POTENTIAL IMPACTS OF CLIMATE AND ENERGY POLICY ON FOREST SECTOR INDUSTRIES: PROVIDING INCENTIVES FOR BIO-ENERGY WHILE PROTECTING ESTABLISHED BIOMASS-BASED INDUSTRIES[1] [2]

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Executive Summary

Current and proposed climate and energy policy, and specifically incentives for the development of bioenergy have the potential to negatively impact established biomass-based industries through increased costs, competition for supplies, and perhaps other unidentified cause and effect relationships. This report assesses short and long-term impacts (both positive and negative) of state and federal climate and bioenergy policies and incentives on the domestic forestry/wood products sector, and in particular the logging, lumber, composite panels, and paper industries, and considers how incentive programs might be modified so as to achieve optimum results for bioenergy producers and established wood-based industries alike. Potential long-term implications of rising energy prices – whether resulting from market forces or public policy – for the domestic wood products industry are also assessed.

Currently, a great number of options for converting biomass to energy products are recognized. Among them are electricity from biomass, combined heat and power (CHP), gasification, district heating, bio-oil, ethanol (via starch or developing cellulosic pathways), biodiesel, Fischer-Tropsch diesel, aviation fuel, biobutanol, gasoline, and fuel pellets. The production of fuel pellets has in itself quickly developed in to a sizeable industry, with production capacity exceeding four million tons annually in the United States.

As with energy, there are a great many options for conversion of biomass to various industrial chemicals – chemicals that are now largely produced from fossil fuels. Technologies are now in place or under development that will allow replacement of virtually all petrochemicals by biomass-derived chemicals.

Bioenergy initiatives were begun by the National Science Foundation and transferred to the Department of Energy in the late 1970s. Since that time, over $3.7 billion has been invested since the 1970s in research, development, deployment, and diffusion programs focused on biofuels, bio-power, biomass feedstocks, municipal wastes, and various bioproducts, with much of that over the past five years. In addition, most of the states have enacted laws in recent years to promote the development and use of biomass energy. In addition, a number of regional coalitions of states have also been formed with the express purpose of providing incentives for biomass energy development.

Within the forest products sector, energy intensive industries would be challenged under every scenario of continued high and increasing energy prices, irrespective of cause, to adapt to the new reality. The paper industry faces significant pressure to accelerate energy efficiency improvements, including capture of a greater portion of the energy value of biomass now used in supplying a portion of energy requirements. At the same time, composite products industries would experience substantial difficulty not only with respect to costs of biomass feedstocks, but with regard to energy-intensive petroleum-based resins, the prices of which would also be impacted by carbon management measures.

At petroleum prices existing at the time of this report (~$100/bbl) equivalent prices based on energy content, across the spectrum of energy products, support the production of many forms of bioenergy, without subsidy, creating potential problems for the forest products industry even in the absence of federal, states, or regional bioenergy initiatives. The pulp and paper, particleboard, and Chip-N-Saw southern softwood sawmill industries in particular will face price pressures. Should energy prices rise further, either as a result of market forces, climate or energy policy, or other factors, upward pressure on biomass materials will result, with efforts even felt in low grade hardwood sawbolt and sawlog markets.

Because even seemingly straightforward measures to encourage bioenergy development can have unintended and detrimental consequences for long-established, value-added domestic industries, including serious erosion of global competitiveness, it is important that policy-makers recognize the impact potential of their actions. This report concludes with a number of observations about how policies and incentive programs, and approaches to development of them, might be changed to provide better protections for established biomass-using, value-added industries.

The dual risks posed to many forest products industry sectors by climate and energy policy on the one hand, and rising market-driven energy prices on the other suggest a need for proactive action on an industry-by-industry basis to assess risks, and to identify and implement strategies to alleviate these risks. A concerted industry-wide focus on energy efficiency and cost-containment appears justified.

Amid the specter of considerable problems going forward it should be noted that rising energy prices and interest in bioenergy also provide dividends to the forest sector. The emergence of bioenergy and biochemicals markets, and potential for development of carbon markets, combined with increasing societal interest in products with low energy and carbon intensity spell opportunity for creative, innovative firms assuming a level playing field in the policy arena.

