTS

Unit product costs vary significantly across the spectrum of wood fuel products, but in general, as fuel product specifications increase, manufacturing costs follow. For example, cordwood is relatively inexpensive to produce, but has limited end market applications (primarily residential heating). Cellulosic ethanol, on the other hand, achieves stringent transportation fuel specifications and could potentially be applied to a wide range of end market uses, but the product comes at a significantly higher cost than producing cordwood. Due to the wide variability in wood fuel production costs as well as wide variability in end market segment prices, it is necessary to consider both manufacturing cost by product, as well as end market applications for that product and the market clearing prices within those end markets.

POLICY & INCENTIVES

The role of public policy and corresponding incentives within the wood fuel manufacturing process is a primary consideration in today's environment. In an effort to address domestic energy security, climate change, agricultural programs, rural development and other issues, significant federal and state initiatives are underway to facilitate the manufacture of wood fuel products, particularly second generation biofuels such as cellulosic ethanol. At the producer level, incentives are typically available in the form of grants, loans, loan guarantees and tax credits. While specific incentive items are emerging rapidly, subject to a rather fluid approval and extension process, and too numerous to list in this document, two examples of major recent initiatives are highlighted below to provide a sense of scale and reach of these efforts.

- Farm Bill 2007's passage would provide $1.6 billion in new funding for renewable energy research, development and production, targeted for cellulosic ethanol, which will support $2.1 billion in guaranteed loans for cellulosic projects and includes $500 million for a bio-energy and bio-based product research initiative (USDA, 2007).

- The DOE will potentially invest up to $385 million over the next four years in six cellulosic ethanol biorefinery projects through EPACT 2005. The six selected companies are to provide 60% or more of their respective project costs. The DOE will be an equity partner, providing up to the remaining 40% cost-share (DOE, 2007).

In aggregate, incentives available to the wood fuel manufacturer provide opportunity to significantly enhance production economics. Additional important incentives also exist at the end market level to facilitate industry growth and to generate increased product demand. This topic is revisited in the Markets section of this report.

REGULATORY ENVIRONMENT

Regulations governing the manufacture of wood fuel products vary by product and location, and must be evaluated on a project specific basis. Federal, state and local regulations must be considered. Common wood fuel manufacturing issues include air and water quality considerations, zoning, as well as materials delivery and transport restrictions.

PRODUCTS

COMPETITION

Within the wood fuel production process, primary competitive considerations include feedstock supply, transportation and employees. Wood basket competition may come from within the wood fuel industry or beyond it. In addition to fuel products, feedstock competition may result from traditional forest products outputs, or in the case of primary and secondary processors, be utilized internally to offset existing energy requirements. Competition may also emerge outside of standard forest products applications, in the form of products such as animal bedding or landscaping materials.

Transportation and human resource requirements encompass a wide range of potential competitive conditions and can also present operational challenges. A common consequence of locating processing facilities in close proximity to feedstock supply is a rural location with limited infrastructure and a relatively small labor pool. While automation generally limits overall staffing requirements at the manufacturing site, local logistics needs around procurement, materials handling and transport may result in a competitive situation for limited resources.

SOCIAL CONSIDERATIONS

A major consideration related to the wood fuel manufacturing process is site location and the resulting impact of a manufacturing operation on the local community. Residential concerns include air and water conditions, noise, traffic and aesthetics. Local resident opposition to perceived and actual negative attributes of a wood fuel processing operation can present significant barriers to new construction as well as time and cost hurdles to existing manufacturers. As an offset to opposition, tax and job benefits directly associated with a local facility, as well as the relatively attractive attributes of woody biomass derived renewable energy, can generate local enthusiasm for projects.

Analytical Considerations

The primary analytical output of this section is an estimated range of unit product costs for each of the highlighted existing fuel products. The cost estimates incorporate feedstock costs and a return on investment for the manufacturer. The estimates are designed to represent the minimum end market selling price required to “break even” at the manufacturer level.

These estimates are generated to provide order-of-magnitude comparisons to market conditions in the major energy end markets, and are <u>not</u> intended to represent precise manufacturing costs. Limited availability of non-proprietary actual cost information within the product categories limits the robustness, precision and overall usefulness of these estimates for applications beyond broad and generalized comparisons.

COMMERCIALIZED FUEL PRODUCTS

Commercialized fuel products define the woody biomass energy market as it exists today. The four primary product segments are Process Residuals, Wood Chips, Cordwood and Wood Pellets. Together these products represent nearly 100% of the woody biomass energy market and 2.2% of the US energy market. Each of these primary existing fuel product groups is highlighted below.

Process Residuals

Process residuals comprise the largest existing wood fuel product category. This category generally represents internal utilization of waste stream material created by primary industrial forest products manufacturers. These users typically have an energy intensive production process and the material is generally already on-site. Utilization of these process residuals to offset existing energy requirements is an established process within the forest products industry, and particularly the pulp and paper manufacturers.

PRODUCT CHARACTERISTICS

Process residuals consist primarily of black liquor, bark and fines mill residues. Black liquor is a by-product of the paper manufacturing process and is the liquid waste stream resulting from the digestive process of separating cellulose from wood in the pulping process. This product represents approximately 50% of total process residuals consumption. Bark and fines residues are by-products of primary wood processing facilities and represent the remainder of demand within this category.

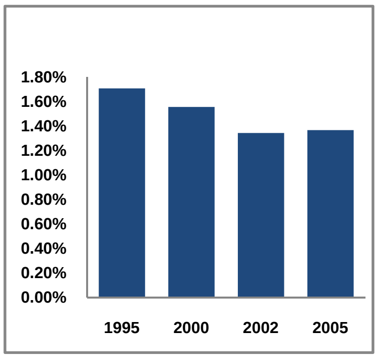
MARKET SIZE

The market for process residuals biomass fuel has experienced modest growth over the past several years, but the longer term consumption trend has been negative, reflecting a corresponding overall decline in total energy consumption within the US industrial sector during the same period.

PRODUCTS

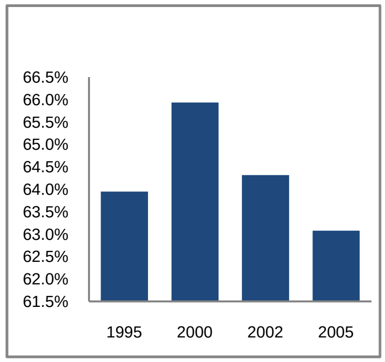
In 2005, process residuals represented 1.4% of total domestic energy consumption and approximately 63% of woody biomass consumption. Consistent with a decline in unit consumption, these market share levels are also modestly lower than levels a decade ago (Figures 33 & 34).

Figure 33: US Process Residuals Historical Share of US Energy Market (btu's)



Source: SRI estimates derived from EIA, 2005; EIA, 2006; Lisle, 2006

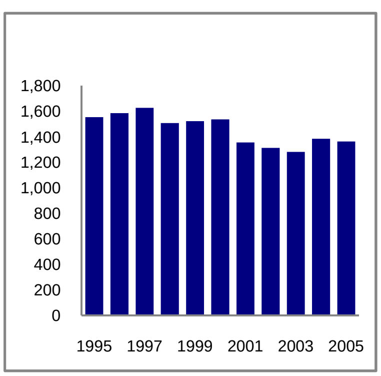
Figure 34: US Process Residuals Historical Share of US Woody Biomass Market (btu's)



Source: SRI estimates derived from EIA, 2005; EIA, 2006; Lisle, 2006

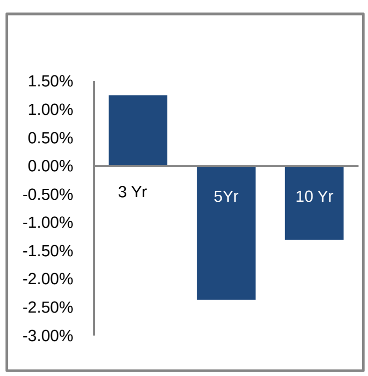
On a btu consumption basis, the market for process residuals was approximately 1.4 quadrillion btu's in 2005. Peak consumption over the last decade occurred in 1997 at 1.6 quadrillion btu's. Three, five and ten year CAGR's measured 1.2%, (2.4%) and (1.3%), respectively (Figures 35 & 36).

Figure 35: US Process Residuals Historical Consumption (btu's trillions)



Source: SRI estimates derived from EIA, 2005; EIA, 2006; Lisle, 2006

Figure 36: US Process Residuals Historical CAGR's (btu's)



Source: SRI estimates derived from EIA, 2005; EIA, 2006; Lisle, 2006

PRODUCTS

CONVERSION PROCESS

The processes of converting residuals into fuel can be moderately complex or essentially nonexistent. In the case of black liquor, the process is more dynamic. Generally, weak black liquor is first concentrated into strong black liquor to improve combustion characteristics. Strong black liquor is then atomized into droplets and processed through a recovery stage where partial or full combustion occurs to recover pulping chemicals from the black liquor. This process also produces heat and gases used to power the manufacturing process. At the other end of the conversion spectrum, a sawmill may simply feed waste sawdust and bark essentially "as-is" into a boiler to produce steam, heat and power.

PRODUCT COST

Process residuals have an inherent cost advantage to other wood fuels in the sense that the materials are by-products of existing operations, are already on-site and generally require limited additional processing to be utilized as fuel. Even in the case of black liquor, the process described above serves the dual function of recovering pulping chemicals and producing energy. The energy production component may be viewed as an incremental beneficial output of the pulping chemical recovery process.

Because of the unique circumstances surrounding process residuals, the true "product cost" may be assessed as the value of the process residuals in the broader marketplace should they be sold instead of utilized internally. This cost represents an opportunity cost to the manufacturer that chooses to utilize these by-products onsite. Further, the true "value" of these products to the manufacturer may even exceed the marketplace price because internal consumption offsets a need to purchase alternative sources of energy (natural gas, electricity, oil, etc.) to meet existing process requirements. In cases where efficiency adjusted unit costs of process residuals are lower than available alternatives, and alternatives prices are higher than the market price for process residuals, it is unlikely the manufacturer will make residuals available externally.

A reasonable conservative estimate of "product cost" for process residuals is the marketplace value of these materials for direct consumption or as a feedstock for further wood fuel processing. Revisiting feedstock cost estimates from the Procurement section of this report, the estimated costs of utilizing primary processor residuals ranges from $1.60 per Mbtu to $2.40 per Mbtu with a point estimate of $2.09 per Mbtu.

PRODUCTS

Wood Chips

Wood chips are a versatile wood fuel with applications in the electric power, industrial and commercial sectors. The existing market for chips is about 30% the size of the process residual market, but demand for this product category is growing at a considerably faster pace than the larger residual market. A diversified set of end market uses for wood chips position this product set well for continued growth as demand for woody biomass expands within the broader energy market.

Wood Chips

PRODUCT CHARACTERISTICS

Wood chips are often segmented into a variety of subcategories, but several primary classifications exist. The important distinguishing characteristic across classifications is fuel "quality". Quality is typically measured by uniformity of the product based upon chip size and material composition. Higher quality chips are preferred because they produce higher operational efficiency levels at end user chip handling and combustion equipment. As a general rule, larger wood chip fuel consumption operations (electric utilities, industrial users) have a higher tolerance for variations in chip quality, and therefore have greater flexibility to utilize a wider range of chip products.

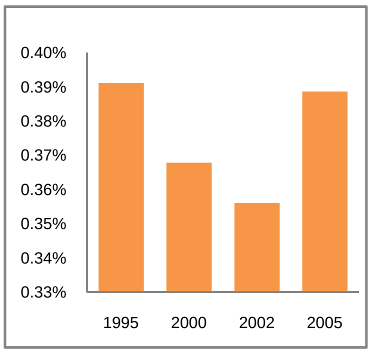
Chips may be categorized by material composition, material source, chipping process, species type and moisture content. Two primary chip classifications include mill chips and whole-tree chips. Mill chips represent sawmill residues which are typically chipped, screened and delivered directly to a trailer for transport. These chips tend to be high "quality" and are desirable for both wood fuel applications as well as for paper mills. Consequently, mill chips can be more expensive in markets with high demand.