Contents

List of Figures

List of Tables

Introduction

Current and proposed climate and energy policy, and specifically incentives for the development of bioenergy have the potential to negatively impact established biomass-based industries through increased costs, competition for supplies, and perhaps other unidentified cause and effect relationships. This report assesses the short and long-term impacts (both positive and negative) of state and federal climate and bioenergy policies and incentives on the domestic forestry/wood products sector, and in particular the composite panels and paper industries, and considers how incentive programs might be modified so as to achieve optimum results for bioenergy producers and established wood-based industries alike. Potential long-term implications of rising energy prices – whether resulting from market forces or public policy – for the domestic wood products industry, including the composite panels industry, are also assessed.

Several scenarios are evaluated herein as a way of examining potential impacts of rising energy prices and related public policy – the impact of 1) low petroleum prices and no climate policy, 2) moderate petroleum prices and no climate policy, and 3) moderate petroleum prices and climate policy, 4) high energy prices with and without climate policy, and 5) record energy prices and abandoned climate policy.

Renewed Attention to Biomass Energy

Uncertainty of Petroleum Supplies

A number of reports in recent decades have raised questions about the adequacy of global petroleum supplies in the face of rising consumption. An example is the 2005 release of the findings of a study commissioned by the U.S. Department of Energy. What became known as the Hirsch report (Hirsch et al. 2005) began with the words "The peaking of oil production[4] presents the U.S. and the world with an unprecedented risk management problem." Among the conclusions were that "prudent risk management requires the planning and implementation of mitigation well before peaking," and that "the oil peak problem deserves immediate, serious attention."

In early 2007 the National Petroleum Council, an oil and natural gas advisory committee to the Secretary of Energy, released a report that addressed "the urgency of today's energy issues", noting accumulating risks to the supply of reliable, affordable energy and significant challenges to meeting projected total energy demand.

Shortly after release of the National Petroleum Council report, the Wall Street Journal carried a front-page news article entitled "Oil Officials See Limit Looming on Production" (Gold and Davis, 2007). The article began with the words "A growing number of oil-industry chieftains are endorsing an idea long deemed fringe: The world is approaching a practical limit to the number of barrels of crude oil that can be pumped every day." The article indicated that evidence is mounting that production of crude oil may reach a plateau

[4] The term "peak oil" originated with Dr. M. King Hubbert, a geophysicist who observed that the amount of oil is finite, and that therefore the rate of discovery must eventually reach a maximum and then decline. He noted that this relationship exists for any geographical area and for the world as a whole.

globally before alternatives are sufficiently developed and “could set the stage of a period marked by energy shortages, high prices and bare-knuckled competition for fuel.”

While additional investigations focused on future petroleum supplies have indicated much the same conclusions, an early 2010 report attracted particular attention because of its source – the U.S. Joint Forces Command. The report included the sobering observation that “Assuming the most optimistic scenario for improved petroleum production through enhanced recovery means, the development of non-conventional oils (such as oil shale or tar sands) and new discoveries, petroleum production will be hard pressed to meet the expected future demand of 118 million barrels per day.” The report went on to indicate that global surplus oil production capacity could entirely disappear by 2012, and that as early as 2015 a shortfall of 10 million barrels per day could develop.

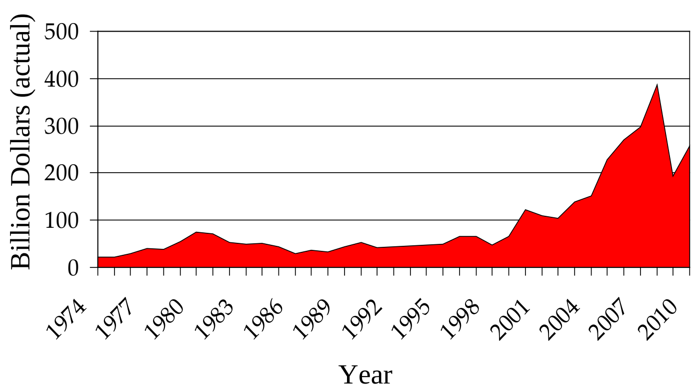
The following November marked the release of the 2010 edition of the IEA’s World Energy Outlook (Morgan 2010), and this caused another stir among energy futures analysts. In a major shift from previous reporting on the matter, the IEA published a graphic of world oil production indicating that a peak in conventional oil production had occurred a year earlier.