Whole-tree chips are generated from tree harvesting operations which may include logging, thinning and general land clearing activities. These chips can include the entire tree or just the stems and primary branches (bole chips). In many circumstances, whole-tree chips can offer a more economical source of chip fuel compared to mill chips in high demand areas. Whole-tree chips also have the potential to be of lower quality due to variations in chip size (twigs and small branches) and contaminants (dirt, pebbles, etc.) resulting from the raw material composition and handling process. In some cases, these quality issues can make this product category less suitable for certain chip fuel markets.

MARKET SIZE

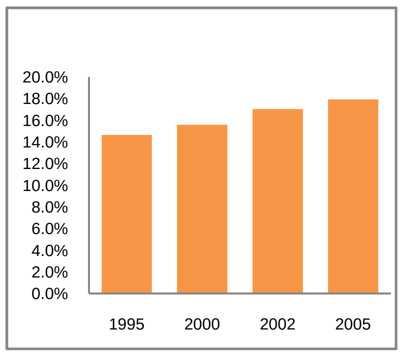
The wood chip market has grown modestly over the past decade, with growth accelerating in the past three to five years as demand from the power generation sector has contributed to the increase. In 2005, wood chips represented 0.4% of total domestic energy consumption and approximately 18% of woody biomass consumption. Share of the US energy market has remained consistent over the past decade, while market share of the woody biomass market has increased as a consequence of the previously highlighted declining process residuals market during the same period. (Figures 37 & 38).

Figure 37: US Wood Chips Historical Share of US Energy Market (btu's)



Source: SRI estimates derived from EIA, 2005; EIA, 2006; Lisle, 2006

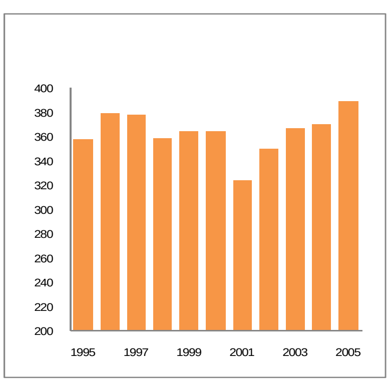
Figure 38: US Wood Chips Historical Share of US Woody Biomass Market (btu's)



Source: SRI estimates derived from EIA, 2005; EIA, 2006; Lisle, 2006

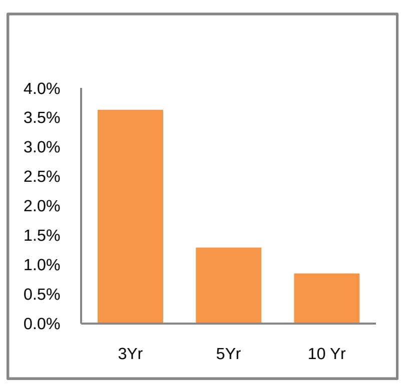
On a btu consumption basis, the market for wood chips was approximately 0.4 quadrillion btu's in 2005. Peak consumption over the last decade occurred in 2005 at 0.4 quadrillion btu's. Three, five and ten year CAGR's measured 3.6%, 1.3% and 0.8%, respectively (Figures 39 & 40).

Figure 39: US Wood Chips Historical Consumption (btu's trillions)



Source: SRI estimates derived from EIA, 2005; EIA, 2006; Lisle, 2006

Figure 40: US Wood Chips Historical CAGR's (btu's)



Source: SRI estimates derived from EIA, 2005; EIA, 2006; Lisle, 2006

PRODUCTS

CONVERSION PROCESS

A variety of wood chipping processes are in existence today, ranging from small portable chippers delivered on-site to the feedstock source, to dedicated stationary chipping plants where it is the feedstocks that are delivered from the source to the chipper. Depending on feedstock type and desired end product, the conversion process may include debarking and screening in addition to the actual chipping of the material. Transportation and materials handling are also elements of the conversion process that are required to varying degrees depending on the process employed. In all cases, woody biomass feedstocks are processed to a reduced size in order to achieve a level of uniformity in the physical characteristics of the material consistent with required handling and end market consumption specifications.

PRODUCT COST

Wood chip production costs are primarily driven by materials cost, chipping cost and transportation cost. While each of these costs can vary significantly, a common rule of thumb for chipping production costs are 1/3 materials, 1/3 chipping, 1/3 transportation. A reasonable average production cost range for delivered wood chips would be from $2.00 per Mbtu to $5.00 per Mbtu with a point estimate of $3.50 per Mbtu, depending on feedstock supply, chipping equipment configuration and required hauling distances[8].

Cordwood

Cordwood, also known as firewood, is primarily utilized as a heating fuel within the residential sector. On par with wood chips, the existing market for cordwood is about 30% the size of the process residual market. Unlike the wood chip market, however, the longer-term cordwood demand trend is negative, as lower cost, more convenient alternative sources of home heating fuels have displaced the use of wood fuel in the residential sector. More recently, demand has begun to rebound in response to significant price increases of these competing fuels, and cordwood is well-positioned to modestly benefit from a widening spread between wood fuels and alternative heating fuel choices within the residential sector. Growth will be somewhat mitigated by the trade-off between the convenience of utilizing less labor intensive alternative heating fuels and the cost advantage of this wood fuel.

Cordwood

[8] SRI estimate derived from Sherman, 2007; Lumberjack Resource Conservation and Development Council, Inc., 2005; Morris,1994.

PRODUCTS

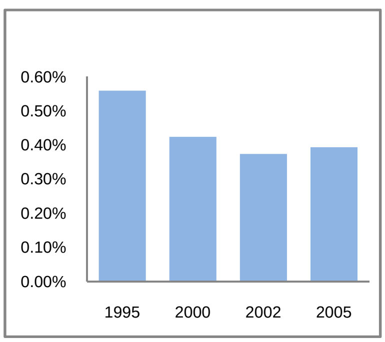
PRODUCT CHARACTERISTICS

Cordwood is typically produced in split log lengths ranging from 12 to 20 inches. The product is sold by volume in cord units. Residential cordwood users primarily burn mixed hardwoods because of the relatively higher density of the material compared to softwoods. Most is air-dried to a moisture content of approximately 20-25%, however, some larger processors offer kiln dried product at lower moisture levels.

MARKET SIZE

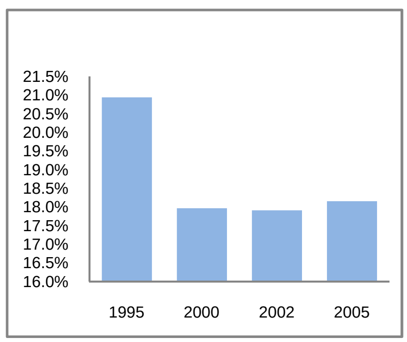
The cordwood market has declined materially over the past ten years, with a modest trend reversal more recently as demand from the residential sector has rebounded moderately. In 2005, cordwood represented 0.4% of total domestic energy consumption and approximately 18% of woody biomass consumption. Market share of both the US energy market and the woody biomass market has declined over the past decade as a result of weakening residential demand.

Figure 41: US Cordwood Historical Share of US Energy Market (btu's)



Source: SRI estimates derived from EIA, 2005; EIA, 2006; Lisle, 2006

Figure 42: US Cordwood Historical Share of US Woody Biomass Market (btu's)

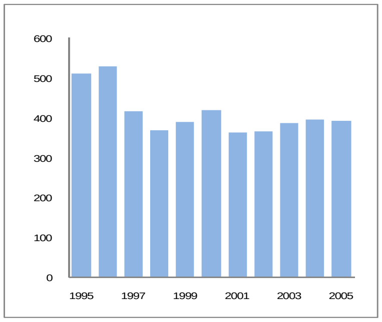


Source: SRI estimates derived from EIA, 2005; EIA, 2006; Lisle, 2006

PRODUCTS

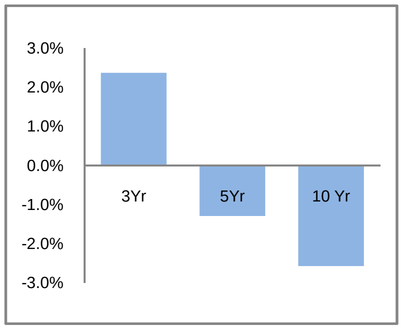
On a btu consumption basis, the market for cordwood was approximately 0.4 quadrillion btu's in 2005. Peak consumption over the last decade occurred in 1996 at 0.5 quadrillion btu's. Three, five and ten year CAGR's measured 2.4%, (1.3%) and (2.6%), respectively (Figures 43 & 44).

Figure 43: US Cordwood Historical Consumption (btu's trillions)



Source: SRI estimates derived from EIA, 2005; EIA, 2006; Lisle, 2006

Figure 44: US Cordwood Historical CAGR's (btu's)



Source: SRI estimates derived from EIA, 2005; EIA, 2006; Lisle, 2006

CONVERSION PROCESS

Cordwood production is a straightforward process. Low-grade cull logs are cut to length and then split as necessary to meet specified size requirements. Various levels of automation may exist, with the process ranging from hand cutting and splitting to a mostly automated log handling, cutting, splitting and loading processes. In some cases, kilns are used to dry "green" wood and provide a lower moisture content product. Cut and split wood is then measured and loaded for transport through a manual or mechanical loading process.

PRODUCT COST

A reasonable cost range for a commercial cordwood production operation is $5.00 per Mbtu to $10.00 per Mbtu with a point estimate of $7.50 per Mbtu[9]. Primary variables influencing production costs are log procurement costs, processing costs and transportation costs. The upper end of the price range may include kiln drying expense at the processing stage as well as longer haul distances and higher stumpage fees for the logs. It is interesting to note that a substantial level of annual

[9] SRI estimate derived from Iowa State University, University Extension, 1998; and from field conversations.

residential cordwood consumption is sourced by the consumer at significantly lower cost than a commercial operation can provide. Typically, in this scenario, logs are retrieved from the consumer's own property at minimal procurement cost and often cut and split by the end user as well.

Wood Pellets

Wood pellets are a standardized wood fuel product set consumed primarily in the domestic residential sector today, but with potential for incremental domestic commercial sector expansion in the future. Additionally, an export market for pellets is rapidly developing within the US to serve overseas market segments which include the electric power sector as well. The existing domestic market for wood pellets is an insignificant component of both the broad energy market and the US wood fuel market. However, pellets are experiencing strong growth, albeit off of very small base, and the outlook for this product set is substantially positive.

Wood Pellets

PRODUCT CHARACTERISTICS

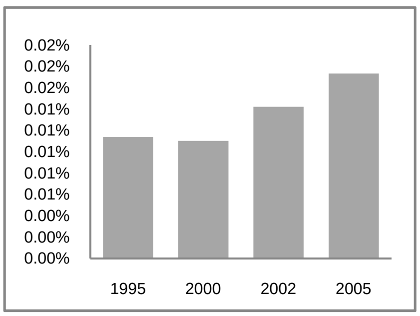
Defining characteristics of the wood pellet include standardized specifications for minimum density, overall dimensions, maximum fines, and maximum salt and ash content. Pellets are up to 1.5 inches in length and have a diameter of 1/4 to 5/16 inches. Two grades of pellets are primarily produced, standard and premium, with the difference between the grades being a higher level of accepted ash content for the standard grade. Pellets typically have a moisture content in the range of 4-10%. The uniformity and density of the fuel provides a convenient and efficient offering, particularly in the residential heating market, when compared to traditional cordwood applications.