These kinds of studies, and growing concerns about climate change have given rise to growing interest in finding and developing alternatives to petroleum and other fossil fuels. Today biomass energy is on the radar screens of governments around the world.

<u>An “Old” Fuel Becomes Modern</u>

Dependence on foreign sources for the preponderance of U.S. energy supplies has long been of concern. Over the past decade, a sharply rising trade deficit for energy products (Figure 1), coupled with increasing concern over carbon emissions, has increased interest in development of alternative forms of energy.

Figure 1
U.S. Trade Deficit, Energy Products, 1974 – 2010

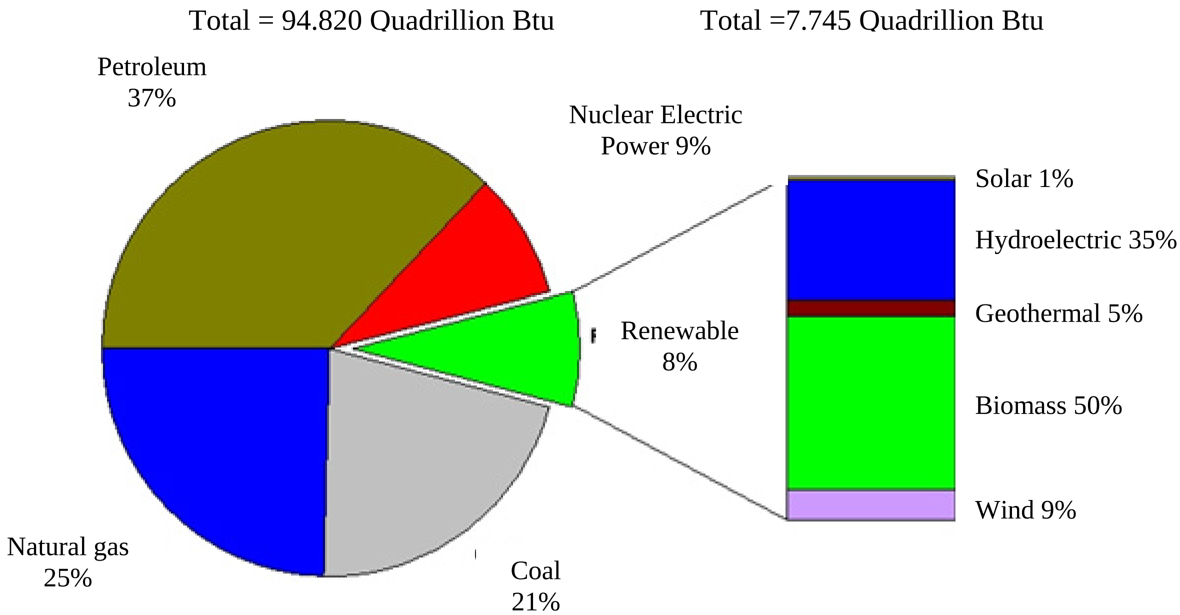


Source: Energy Information Administration, 2011.

An alternative source of energy that has recently gained considerable attention is wood and other forms of biomass. Though viewed by many as a “new” energy resource, wood and other forms of biomass provided more than 90 percent of U.S. energy and fuel needs about

150 years ago. Today, biomass supplies just 4 percent of U.S. energy consumption, but 50 percent of renewable energy (Figure 2).

Figure 2
Renewable Energy Consumption in the U.S. Energy Supply, 2009



Source: U.S. Energy Information Administration (2010b)
(http://www.eia.doe.gov/cneaf/alternate/page/renew_energy_consump/rea_prereport.html)

The U.S. forest products industry has long been a leader in biomass energy production (and consumption). Spurred by the oil shocks of the early 1970s, manufacturers began capturing energy from what had previously been discarded or incinerated wastes. Today, more than half of biomass energy production and consumption occurs within the forest products industry, with the majority of this in the form of process heat and steam. In addition, some mill facilities provide electricity to local and regional energy grids from combined heat and power (CHP) operations. Generation of electricity by itself is inefficient. About 20 percent efficiency is reasonable to expect. However, if ways can be found to use waste heat effectively, overall efficiency may be as high as 60 percent. In terms of *industrial* biomass energy production and consumption, the forest products industry role in biomass energy is even more impressive. For instance, in 2008 the paper and allied products industry accounted for 66 percent of biomass energy consumption by all sectors of industry (EIA 2010a).

While the forest products industry was quietly adapting its mills to make use of biomass energy, others had visions of biomass-derived transportation fuels. Based perhaps in part on recognition that ethanol was commercially produced from wood in the United States more than a century ago for use in early automobiles, and in the course of the two world wars (E-85 2010), ethanol was the first form of renewable energy to receive legislative attention in the modern era. The potential for domestic manufacture of this fuel drew the attention of Congress in 1978 following the second oil embargo of the decade. With the active involvement of agricultural interests, the next several years marked passage of the Energy Tax Act of 1978, which exempted 10-percent-ethanol-blended gasoline from the federal gasoline excise tax. The Energy Security Act of 1980 also contained incentives for domestic energy production. More recently, a host of federal and state incentives have focused on ethanol and biodiesel production (Table 1).

Table 1
Recent Federal Legislation and Executive Branch Actions in Support of Bioenergy and Biochemicals Development

Date	Initiative	Essential features
August 2005	Energy Policy Act of 2005	Renewed and strengthened federal policies fostering ethanol production, including incentives for the production and purchase of biobased products; incentives included authorization of demonstration projects, tax credits, and loan guarantees.
December 2007	Energy Independence and Security Act of 2007	Supported the continued development and use of biofuels, including a significantly expanded Renewable Fuels Standard, requiring 36 billion gallons per year of renewable fuels by 2022 with annual requirements for advanced biofuels, cellulosic biofuels, and biobased diesel.
May 2008	Food, Conservation, and Energy Act of 2008 (Farm Bill)	Provided grants, loans, and loan guarantees for developing and building demonstration and commercial-scale biorefineries, established a $1.01 per gallon producer tax credit for cellulosic biofuels, established the Biomass Crop Assistance Program (BCAP) to support the production of biomass crops, and provided support for continuation of the Biomass R&D initiative (2000), the Biomass R&D Board, and the Technical Advisory Committee.
February 2009	American Reinvestment and Recovery Act	Provided funds for grants to accelerate commercialization of advanced biofuels R&D and pilot-, demonstration-, and commercial-scale integrated biorefinery projects. Also provided funds to other DOE programs for basic R&D, innovative research, various other projects, and tax credits.
May 2009	Presidential Memorandum on Biofuels (Obama 2009)	Established a Biofuels Interagency Working Group, co-chaired by the Secretaries of the Departments of Energy and Agriculture and the Administrator of the EPA, to consider policy actions to accelerate and increase biofuels production, deployment, and use.

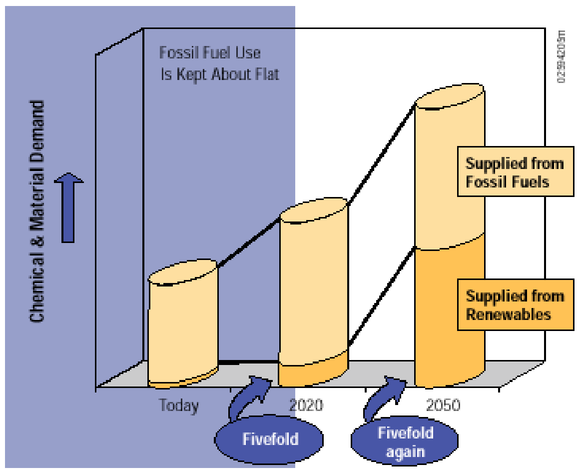
Source: Source: US Department of Energy (2010a), p. 1-10.

Other than transportation fuels, and despite success on the part of the forest sector in producing and utilizing energy from biomass, renewable energy initiatives through the year 2000 were mostly directed toward encouraging the capture and use of solar and wind energy. That, however, has changed over the past five years, with forest biomass, crop residues, and various energy crops now clearly on the radar screens of policy-makers.