PRODUCTS

MARKET SIZE

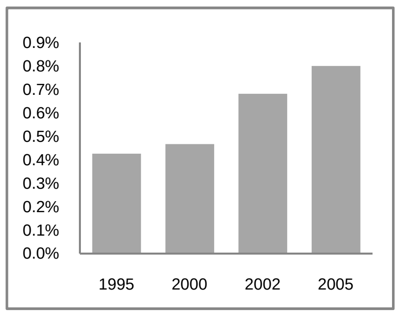
The wood pellet market has been the fastest growing of the commercialized wood fuel products over the past decade, with growth accelerating in the past three to five years as domestic residential and export demand have driven the increase. In 2005, wood pellets represented 0.0% of total domestic energy consumption and approximately 0.8% of wood fuel consumption. Share of the wood fuel market has doubled since 1995 (Figures 45 & 46).

Figure 45: US Wood Pellet Historical Share of US Energy Market (btu's)



Source: SRI estimates derived from EIA, 2005; EIA, 2006; Lisle, 2006

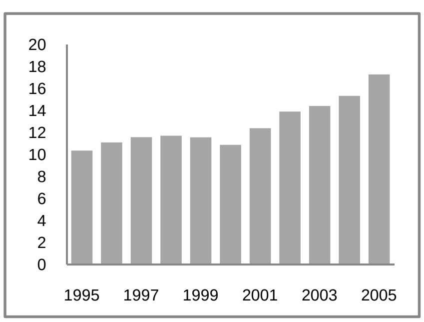
Figure 46: US Wood Pellet Historical Share of US Woody Biomass Market (btu's)



Source: SRI estimates derived from EIA, 2005; EIA, 2006; Lisle, 2006

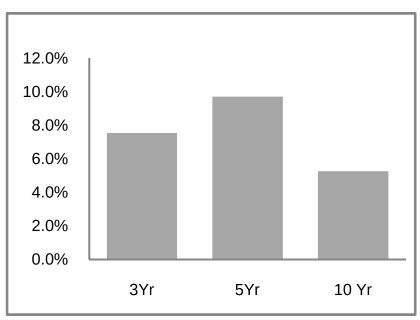
On a btu consumption basis, the market for wood pellets was approximately 0.02 quadrillion btu's in 2005. Peak consumption over the last decade occurred in 2005 at 0.02 quadrillion btu's. Three, five and ten year CAGR's measured 7.5%, 9.7% and 5.3%, respectively (Figures 47 & 48).

Figure 47: US Wood Pellet Historical Consumption (btu's trillions)



Source: SRI estimates derived from EIA, 2005; EIA, 2006; Lisle, 2006

Figure 48: US Wood Pellet Historical CAGR's (btu's)



Source: SRI estimates derived from EIA, 2005; EIA, 2006; Lisle, 2006

PRODUCTS

CONVERSION PROCESS

The primary steps in the wood pellet manufacturing process begin with sizing, screening and drying, if necessary, raw feedstock. Feedstock can take a variety of forms, ranging from dry sawdust, to green whole tree chips, to delivered low-grade logs. The feedstock may be initially processed through a hog mill, tub mill, debarker and/or chipper and then dried to an acceptable moisture content. A hammermill further reduces particle size to specifications. A pellet mill compresses the material into the final wood pellet product which is then cooled, has the process fines separated, and is stored or bagged for transport. In the US today, pellets are primary packaged in 40 pound bags for delivery. Efforts are also underway to establish a bulk delivery system that would eliminate the bagging process and allow for delivery of pellets directly to a consumer holding bin for direct feed into an end user fuel system.

PRODUCT COST

A reasonable unit production cost range for wood pellets is $5.00 per Mbtu to $9.00 per Mbtu with a point estimate of $7.00 per Mbtu[10]. Primary variables influencing production costs are feedstock procurement costs, personnel costs, drying costs and transportation costs. The upper end of the price range is driven by higher feedstock and drying costs.

EMERGING FUEL PRODUCTS

Next generation wood fuels represent a developing product set with the potential to significantly expand demand for woody biomass. As the broad biofuels market continues to emerge and integrated biorefinery concepts are explored, a wide range of potential woody biomass derived products becomes visible. The emerging products discussed below represent four promising next generation products with large potential end markets derived from two primary technology platforms. This product set is by no means inclusive and these selected products may or may not achieve widespread commercial adoption. What these products do offer is a perspective into initiatives underway today to develop second-generation biofuels derived from woody biomass.

[10] SRI estimate derived from Pellet Fuels Institute, 1994; University of British Columbia, Biomass and Bioenergy Research Group, 2006; and Great Lakes Regional Biomass Energy Program, 1995; and from field conversations.

PRODUCTS

Technology Platforms

Today, the conventional widely adopted wood fuel technology is direct combustion. This is the common process utilized to generate heat, hot water and steam for residential, industrial, commercial and power generation applications. Beyond direct combustion, five additional primary wood biomass conversion platforms have been established. These include thermochemical conversion, biochemical conversion, direct liquefaction, physical/mechanical extraction, and electrochemical conversion (Evans, McCormick, 2006). These additional platforms hold promise for an increased biomass derived product suite, as well as efficiency gains and manufacturing cost savings within the existing processing applications of biomass. Within the US today, the biochemical and thermochemical platforms are receiving particular emphasis from a research and redevelopment standpoint largely because of their potential to produce liquid fuels for the transportation sector at a commercial scale in a relatively short timeframe, in a cost competitive manner.

BIOCHEMICAL PLATFORM

The biochemical platform, also known as the "sugar platform", is a process that breaks down two major biomass components, cellulose and hemicellulose, into their component sugars, which can then be further processed into fuel into other chemicals. This process typically includes a materials sizing stage, a pretreatment stage, a conversion stage which include enzymatic hydrolysis and fermentation of cellulose sugars, and a product recovery stage. This process is similar to that of the rapidly expanding corn-based ethanol industry, but with added challenges around extracting and fermenting the sugars contained within the biomass material. A primary end market product objective of this process is cellulosic ethanol for consumption in the transportation sector.

THERMOCHEMICAL PLATFORM

The thermochemical platform applies heat to biomass within a limited oxygen environment to convert the solid biomass material into products, primarily gases and liquids, that can be utilized more efficiently as wood fuels than the traditional direct combustion process, and also may be further processed into more refined products and chemicals. Two primary approaches within the thermochemical platform are gasification and pyrolysis. Gasification seeks to optimize the gaseous output of the thermochemical process and maximize synthesis gas (syngas) production. Pyrolysis emphasizes the liquid output of the thermochemical process and maximizes pyrolysis oil (bio-oil) production.

PRODUCTS

INTEGRATED BIOREFINERY

The integrated biorefinery concept represents an intriguing potential evolutionary direction for the various platform initiatives underway today. In a biorefinery scenario, multiple integrated process platforms are combined in a single facility to produce a spectrum of fuels and products from biomass feedstock. Similar to the widely adopted petroleum refinery model, the production output of the facility can be optimized to maximize profitability and market needs at a given point in time, and the facility designed to maximize operating efficiency.

Products

Within the two emerging technology platforms highlighted above, four primary emerging products will be briefly introduced. These products include cellulosic ethanol, syngas, bio-oil and Fischer Tropsch ("FT") liquids. Syngas and bio-oil represent potential intermediate fuels that can be both utilized "as-is" or further refined into additional products and chemicals. Cellulosic ethanol and FT liquids represent a strongly desired wood fuel group that could contribute to the domestic transportation fuel supply. Significant efforts are underway to rapidly advance these fuels and technologies, and while meaningful volume production of this product set does not yet exist, successful commercial adoption of any of these or other early stage second-generation wood fuel products could have a meaningful impact on the dynamics of the woody biomass energy opportunity. Consequently, development progress of these initiatives is an important consideration.

SYNGAS

A primary output of the thermochemical gasification platform, syngas' attractive characteristics include its usefulness as an intermediate product that can be reacted with catalysts to produce additional more refined products, such as FT liquids, as well as its properties as a more efficient combustible fuel source for heat and power generation than solid biomass. An area of emphasis around the development of this product is the gasification of black liquor within the pulp and paper industry. Initiatives are also underway to produce cellulosic ethanol via biomass gasification, with syngas as an intermediate product.

BIO-OIL

Representing the thermochemical pyrolysis platform, bio-oil, similar to syngas, is an intermediate product with potential direct combustion applications as well. Some storage challenges exist around corrosiveness and viscosity, but one potentially interesting application of bio-oil is the concept of distributed pyrolysis plants serving a centralized biorefinery with bio-oil as the intermediate feedstock transported from the "spokes" to the "hub". To the extent that transportation and other costs could be reduced by substituting green wood chips as a feedstock with bio-oil, this scenario may allow a larger, more economically viable, biorefinery to exist than a local wood basket could support. Pyrolysis is a relatively proven process and efforts to commercialize bio-oil are well underway.

CELLULOSIC ETHANOL

A promising liquid wood fuel, cellulosic ethanol's potential contribution to the transportation fuels sector is highly anticipated. This product is currently in the early commercialization stage with multiple pilot plants under construction. Interestingly, both the biochemical and thermochemical platforms contain biomass-to-ethanol pathways, and both are currently being actively explored. Significant incentives are being provided to jumpstart this industry, as biomass derived transportation fuels are an essential component of efforts to reduce dependence on imported petroleum.

FT LIQUIDS

The Fischer Tropsch process technology was originally developed in the 1920's and has been applied to syngas produced from a variety of feedstocks including coal, natural gas and biomass. FT liquids represent a broad synthetic fuel product set that can be tailored to meet a variety of end-market specifications, and have the potential to contribute to a variety of submarkets within transportation fuels sector. As a result, the FT process is receiving renewed interest in the conversion of biomass to liquids.

MARKETS

MARKETS

The markets for wood fuels are not forest products markets, but rather energy markets. The energy industry is a global marketplace, where fuels are sourced, transported and consumed around the world. Although the majority of the EHFR woody biomass market opportunity today is domestic, biomass fuels are competing in a global environment. Domestic market prices are heavily influenced by global dynamics and consequently the EHFR opportunity will be also be defined to a significant extent by macro market conditions, which are ultimately reflected in the regional and even local energy markets within which wood fuels must compete. This section of the report will examine the US energy market segments broadly, as well as the role of wood fuels within these primary markets.

The United States annual energy consumption is approximately 100 quadrillion Btu's.

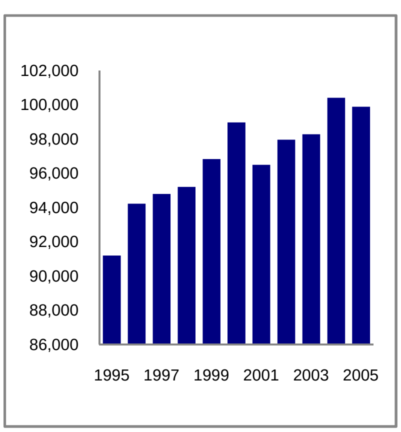
US ENERGY MARKET

The domestic energy market has broad reach across the US marketplace. Energy is consumed by nearly every facet of the US economy, and when energy prices are stable, emphasis on this economic engine is limited. A sustained rise or decline in aggregate energy prices, however, creates a ripple effect that permeates individual, commercial and industrial activities throughout the system. Consumption, pricing and landscape parameters are highlighted below to introduce the macro dynamics influencing today's energy market environment.