While a number of factors might be identified as bringing biomass to the attention of policy-makers, two of the most important were reports of two federal agencies: Energy and Agriculture. Perhaps the most compelling was a joint U.S.D.A./DOE publication that is commonly referred to as the *One Billion Ton Report* (Perlack et al., 2005). This report suggested annual availability of over 1.3 billion dry tons of biomass beyond that needed for food, livestock feed, fiber, and soil conservation, and indicated the potential for biomass to supply 5 percent of the nation's power, 20 percent of its transportation fuels, and 25 percent of its industrial chemicals and chemical feedstocks by 2030 – a quantity of energy equivalent to over 30 percent of 2005 petroleum consumption.

An earlier Department of Energy report had piqued interest in biomass (U.S. Department of Energy 1999), by calling attention to the potential for production of industrial chemicals from biomass. Therein it was predicted that some 10 percent of industrial chemicals and materials would be produced from renewable resources by as early as 2020, with this number approaching 50 percent by 2050 (Figure 3). It was subsequently noted that even at a 10 percent share, such chemicals would have an annual value of about $400 billion (1999 dollars), or about twice the value of all forest products produced in the U.S. in that year.

Figure 3
Projected Chemical and Material Demand from Renewable Resources, 1999-2050.



Source: US Department of Energy (1999).

Energy and Chemicals from Biomass – Many Options

Bio-Energy Alternatives

Currently a great number of options for converting biomass to energy products are recognized. These include:

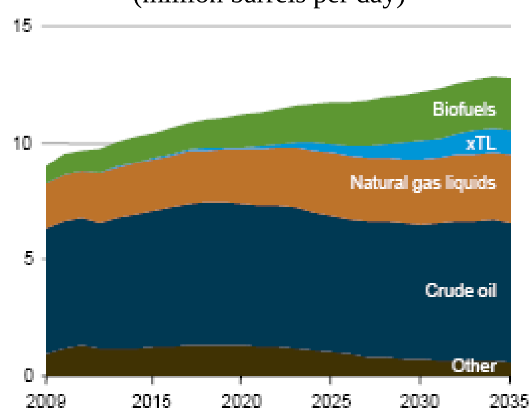
Ethanol

Although current U.S. ethanol production is almost totally based on corn starch, second generation biofuels technology will allow economic production of ethanol from the cellulose and hemicellulose components of plants. When this technology is commercialized, all forms of biomass will become potential raw materials for ethanol production. Beyond that point, future expansion of ethanol production is expected to be based both fermentation and thermochemical processing technologies. This is because advanced synthetic processes will yield more gallons of ethanol per dry ton of material produced, leading to substantial improvements in the net energy balance realized in conversion.

Research is steadily helping to erase early concerns about the high costs of producing cellulosic ethanol. The National Renewable Energy Laboratory (2011) reports that technological advances have been demonstrated in both biochemical and thermochemical approaches to cellulosic ethanol production such that modeled costs of commercial production have decreased from more than $6.50 per gallon in 2001 to less than $2 per gallon in 2010. An Asia-Pacific Economic Cooperation (APEC) Biofuels Task Force had earlier reported (2007) that at world petroleum prices of US$80-100 per barrel, biofuels from a wide variety of cellulosic feedstocks, including crop and forest residues would be cost competitive; the task force report also noted that costs of biofuels production using lignocellulosic feedstocks were expected to decline rapidly with continued technological advances, further enhancing economic competitiveness.

Despite the widely shared positive outlook for cellulosic ethanol it is worth noting that the technology is still not commercially viable, with production thus far only within laboratories and a number of pilot plants. Some cellulosic ethanol production is being used for publicity purposes such as auto racing and some existing plants and plants in the building stage show promise for commercial production soon. These include DuPont Danisco in Vonore, Tennessee; KL process Design Group in Upton, Wyoming; Iogen in Ottawa, Ontario, Canada, Fiberight in the Baltimore, MD-Washington, DC area; Coskata in Alabama, Poet in South Dakota, and Mascoma in Michigan. Biofuels production is predicted to increase by about 1.5 million barrels per day (to about 2.0 million barrels) by 2035, with ethanol comprising just over one-half this amount (EIA 2011a). Ethanol is expected to displace about 12 percent of domestic gasoline consumption by 2035 (Figure 4), compared to 3 percent currently.

Figure 4
U.S. Domestic Liquids Production by Source, 2009-2035
(million barrels per day)



Source: EIA (2011a)

Biobutanol

Butanol is a platform chemical with several large volume derivatives, used as a solvent and in plasticizers, amino resins, and other compounds. Butanol can also be used as a bio-based transportation fuel and is more fuel efficient than ethanol on a volume basis in this application. A very attractive feature of a common isomer out of four possible isomers of butanol is that its energy content is about 105,000 Btu/gallon, much higher than ethanol

(75,000 Btu/gal), and only slightly lower than gasoline (114,000 Btu/gal). Butanol is also less volatile than ethanol and can be mixed in motor fuels without modification of engines. Unlike ethanol butanol is not readily miscible with water so that it is more suitable for shipment in pipelines.

Biodiesel

Biodiesel is usually made by transforming animal fat or vegetable oil with methanol. Ethanol could also be used. . Biodiesel is not the same as Fischer-Tropsch diesel or petroleum diesel. Biodiesel is usually used in a mixture with petroleum diesel, such as B20 that is 20 percent biodiesel and 80 percent petroleum diesel. In Europe, the largest producer and user of biodiesel, the fuel is usually made from rapeseed (canola) oil. In the United States, the second largest producer and user of biodiesel, the fuel is usually made from soybean oil or recycled restaurant grease. Biodiesel can also be produced from wood.

Fischer-Tropsch Products and HDRD

The Fischer-Tropsch synthesis process is often applied to make fuels such as gasoline, diesel, and jet fuel from synthesis gas (a combination of hydrogen and carbon monoxide) derived from coal or lignocelluloses. With suitable catalysts the normal progression of the process may also be modified to produce various specific alcohols, or more commonly a mixture of alcohols. The process in the way it is normally operated produces straight chain non-oxygenated hydrocarbons (alkanes). Diesel made this way is interchangeable with petroleum diesel.

HDRD or hydrogen-derived renewable diesel is produced by refining fats or vegetable oils alone or blended with petroleum. With this process it's possible to produce true hydrocarbons with the same feedstocks as are used to make biodiesel. Neste in Finland makes a branded product termed NExBTL. With refiners using this process emphasis seems to be on jet fuel, but diesel made in this way would also be compatible with petroleum diesel.

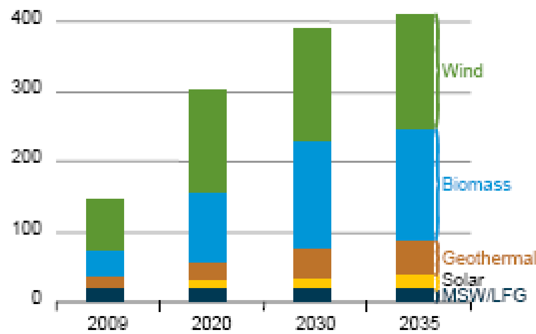
Bio-Oil

Bio-oil can be produced from rapid heating of biomass in the absence of oxygen leading to decomposition of cellulose, hemicelluloses, and lignin that also results in production of charcoal and gas. The raw oil has an energy content about one-half that of diesel fuel and can be burned in boilers or turbines or further processed into transportation fuels (Mullen and Boateng 2008). Presently, KIOR, a commercial next-generation fuel company is reportedly developing in the state of Mississippi several pulp-mill scale production facilities for what is described as renewable crude that can be refined to produce gasoline and diesel blend stocks. Bio-oil processing facilities on a smaller scale have been suggested for use in distributed locations close to the lignocellulosic fuel source. The bio-oil from a number of sources is than sent to a central processing facility to make diesel or gasoline. This would save on sending harder to handle tree branches and other residues longer distances.

Electricity from Biomass

Based on the 2011 Annual Energy Outlook (EIA, 2011a), electricity generation from biomass is expected to more than triple from 2009 to 2035, with biomass generating capacity expected to grow from 7 gigawatts to 20.2 gigawatts during that period (Figure 5). With much of current wood use in electricity generation attributable to co-firing with coal, most of the increase in future generating capacity is expected to occur in biorefineries, driven by mandates in the Federal Renewable Fuels Standard.