Market Consumption

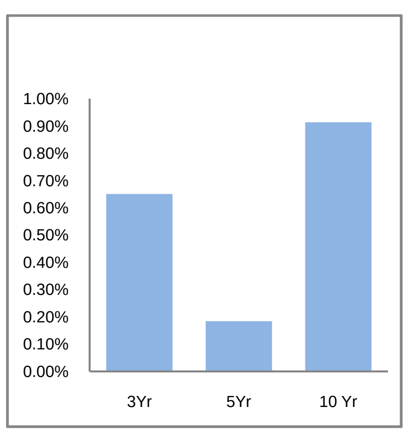
The United States annual energy consumption is approximately 100 quadrillion Btu's and has increased over the past decade at a CAGR of nearly 1%. It is worth highlighting that three year and five year growth rates are lower than the ten year rate, suggesting that while domestic demand has continued to increase, the rate of domestic consumption growth has been moderating (Figures 49 & 50).

Figure 49: US Energy Market Annual Consumption (trillion btu's)



Source: EIA, 2006a

Figure 50: US Energy Market Consumption CAGR's (btu's)



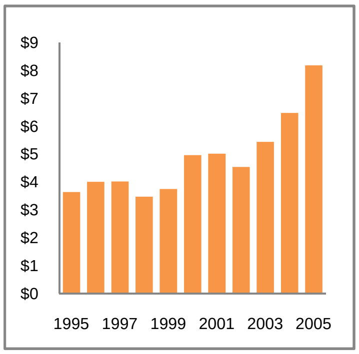
Source: EIA, 2006a

MARKETS

Market Prices

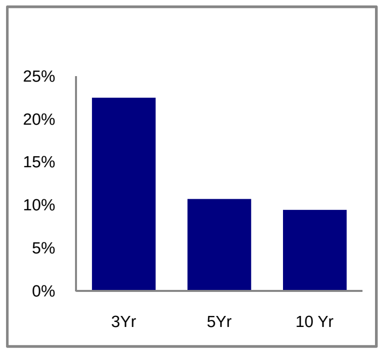
Fuel prices are unquestionably the story in the today's domestic energy market. Primary energy costs have more than doubled over the past decade and the rate of increase has accelerated in the past three and five years. A three year average price

Figure 51: US Energy Market Wtd Average Primary Energy Cost (Nominal $/Mbtu)



Source: EIA, 2006

Figure 52: US Energy Market Wtd Average Primary Energy Cost CAGR's (Nominal $/Mbtu)



Source: EIA, 2006

CAGR in excess of 20% has created significant economic disequilibrium, which is driving substantial activity throughout the broad marketplace, including a renewed focus on developing and promoting alternative sources of energy (Figures 51 & 52).

Landscape Dynamics

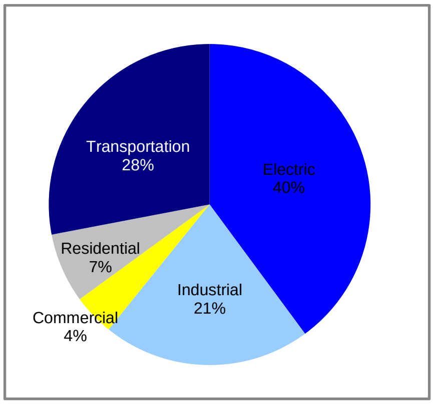
The energy market may be broadly described as five major fuel types participating in five primary market segments. Fossil fuels dominate the marketplace and market clearing prices are a function of global fossil fuel supply and demand characteristics. Policy and incentives play an important role within the broad energy markets, and emissions profiles and social considerations influence market dynamics as well.

MARKET DELINEATIONS

The US energy market is commonly segmented into the following five primary sub-markets: electric power, industrial, commercial, residential, and transportation. On a primary unit consumption basis, the electric power, transportation and industrial sectors dominate consumption patterns (Figure 53).

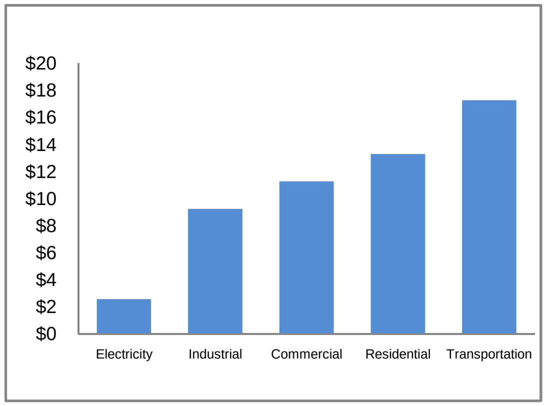
MARKETS

Figure 53: US Primary Energy Market Segments (btu's)



Source: EIA, 2006a

Figure 54: US Primary Fuel Costs per Segment ($/Mbtu, 2005)



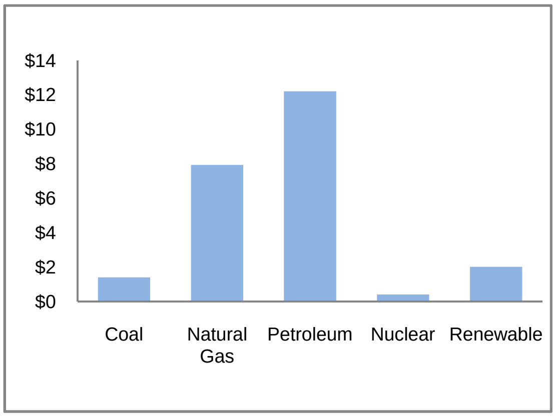
Source: EIA, 2006

Segment fuel costs vary significantly across energy market segments. This is an essential consideration because the price competitiveness of any given wood fuel will also vary considerably across energy market segments. As a general rule, in a static supply/demand environment, these price differences are primarily a function end market fuel specification tolerances and the corresponding fuels types utilized. For example, the electric power market is comprised primarily of larger fuel processors that have the capability to handle and utilize a wide range of fuel qualities in the generation process. Consequently, this market can utilize inexpensive, low-grade fuel types such as coal and hog fuel. At the other end of the spectrum, the transportation market requires highly refined liquid fuels which meet strict specifications in order to be utilized in specialized market equipment. These liquid fuels are generally more expensive to produce and those higher costs are reflected in transportation market prices.

ENERGY FUEL SOURCES

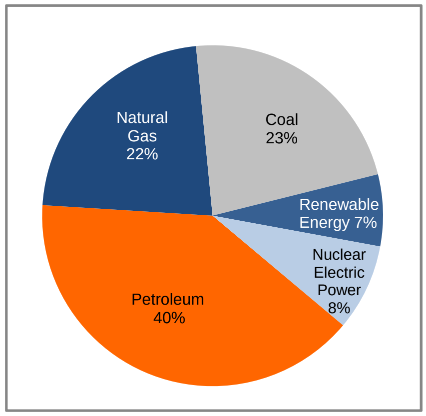
There are five primary fuel categories consumed within the domestic energy market. These are petroleum, coal, natural gas, nuclear and renewable energy. Fuel costs diverge significantly across categories with unit petroleum costs exceeding all other category costs, and exceeding renewable fuel costs, specifically, by a factor of six (Figure 55). Petroleum also comprises the largest fuel segment within the US, representing 40% of total domestic energy consumption. Renewable energy, of which wood fuels are a component, represents in aggregate, only 7% of US energy consumption (Figure 56).

Figure 55: US Price by Fuel Type ($/per Mbtu, 2004)



Source: EIA, 2004

Figure 56: US Energy Consumption by Energy Type



Source: EIA, 2006b

COMPETITION

At the market level, competition is defined as the efficiency adjusted clearing price for energy within a specific market. Within each of the primary market segments, fossil fuels possess overwhelming market share, and thus will set market prices. Renewable energy in all of its forms is currently a relatively insignificant participant within the overall marketplace. As a result, wood fuels will be price takers for the foreseeable future, and will primarily compete against the fossil fuel market rather than amongst other forms of renewable energy or biomass based fuels. To compete successfully, wood fuels must price to a spread between the market and themselves that encourages conversion from alternative fuel sources.

POLICY & INCENTIVES

Incentives have the potential to significantly influence development of wood fuel end markets. Economic vehicles that increase the relative competitiveness of wood fuels compared to existing alternatives offer important catalysts for project and market development. Primary incentives at the market level include tax credits, renewable portfolio standards and renewable energy credits, public benefit funds, clean energy funds, net metering, import tariffs, and other programs to encourage wood fuel consumption. The impact of programs implemented at the market level can be meaningful. For example, production of corn ethanol has dramatically increased over the past several years primarily as a result of tax incentives and import tariffs established at the federal level to facilitate market growth.

EMISSIONS

Because end market fuel consumption represents by far the largest emissions footprint of any stage within the wood fuel product cycle, this topic is of particular importance when considering end market dynamics. Fuel categories are defined and distinguished by their emissions profiles, and given rising attention to climate change issues, fuel product emissions are influencing consumption patterns more than ever. In general, wood fuels are viewed favorably in this category when compared to the other dominant fuel types highlighted above. Other renewable technologies such as wind, hydro and solar are better positioned in this regard, but these participants are minor components of the broad energy market and today do not drive market dynamics.

SOCIAL CONSIDERATIONS

Social issues around end market wood fuel consumption are similar to wood fuel production considerations, but often at greater levels of magnitude. Concerns are heavily focused on perceived and actual emission issues, as well as water conditions, noise, traffic and aesthetics. Potential tax and job benefits directly associated with large scale wood fuel consumption, and the relatively positive attributes woody biomass derived renewable energy, can serve as offsets to public concerns related to wood fuel consumption.

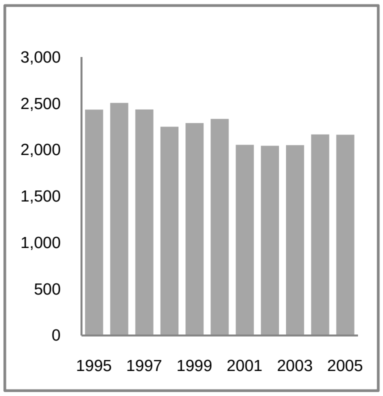
WOOD FUEL END MARKETS

Consistent with the broad energy market, the wood fuel end market is an aggregation of the five distinct energy consumer categories highlighted above; electric power, residential, commercial, industrial and transportation. This section of the report will introduce the wood fuel component of the domestic energy market in aggregate, and then highlight the role of wood fuels within each of the primary submarket categories.

Wood Fuel Consumption

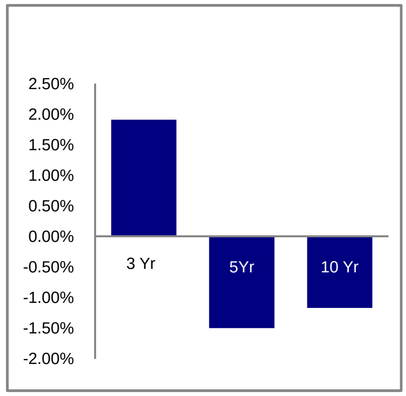
Despite increasing domestic energy consumption over the last decade, longer term domestic wood fuel consumption has declined during the same period. This trend has reversed recently, as the market has reacted to dramatic petroleum price increases and the ripple effect of those increases across substitutable major fuel types (Figures 57 & 58).