Figure 5
Non-hydropower Renewable Electricity Generation by Energy Source, 2009-2035
(billion kilowatt hours)



Source: EIA (2011a)

Syngas

Producer gas is produced through gasification of a carbon-containing fuel such as coal, municipal solid waste, or wood to a gaseous product. It consists primarily of carbon monoxide and hydrogen, but also carbon dioxide, methane, and nitrogen in various proportions.It may then be processed to reduce the dilution of the main hydrogen and carbon monoxide components. The result is syngas or synthesis gas and it then has about one-half the energy density of natural gas. Producer gas is combustible and can be used as a fuel source. Syngas may be used as an intermediate for the production of other chemicals. There is considerable potential for production of synthesis gas as a by-product of pulping in the papermaking process.

Hydrogen

Another possibility for producing fuels from biomass involves the production of hydrogen using gasification or other technologies in combination with steam reforming and what is referred to as the water-gas shift reaction to produce more hydrogen, but less carbon monoxide ($CO + H_2O \rightarrow H_2 + CO_2$). Despite low levels of hydrogen within biomass (about 6 percent by weight) the process of biomass conversion captures hydrogen from the water in the biomass (steam), providing a yield of approximately 9 percent per ton of dry biomass. Biomass-derived hydrogen is not yet economically feasible, but it is estimated that in the long-term, biomass may provide an economically viable source of hydrogen fuels (Czernik et al. 2004). Accordingly, a goal of economic competitiveness with gasoline by 2015 has been established by NREL scientists.

Industrial Energy Generation

In 1998 of the 190 million tons of biomass used annually for production of energy or bio-products that directly displaced petroleum-based feedstocks, some 96 million tons, or slightly more than 50 percent of energy from biomass was produced by the forest products industry for use in powering manufacturing operations. Then, as now, this industry had a high degree of energy self-sufficiency, with over one-half of all energy used in the primary forest products industry self-generated (EIA 1998a, b, Mayes 2003).

By 2008 the forest sector accounted for 66 percent of energy production from biomass, producing 1,342 trillion Btu in that year; 86 percent of this was thermal output, with the rest going to generation of just over 27 million kilowatt hours of electricity (EIA 2010a). Considering *industrial* biomass energy consumption the paper and allied products industry alone accounted for 55 percent of biomass energy consumption by all of industry, and by 2010 the paper industry had increased its energy self-sufficiency to 65% (AF&PA 2011).

District Heating

District heating involves production of steam or hot water for use in heating and cooling a cluster of buildings connected by an energy core. Long a common feature of rural communities of northern Europe, district heating has come to North America much more recently, although there were district heating plants in some cities including Pottsville, PA during the 1800s (New York Times 1895). The availability of biomass, coupled with programs to promote its use, have led several larger and many small municipalities across the U.S. to invest in such facilities.

Fuel Pellets

Fuel pellets are made from various forms of biomass (corn stalks, straw, wood) and are used as a clean fuel for production of heat within a closed combustion stove used for heating. These have been in common use in some regions of Europe for a number of decades, and market growth occurred in North America in the 1970s and '80s following the energy shocks of that period. Although North America's production of fuel pellets increased almost six-fold between 2003 and today, to about 7 million tons, wood fuel pellets enjoy only limited regional markets in the US and Canada today, with a significant portion of annual production exported to Europe. The EU is the leader globally in pellet production, with output there exceeding 11 million metric tons in 2010 (Ekstrom 2011b) from approximately 650 pellet plants (Sikkema et al. 2011); over 98 percent of that production was consumed within the EU.