Figure 57: US Woody Biomass Market Annual Consumption (trillion btu's)



Source: SRI estimates derived from EIA, 2005; EIA, 2006

Figure 58: US Woody Biomass Market Consumption CAGR's (btu's)

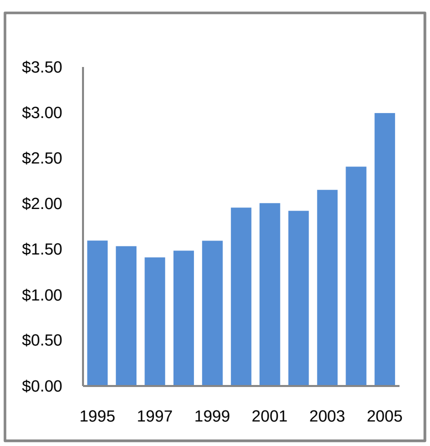


Source: SRI estimates derived from EIA, 2005; EIA, 2006

Wood Fuel Pricing

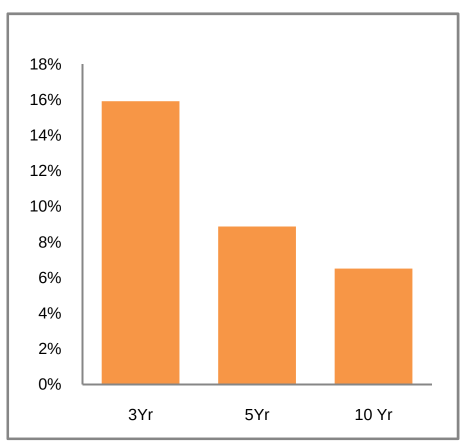
Wood fuel price levels have responded to higher market clearing prices and have moved materially higher over the past several years. While these price increases have moderately underperformed the price growth rates of the aggregate energy market, a three year CAGR in excess of 15% for wood fuel prices is quite significant and meaningfully improves the economics of the wood fuel category (Figures 59 & 60).

Figure 59: US Woody Biomass Market Wtd Average Energy Cost (Nominal $/Mbtu)



Source: Actuals and SRI estimates derived from EIA 2006; EIA, 2004

Figure 60: US Woody Biomass Market Wtd Average Energy Cost CAGR's (Nominal $/Mbtu)



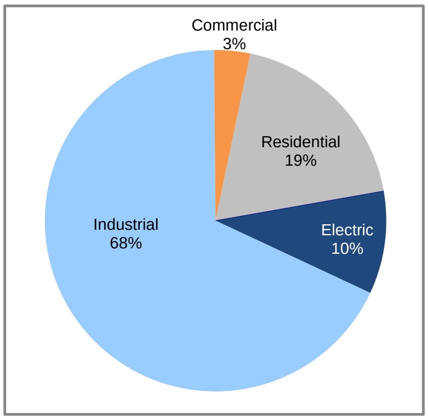
Source Actuals and SRI estimates derived from EIA, 2006; EIA, 2004

MARKETS

Woody Biomass Segmentation

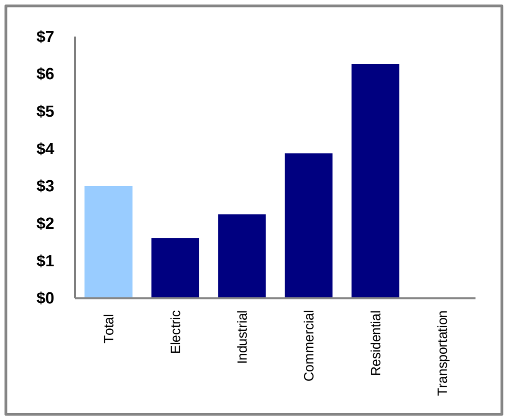
The role of wood fuels within the primary energy market segments varies considerably. Approximately two-thirds of all wood fuel consumption occurs in the industrial sector. Residential and electric power markets represent the majority of the remaining wood fuel demand. Of note, is the fact that woody biomass today has essentially zero contribution within the transportation sector of the energy market, a

Figure 61: US Woody Biomass Energy Market Segmentation (btu's)



Source: SRI estimates derived from EIA, 2005; EIA, 2006

Figure 62: US Woody Biomass Market Wtd Average Energy Cost by Segment (2005 Nominal $/Mbtu)



Source: SRI estimates derived from EIA, 2005; EIA, 2006; EIA, 2004

sector that represents 28% of total domestic consumption, and nearly 70% of US petroleum consumption. This dynamic highlights the potential market opportunity of a liquid wood fuel product set that could service the transportation sector (Figure 61). In terms of prices, consistent with aggregate market segment pricing, wood fuel prices vary significantly across market segments with the lowest prices paid by the electric power segment and the highest by the residential sector (Figure 62).

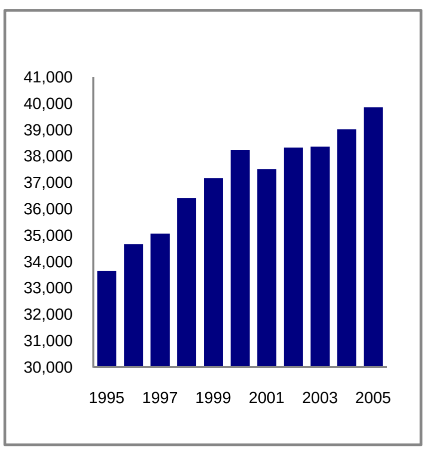
Electric Power

The electric power sector is the largest submarket on a btu consumption basis of the primary domestic energy segments. Consumption is growing faster than the aggregate market average, and the electric power sector pays the least for fuel of the major market segments. This sector consumes all nuclear power generated in the US and accounts for the majority of coal consumption as well. Wood chips are the primarily woody biomass fuel product provided to this submarket. Sector details are highlighted below.

MARKET PARAMETERS

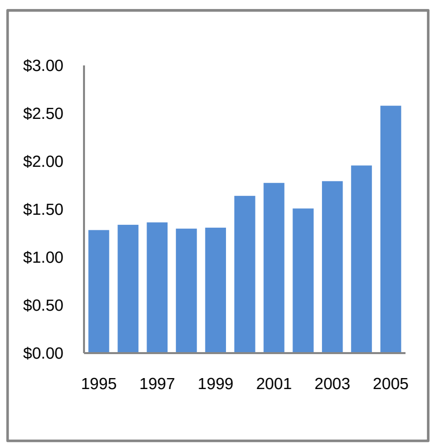
The electric power segment consumes approximately 40 quadrillion btu's annually, representing 40% of domestic energy consumption. Unit consumption has increased at three, five and ten year CAGR's of 1.3%, 0.8%, and 1.7%, respectively (Figure 63). Average fuel costs approximate $2.50 per Mbtu and prices have increased over the past three, five and ten years at CAGR's of 19.6%, 9.5% and 7.2%, respectively (Figure 64).

Figure 63: US Electric Power Segment Annual Consumption (trillion btu's)



Source: EIA, 2006a

Figure 64: US Electric Power Sector Wtd Average Energy Cost (Nominal $/Mbtu)

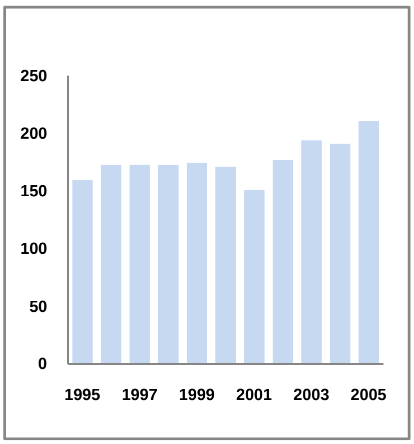


Source: Actuals and SRI estimates derived from EIA, 2006; EIA, 2004

WOODY BIOMASS

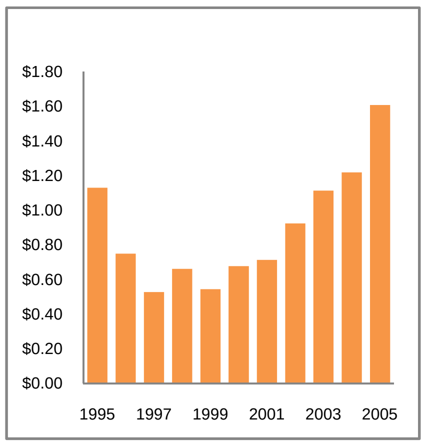
Wood fuel consumption within the electric power segment is approximately 210 trillion btu's annually, representing 0.5% of annual power sector consumption. Unit consumption has increased at three, five and ten year CAGR's of 6.0%, 4.2%, and 2.8%, respectively (Figure 65). Average wood fuel costs approximate $1.60 per Mbtu and prices have increased over the past three, five and ten years at CAGR's of 20.3%, 18.9% and 3.6%, respectively (Figure 66).

Figure 65: US Electric Power Sector Woody Biomass Annual Consumption (trillion btu's)



Source: SRI estimates derived from EIA, 2005; EIA, 2006

Figure 66: US Electric Power Sector Woody Biomass Market Wtd Average Energy Cost (Nominal $/Mbtu)



Source: Actuals and SRI estimates derived from EIA, 2006; EIA, 2004

COMPETITIVE LANDSCAPE

The electric power landscape is dominated by the low-cost, readily available, domestically sourced fuel, coal. This is a very difficult set of characteristics to compete against, but for the negative emissions profile of the fuel. Because coal is "dirty" from an emissions standpoint, other fuels are actively being pursued to improve the overall emissions position of the power generation sector. Incentives such as renewable energy credits and renewable portfolio standards have been implemented to improve the economics of alternative, less polluting fuel sources. Biomass is a beneficiary of these efforts, and the electric power sector is currently the fasting growing of the wood fuel markets. The outlook for increased woody biomass consumption in this submarket remains positive, as continuing concern related to climate change, an increasingly favorable pricing environment, and a generally increasing interest in renewable energy are supporting growth. Wood chips are the primary product utilized in this market, and this product group should continue to benefit from power sector demand.

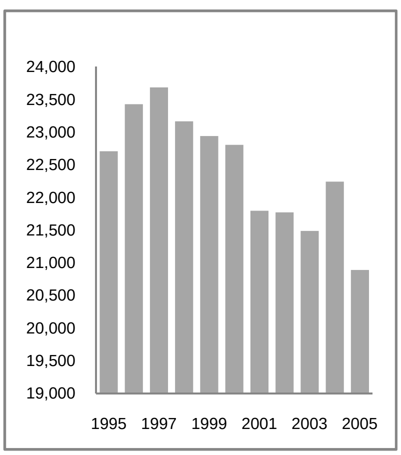
Industrial

The industrial sector is the third largest submarket on a primary btu consumption basis of the domestic energy segments. Consumption is growing considerably slower than the aggregate market average, and the industrial sector pays the second least for energy of the major market segments. This sector is a large consumer of petroleum and natural gas, and is the largest submarket consumer of wood fuels, primarily process residuals. Sector details are highlighted below.

MARKET PARAMETERS

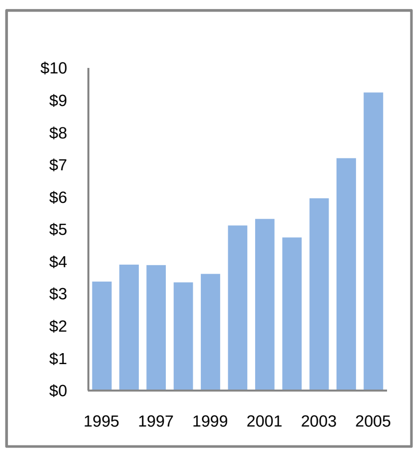
The industrial segment consumes approximately 21 quadrillion primary energy btu's annually, representing 21% of primary domestic energy consumption. Unit consumption has increased (decreased) at three, five and ten year CAGR's of (1.4%), (1.7%) and (0.8%), respectively (Figure 67). Average energy costs approximate $9.25 per Mbtu and prices have increased over the past three, five and ten years at CAGR's of 24.8%, 12.5% and 10.6%, respectively (Figure 68).

Figure 67: US Industrial Segment Annual Consumption (trillion btu's)



Source: EIA, 2006a

Figure 68: US Industrial Sector Wtd Average Energy Cost (Nominal $/Mbtu)



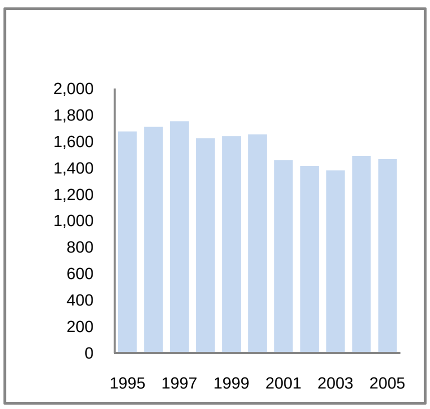
Source: Actuals and SRI estimates derived from EIA, 2006; EIA, 2004

MARKETS

WOODY BIOMASS

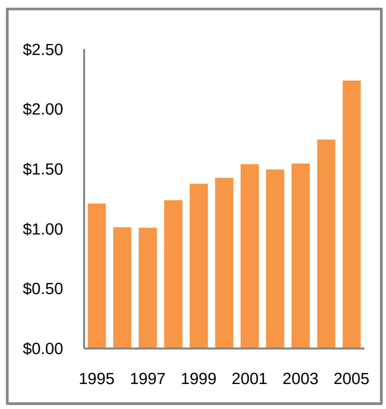
Wood fuel consumption within the industrial segment is approximately 1,470 trillion btu's annually, representing 7.0% of primary annual industrial sector consumption. Unit consumption has increased (decreased) at three, five and ten year CAGR's of 1.2%, (2.4%), and (1.3%), respectively (Figure 69). Average wood fuel costs approximate $2.25 per Mbtu and prices have increased over the past three, five and ten years at CAGR's of 14.4%, 9.4% and 6.3%, respectively (Figure 70).

Figure 69: US Industrial Sector Woody Biomass Annual Consumption (trillion btu's)



Source: SRI estimates derived from EIA, 2005; EIA, 2006

Figure 70: US Industrial Sector Woody Biomass Market Wtd Average Energy Cost (Nominal $/Mbtu)



Source: Actuals and SRI estimates derived from EIA, 2006; EIA, 2004

COMPETITIVE LANDSCAPE

Industrial sector energy consumption in general has been contracting, and as a result, wood fuel demand in this market has been weaker. As conventional sources of heat and power become increasingly less cost competitive relative to biomass, there is a reasonable possibility that wood fuel consumption within the industrial sector could accelerate despite an overall tepid energy consumption growth profile for this sub market. An additional potential source of wood fuel growth within the industrial sector could be generated by initiatives to develop biorefineries dedicated to processing biomass for a variety of products. This market has yet to develop in a meaningful way within the US.

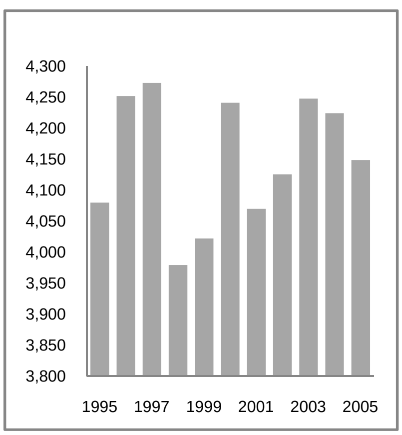
Commercial

The commercial sector is the smallest submarket on a primary btu consumption basis of the major domestic energy segments. Consumption is growing more slowly than the aggregate market average, and the commercial sector pays above average prices for energy within the major market segments. This sector is a large consumer of natural gas and electricity, and is the smallest submarket consumer of wood fuels, primarily wood chips. Sector details are highlighted below.

MARKET PARAMETERS

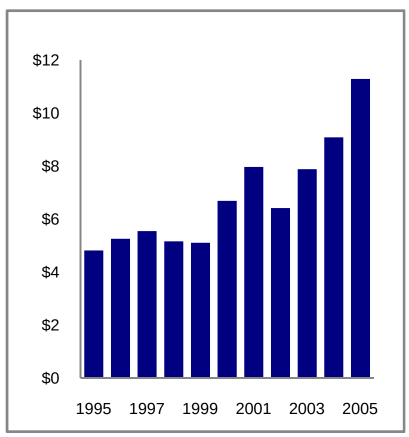
The commercial segment consumes approximately 4 quadrillion primary energy btu's annually, representing 4% of primary domestic energy consumption. Unit consumption has increased (decreased) at three, five and ten year CAGR's of 0.2%, (0.4%) and 0.2%, respectively (Figure 71). Average energy costs approximate $11.30 per Mbtu and prices have increased over the past three, five and ten years at CAGR's of 20.8%, 11.0% and 8.9%, respectively (Figure 72).

Figure 71: US Commercial Segment Annual Consumption (trillion btu's)



Source: EIA, 2006a

Figure 72: US Commercial Sector Wtd Average Energy Cost (Nominal $/Mbtu)

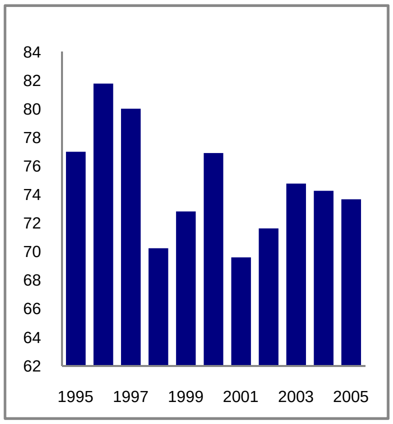


Source: Actuals and SRI estimates derived from EIA, 2006; EIA, 2004

WOODY BIOMASS

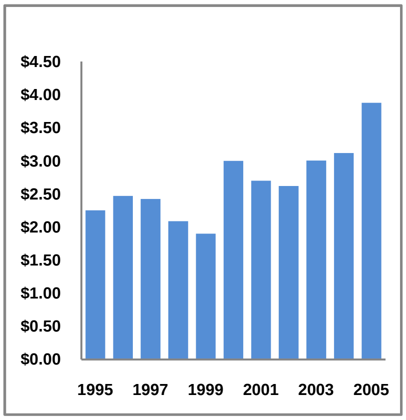
Wood fuel consumption within the commercial segment is approximately 74 trillion btu's annually, representing 1.8% of primary annual commercial sector consumption. Unit consumption has increased (decreased) at three, five and ten year CAGR's of 0.9%, (0.9%), and (0.4%), respectively (Figure 73). Average wood fuel costs approximate $3.90 per Mbtu and prices have increased over the past three, five and ten years at CAGR's of 14.0%, 5.3% and 5.6%, respectively (Figure 74).

Figure 73: US Commercial Sector Woody Biomass Annual Consumption (trillion btu's)



Source: SRI estimates derived from EIA, 2005; EIA, 2006

Figure 74: US Commercial Sector Woody Biomass Market Wtd Average Energy Cost (Nominal $/Mbtu)



Source: Actuals and SRI estimates derived from EIA, 2006; EIA, 2004

COMPETITIVE LANDSCAPE

Within the commercial market, wood fuels compete primarily against grid sourced electricity for general uses and traditional fuel products for heat and hot water applications. With 78% of energy consumption within the commercial/institutional marketplace in the form of grid electricity for general power applications, it is unlikely that outside of the heating sub-market within this category, much opportunity exists for woody biomass to displace current market consumption patterns. Small scale co-gen may assume a niche role in geographies with high electricity costs and readily accessible biomass sources, however much of the commercial market is unlikely to relinquish the convenience of grid power or is unable to convert to due to storage constraints. Campus-type facilities with centralized heat and power may have an interest in woody biomass energy applications and could represent a market for biomass heating and co-gen systems. Chips are the dominant wood fuel within the commercial/institutional market today, but a market could also develop for wood pellets over time.

MARKETS

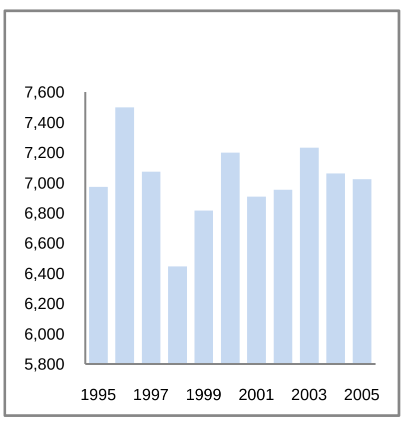
Residential

The residential sector is the second smallest submarket on a primary btu consumption basis of the domestic energy segments. Consumption is growing more slowly than the aggregate market average, and the residential sector pays the second most for energy of the major market segments. This sector is a large consumer of natural gas and electricity, and is the second largest submarket consumer of wood fuels, primarily cordwood. Sector details are highlighted below.

MARKET PARAMETERS

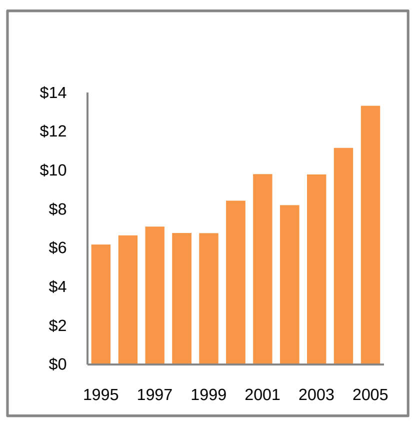
The residential segment consumes approximately 7 quadrillion primary energy btu's annually, representing 7% of primary domestic energy consumption. Unit consumption has increased (decreased) at three, five and ten year CAGR's of 0.3%, (0.5%) and 0.1%, respectively (Figure 75). Average energy costs approximate $13.30 per Mbtu and prices have increased over the past three, five and ten years at CAGR's of 17.5%, 9.6% and 8.0%, respectively (Figure 76).

Figure 75: US Residential Segment Annual Consumption (trillion btu's)



Source: EIA, 2006a

Figure 76: US Residential Sector Wtd Average Energy Cost (Nominal $/Mbtu)



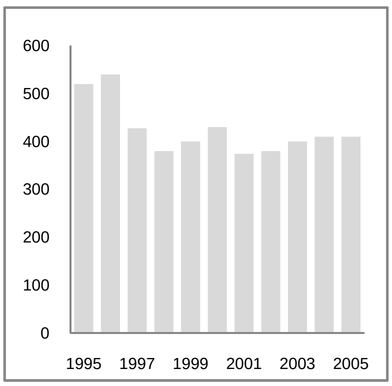
Source: Actuals and SRI estimates derived from EIA, 2006; EIA, 2004

MARKETS

WOODY BIOMASS

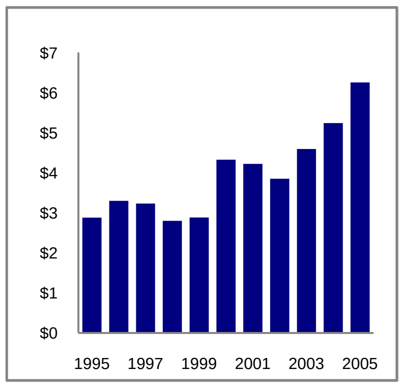
Wood fuel consumption within the residential segment is approximately 410 trillion btu's annually, representing 5.8% of primary annual residential sector consumption. Unit consumption has increased (decreased) at three, five and ten year CAGR's of 2.6%, (0.9%), and (2.3%), respectively (Figure 77). Average wood fuel costs approximate $6.30 per Mbtu and prices have increased over the past three, five and ten years at CAGR's of 17.6%, 7.7% and 8.1%, respectively (Figure 78).

Figure 77: US Residential Sector Woody Biomass Annual Consumption (trillion btu's)



Source: SRI estimates derived from EIA, 2005; EIA, 2006

Figure 78: US Residential Sector Woody Biomass Market Wtd Average Energy Cost (Nominal $/Mbtu)



Source: Actuals and SRI estimates derived from EIA, 2006; EIA, 2004

COMPETITIVE LANDSCAPE

The residential market segment most readily available to wood fuel consumption is the home heating market. Cordwood has been a long-standing participant in this market, and with a significant increase in heating oil, natural gas and propane prices, cordwood is becoming a more attractive source of heating fuel. A particularly well positioned wood fuel product for the residential heating market is wood pellets. Pellets offer a level of convenience that is superior to traditional cordwood and they require less storage. While pellets do sell at a premium to cordwood, pellet stoves and boilers are efficient and offer an attractive tradeoff between very low maintenance, but expensive traditional heating systems, and a lower cost, but significantly more labor intensive cordwood option. Whether the wood fuel product is cordwood or pellets, the residential heating market outlook for biomass is positive at today's market clearing heating fuel prices.

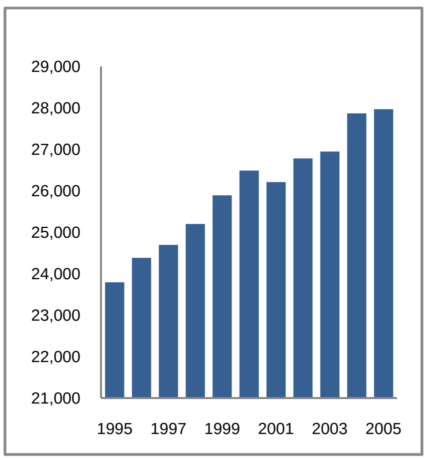
Transportation

The transportation sector is the second largest submarket on a primary btu consumption basis of the domestic energy segments. Consumption is growing faster than the aggregate market average, and the transportation sector pays the most for energy of the major market segments. This sector is the largest consumer of petroleum and does not currently have a commercialized wood fuels market. Sector details are highlighted below.

MARKET PARAMETERS

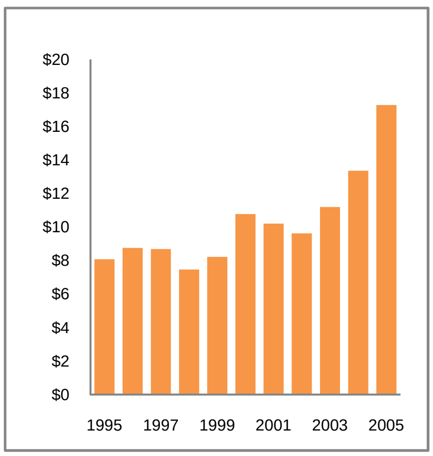
The transportation segment consumes approximately 28 quadrillion primary energy btu's annually, representing 28% of primary domestic energy consumption. Unit consumption has increased at three, five and ten year CAGR's of 1.5%, 1.1% and 1.6%, respectively (Figure 79). Average energy costs approximate $17.30 per Mbtu and prices have increased over the past three, five and ten years at CAGR's of 21.5%, 9.9% and 7.9%, respectively (Figure 80).

Figure 79: US Transportation Segment Annual Consumption (trillion btu's)



Source: EIA, 2006a

Figure 80: US Transportation Sector Wtd Average Energy Cost (Nominal $/Mbtu)



Source: Actuals and SRI estimates derived from EIA, 2006; EIA, 2004

COMPETITIVE LANDSCAPE

The transportation sector is dominated by petroleum. Prices have sharply escalated and alternative fuel sources are being actively pursued. The liquid transportation fuels market is particularly attractive for several reasons. It is a very large market segment from a consumption standpoint, demand is increasing, and market prices are at a premium to any other major energy segment. The race is on to develop a commercially viable liquid wood fuels product set. Successful commercialization of cellulosic ethanol or an FT product from woody biomass would represent a major market opportunity for the expansion of wood fuel consumption with the US.

INTEGRATED OBSERVATIONS

INTEGRATED OBSERVATIONS

The final section of this report offers an integrated perspective of the EHFR woody biomass energy opportunity as it exists today. Key economic drivers are highlighted, followed by a summary assessment of the aggregate opportunity and some brief concluding remarks.

ECONOMIC DRIVERS

An important objective of this document is to offer an introductory evaluation of the dynamics shaping the EHFR woody biomass energy opportunity. As this report has explored the physical and economic pathways from feedstock procurement to end market delivery, a variety of conditions and factors have been introduced. The following comments seek to highlight the most relevant of these variables from an economic opportunity standpoint. Drivers have been segmented into two tiers, primary and secondary, to delineate the magnitude of potential impact for each set of variables on the overall opportunity.

Primary Drivers

While a host of factors will ultimately influence the development and growth profile of the wood fuel market, several key variables are likely to have a disproportionate role in defining the market going forward. The following variables have been identified as essential drivers of the woody biomass energy opportunity within the EHFR. These drivers are generally listed in order of magnitude of potential impact on the opportunity profile, and include market fuel prices, policy & incentives, feedstock supply dynamics, technology & infrastructure investment, and price sensitivity of demand.

Primary Economic Drivers:

- ***Market Fuel Prices***
- ***Policy & Incentives***
- ***Feedstock Supply Dynamics***
- ***Technology & Infrastructure Investment***
- ***Price Sensitivity of Demand***

MARKET FUEL PRICES

The relatively minor role of wood fuels within the broader energy marketplace will, in most cases, cause these fuels to be price takers. Over the intermediate to long term, these products will likely not have pricing power in the marketplace. This is an important consideration because both the level and growth rate of wood fuel applications is a function of the profit opportunity associated with these fuels, the selling price of which, absent artificial market conditions, will be determined by prevailing market pricing, not a spread over biomass fuel production costs.

The trend towards meaningfully higher nominal and real energy prices over the past several years is a significant positive for the advancement of wood fuels. Higher market prices increase the relative cost-competitiveness of biomass in the marketplace, create potential for increased adoption and conversion of wood fuel technologies, offer higher profit potential to existing biomass suppliers and encourage industry investment. It is also worth noting, that while the impact of higher petroleum prices is a material net positive for woody biomass fuels, some of the benefit gained from higher fuel prices will be offset by higher costs associated with the fossil fuel energy intensive nature of the collection, processing and transportation activities surrounding woody biomass fuel. On balance, however, over the intermediate to long term time horizon, prevailing market fuel prices will be an essential driver of wood fuel opportunities.

POLICY AND INCENTIVES

The role of policy and incentives to promote or deter growth of wood fuels should not be underestimated. Federal and state initiatives in this area have the potential to materially influence demand, supply and pace of adoption/conversion across the value creation chain. At the procurement level, examples include biomass feedstock subsidies and programs designed to promote and advance the use of low-grade woody biomass. At the production level, cost share programs, tax incentives, loans, loan guarantees and rebates exist to facilitate fuel production. End market programs include renewable portfolio standards, public benefit funds, clean energy funds, fuels for schools, net metering and others.

Significant momentum exists today at both the federal and state level to provide policy and incentives designed to facilitate the advancement of domestic renewable energy sources that address alternative energy and climate change objectives. This favorable environment has the potential to meaningfully stimulate wood fuel market growth.

FEEDSTOCK SUPPLY DYNAMICS

Raw materials cost is an important factor influencing the economic viability of wood fuel markets. While significant quantities of wood processor “waste” are readily available, they are unlikely to be priced as such in today’s market. Most of the convenient and attractive primary processor “waste” material is currently being consumed by industry or sold for higher value applications. Consequently, incremental feedstock supplies are going to be derived from the other two primary source categories, forest materials and urban waste streams, and then likely at higher price points.

Under this scenario, baseline collection and transportation costs set a minimum cost threshold from which woody biomass products can be produced. Today, within the EHFR, a reasonable average regional level cost appears to be approximately $2.00 per Mbtu, with significant localized variability. Regional supply curve dynamics addressed in the Procurement section of this report suggest significant additional material is available at moderately higher prices, where a 15% increase in demand would result in a 3% increase in regional feedstock costs and a 50% increase would result in a 19% increase in regional feedstock costs. In the context of today's market energy prices, these supply curve dynamics do not appear to be a major growth constraint for most wood fuel avenues.

Ultimately, sustainable feedstock supply will set a cap on wood fuel market size. Under optimal market conditions, the maximum opportunity appears to be two to three times current woody biomass consumption levels. This cap is simply a function of available raw material and infrastructure to support this market. Nonetheless, a feedstock resource available to double current market size offers significant opportunity and room for market expansion.

TECHNOLOGY & INFRASTRUCTURE INVESTMENT

Technology and infrastructure investment has historically and will continue to play a vital role in the evolution of the broad energy industry. Advances have the effect of lowering costs, overcoming production barriers, driving efficiencies and increasing market growth rates.

In the case of wood fuels, significant developments in procurement, production and utilization processes can meaningfully impact the profile of the industry. Particularly within the emerging products category, technology advances will be critical drivers of the commercial viability of these products. Under a broader market growth scenario, investment in infrastructure to support this industry growth will be required. Technology and infrastructure development can also play an important role in market adoption rates by lowering or eliminating conversion thresholds from mainstream fuel choices to alternative fuels.

Beyond woody biomass, technology and infrastructure advances will also impact the competitive landscape within which wood fuels participate. For example, development of additional petroleum resources such as the Canadian oil sands have the potential to influence market prices; advances in emissions reduction technology could increase the relative attractiveness of less expensive fossil fuels such as coal. Given the significantly larger resource base of the fossil fuel energy suppliers and the vested interests of these market participants, it is a safe assumption that this group will continue to work towards leveraging technology and infrastructure investment opportunities to their advantage and potentially the disadvantage of the wood fuel market.

INTEGRATED OBSERVATIONS

PRICE SENSITIVITY OF DEMAND

Change in wood fuel consumption patterns as a result of changes in market clearing prices is an interesting dynamic. On a relative cost per btu basis, wood fuels today compete favorably against most other fuel alternatives, and in many cases, have for some time. Despite this condition, until recently, most wood fuel markets have stagnated or contracted. A variety of conditions may contribute to the resistance of users to convert to wood fuels from existing sources. The relevance of these conditions will vary by market segment, but potential contributors to relative insensitivity of demand to rising fossil fuel prices include the following:

- Conversion Costs – End user costs to convert from one fuel type to another.
- Operating Costs – Relative cost of handling, processing and maintaining the system. Efficiency of fuel processing system relative to alternatives.
- Logistical Issues – Availability and reliability of fuel supply as well as fuel storage.
- Regulatory Considerations – Zoning and emissions issues.
- Convenience – Automation and ease of fuel handling and use compared to alternatives.
- Awareness – Understanding of relative pricing among fuel types and general knowledge of alternative options.

Initiatives that increase price sensitivity of demand for wood fuels have the potential to drive industry growth. Within today's energy cost framework, relative wood fuel pricing is attractive, and to the extent that this competitive advantage may be leveraged through higher adoption and conversion rates, industry advancement opportunities exist.

SECONDARY DRIVERS

In addition to the primary drivers influencing the woody biomass energy opportunity at the macro level, a series of important secondary drivers will likely play an important role to varying degrees within the major product and market segments comprising the aggregate opportunity. These variables include market size, transportation costs, import/export markets, local market conditions and market presence and education.

Secondary Economic Drivers:

- ***Market Size***
- ***Local Market Conditions***
- ***Transportation Costs***
- ***Import/Export Markets***
- ***Market Presence & Education***

INTEGRATED OBSERVATIONS

MARKET SIZE

The woody biomass energy market is a relatively insignificant participant in the considerably larger energy industry. This dynamic offers both challenges and opportunity. To the negative, as was addressed earlier, absent artificial market conditions, wood fuels will have little pricing power within the broader energy sector over the intermediate to long term. In addition, woody biomass faces all the challenges of scale associated with a smaller participant in a larger market. Limited relative resources and market presence are very real hurdles.

To the positive, a high rate of growth off of a small base is much easier to achieve than a similar growth rate off a large base. There exists significant opportunity for the woody biomass market to grow rapidly on a percentage basis, making this industry a potentially attractive investment arena. In addition, from a market share standpoint, current and reasonably achievable in the future, woody biomass is not a major threat to the dominant industry players, and consequently an increasing wood fuel may not be as actively resisted as otherwise would be the case.

LOCAL MARKET CONDITIONS

The EHFR woody biomass energy opportunity is not a homogenous regional landscape, but rather an aggregation of local market conditions within the region. Feedstock costs, processing facilities and end market dynamics can vary significantly at the local level, with each sub-market possessing a unique variable set from which wood fuel opportunities may exist. Localized feedstock costs can be influenced by the size and characteristics of the available wood basket from which to draw, as well as current utilization levels of that wood basket. Woody biomass processing facilities are subject to localized conditions such as proximity to both feedstock supply and end markets, business incentives, as well as local support/resistance to these facilities. End market demand is influenced by variables including availability of competing fuel, competing alternatives, demographics and climate. The wide variability of these factors and others across EHFR sub-markets meaningfully influences the attractiveness of wood fuels at a local level.

TRANSPORTATION COSTS

An important contributor to the existence of localized market conditions is the role of transportation costs within the value-creation chain. Transportation of feedstocks and wood fuels is an expensive process component that often restricts the effective operating radius for collection and distribution. While this condition affects nearly all primary fuel types, wood fuels are particularly sensitive to this variable given their lower energy density per unit of weight compared to other major fuel types. In other words, on an energy equivalent basis, it is generally more expensive to transport wood fuel products. As a result, to compete more effectively, in many cases, geographic dispersion of procurement activities and end market distribution is minimized, which contributes to varying localized market conditions.

IMPORT/EXPORT MARKETS

Given high transportation costs and the relatively low energy density of biomass based fuel compared to competing fossil fuels, this report has focused on the US domestic opportunity for EHFR sourced wood fuel products. In certain circumstances, despite these conditions, economics may favor a larger geographic footprint. For example, recently several announcements have been made regarding construction of new wood pellet facilities based within the EHFR, with Europe as the primary end market. Conversely, there also exists a wood pellet producer in New England that is importing pellets from British Columbia by rail in order to meet local demand. In these and other cases, prevailing market conditions are sufficiently positive to overcome the transportation cost burden associated with longer haul distances.

MARKET PRESENCE & EDUCATION

Utilization of woody biomass for energy applications is not a new concept. In particular, the forest products industry and residential consumers have a well established history with this energy source. Nonetheless, as inexpensive and readily available fossil fuel alternatives have permeated the marketplace, wood fuel usage has declined over the past decade. As has been highlighted throughout this report, economics have recently shifted to the advantage of woody biomass. Recognition of this new paradigm varies by market segment, but in all cases, an increased level of market awareness and education about current conditions has the potential to improve adoption and conversion rates towards wood fuels.

SUMMARY ASSESSMENTS

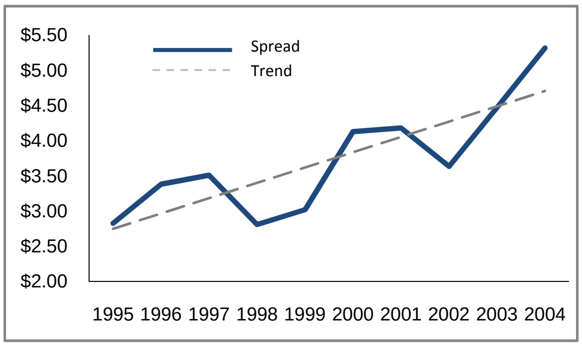
Wood fuels represent a unique and dynamic market opportunity. The value creation chain begins in the forest and terminates in the energy sector. The conversion process may be simple or highly complex. Technology requirements may be minimal or highly sophisticated. Logistics matter. The transition from forest to fuel reaches beyond economics and encompasses active global political and social issues. The following comments seek to highlight some general observations as the integrated opportunity is reflected upon.

The Big Picture

Despite the complexities of an integrated wood fuel value creation matrix, the relative attractiveness of this category in aggregate within the broad energy landscape may be condensed into a single salient point: woody biomass is becoming more cost competitive as a fuel source. Figure 81 illustrates the spread between the aggregate fuel price paid for energy in the US compared to aggregate price paid for woody biomass fuel in the US.

As this chart highlights, over the past 10 years, this spread has been widening. While each of the variables described throughout this report will impact, to some degree, conversion thresholds and adoption rates, the long term macro pricing environment trend favors increased wood fuel consumption relative to other alternatives.

Figure 81: US Average Energy Price / Biomass Price Spread ($/Mbtu)



Source: SRI derived from EIA, 2004

Sustainability

As highlighted earlier in this report, ultimately, a primary constraint of the woody biomass energy opportunity is availability of affordable feedstock. Supply curve estimates provided have been based upon industry expert assessments of sustainable feedstock supply levels, as opposed to what is available on an absolute basis. Some debate exists today around what constitutes a sustainable supply, and this debate revolves around issues such as harvestable forest residues required to be left in the forest to insure proper nutrient retention within the forests, or what are appropriate harvest levels in general from an environmental and habitat protection standpoint. This topic is important from a long-term industry supply perspective as well as from a social and political context. Today, woody biomass is generally regarded as one of the more attractive alternative sources of energy in the US based upon its overall environmental impact and potential social benefits. Perceived or actual mismanagement of the forest resource would have the potential to negatively impact public sentiment, which eventually translates into higher costs and reduced supply. Consequently, while certain unsustainable procurement practices may produce more attractive short-term economic outcomes, longer-term industry success will be heavily influenced by the practical and sometimes emotional considerations surrounding sustainable biomass removal practices.

Fragmented Markets

A common thread throughout the woody biomass value creation chain is market fragmentation. From procurement through end markets, the EHFR opportunity is an aggregation of submarket conditions, and relatively high transportation costs restrict the widespread homogenizing of these submarkets. At the procurement level, a diverse set of local wood baskets and local resource demands define submarket feedstock supply curves. End market demand is heavily influenced by local demographic, industry, and climate conditions, as well as competing fuel dynamics, the availability and costs of which materially vary by submarket. Wood fuel products are generated at the intersection of favorable end-market demand conditions and reasonable feedstock supply conditions, and the result is a diverse opportunity set within the EHFR.

Variables are Variable

A consequence of market fragmentation within the EHFR is variability in the primary economic factors driving the wood fuel opportunity. Procurement and processing costs as well as end market prices can vary significantly across submarkets. As a result, local market dynamics have the potential to provide materially different outcomes for otherwise similar projects, and while the general conclusion of this report suggests that conditions are attractive for an expanding wood fuel market at the regional level, this submarket economic variability creates a need for reliable cost and pricing information at the local level in order to encourage and facilitate market growth.

Opportunity & Risk

On balance, the tone of this report has been positive in favor of an expanding woody biomass market. This generally optimistic view is a function of the primarily attractive market conditions identified throughout this assessment. However, history has demonstrated several false starts within the renewable energy arena, and while it truly does appear that an inflection point has been reached in terms of a sustainable alternative energy market, within which woody biomass may participate, conditions are variable and downside risk should not be dismissed. Obvious examples of potential negative influences include a global economic contraction on the demand side and major advances in competing energy sources and technologies on the supply side.

INTEGRATED OBSERVATIONS

EHFR Competitive Positioning

In the context of the broad domestic wood fuel opportunity, the EHFR is well positioned to lead the country in growth. The EHFR contains over 70% of the country's estimated woody biomass feedstock base, represents 85% of current biomass consumption, and 85% of EHFR timberland resource base is privately owned. While a rapid growth scenario could strain EHFR feedstock availability over the short term, the benefits of a well established regional forest products industry infrastructure in place today suggest the region is a logical and attractive location for expanded wood fuel use. It is also worth noting that the scale of the broad energy market relative to the woody biomass market implies that widespread demand for cost effective biomass feedstock comfortable incorporates all domestic regions, and limits the relevance of interregional competitive assessments.

Climate Change

The issue of global warming is rapidly emerging as a leading political and social hot button. Woody biomass is generally considered to have a favorable "carbon-neutral" greenhouse gas emissions profile, and consequently heightened climate change concern has the potential to positively influence demand for wood fuels. An interesting offset to the beneficial impact of emission reduction initiatives on wood fuel opportunities is the issue of carbon sequestration. Because forests remove and store carbon dioxide, they are viewed as a viable means to reduce greenhouse gases. To the extent that forest carbon sequestration activities reduce viable woody biomass supply, climate change initiatives could negatively impact feedstock economics. On balance, it appears that climate changes initiatives are a net positive for wood fuels and that emerging forest carbon sequestration projects could be implemented without a significant detrimental impact to low-grade biomass removal activities.

Energy Density

On a comparable weight basis, wood fuels are at an energy density disadvantage compared to many other liquid and solid fuels. Figure 82 highlights the relative energy contents of common fuel types.

Figure 82: Approximate Energy Content per Pound (btu's)

Product	Approximate Energy Content
Wood Chips (50% moisture)	4,300 btu/lb
Cordwood (20% moisture)	6,800 btu/lb
Bio-oil	7,500 btu/lb
Wood Pellets (5% moisture)	8,200 btu/lb
Ethanol	11,500 btu/lb
Coal	14,000 btu/lb
#2 Heating Oil	19,400 btu/lb
Gasoline	19,500 btu/lb

Several implications result from energy density differentials. First, transportation, handling and storage costs are likely to be higher for lower energy density fuels, decreasing relative cost competiveness of these products. Second, lower energy density fuels may be less desirable to end market consumers, given the increased storage requirements or lower energy output for comparable storage systems. Third, in order to offset a transportation cost disadvantage, lower energy density fuels favor a more decentralized approach to production and consumption. Finally, within the wood fuels category, energy densification activities could potentially improve wood fuel economics if the cost of densification is more than offset by the benefits of a higher energy density product.

Opportunity Matrix

As this report has illustrated, the woody biomass energy opportunity for the Eastern Hardwood Forest Region is a not a single vector to growth, but instead a set of linked matrices of feedstocks, products and market segments, each with unique characteristics and sensitivities to macro conditions and drivers. At the regional level, market conditions appear favorable for growth and advancement of the EHFR wood fuels industry. Within the EHFR, submarket opportunities will be a function of local wood baskets, production factors and end markets. While this diverse regional opportunity set may initially generate conflicting conclusions about wood fuel growth potential, a prolonged positive macro environment should ultimately result in a multidimensional expansion of the wood fuel market.

CONCLUDING REMARKS

The woody biomass energy opportunity is an evolving landscape. It represents one of multiple component pathways towards achieving the dual macro objectives of domestic energy resource diversification and climate change mitigation. While the sheer size of the US energy market relative to the sustainable EHFR feedstock base will ultimately restrict the role of EHFR generated woody biomass to a small percentage of the overall energy market, in the context of the existing woody biomass energy market and the absolute dollar value of today's in-place industry, the potential for significant growth off the existing base represents a meaningful opportunity.

This report has highlighted the broad dynamics of the market at a regional level. It has also been demonstrated in this assessment that significantly volatility and variability of key input variables exists throughout the value-creation chain. Specific growth opportunities will be heavily influenced by local market dynamics in the context of a broader positive macro and regional environment. Consequently, under attractive local market conditions, opportunities exceeding the regional average will likely exist, providing a favorable environment for attractive risk-adjusted capital deployment opportunities.

ACRONYMS AND ABBREVIATIONS

Btu	British Thermal Unit
C&D	Construction and Demolition
CAGR	Compound Annual Growth Rate
DOE	US Department of Energy
EHFR	Eastern Hardwood Forest Region
EIA	Energy Information Administration
FT	Fischer Tropsch
GDP	Gross Domestic Product
Mbtu	Million British Thermal Units
MSW	Municipal Solid Waste
SRI	Summit Ridge Investments, LLC
USDA	US Department of Agriculture

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