Biochemicals

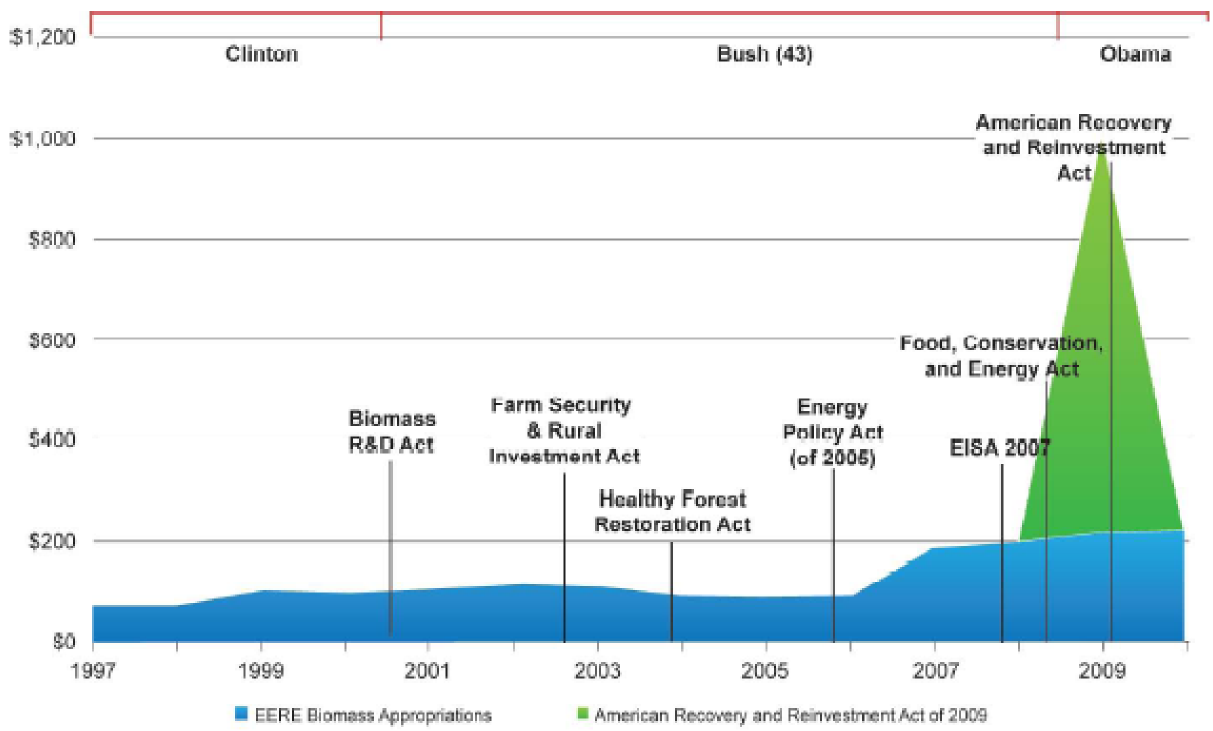
As with energy, there are a great many options for conversion of biomass to various industrial chemicals – chemicals that are now largely produced from fossil fuels – that include, for example, lubricants, resins, coatings, and feedstocks for a range of products including plastics, synthetic fiber and fabrics, medicinals, and more. Technologies are now in place or under development that will allow replacement of virtually all petrochemicals by biomass-derived chemicals. Animal feed in the form of molasses for cattle has also been made from hemicelluloses as a byproduct of ethanol production.

The Politics of Biomass Energy

Federal Initiatives

As noted in a recent Department of Energy report (USDOE 2010), bioenergy initiatives were begun by the National Science Foundation and transferred to DOE in the late 1970s. Early projects focused on biofuels and biomass energy systems. In 2000 the Biomass Research and Development Act established formal cooperation between DOE and USDA through authorization for formation of the Biomass Research and Development Board. The body is co-chaired by USDA and DOE and serves a coordinating role in research and development, and associated loans and grants, relative to cellulosic biofuels development.
In 2002 DOE created the Biomass Program within its Energy Efficiency and Renewable Energy Division, consolidating all biomass-related research efforts, including that related to bioproducts and bio-power. DOE notes that over $3.7 billion has been invested since the 1970s in research, development, deployment, and diffusion programs focused on biofuels, bio-power, biomass feedstocks, municipal wastes, and various bioproducts, with much of that over the past five years (Figure 6).

Figure 6
Funding for Biomass-Related Research, Development, Deployment, and Diffusion within the Department of Energy, 1997-2010



Source: US Department of Energy (2010a), p. 1-10.

In October 2008 the Secretaries of Energy and Agriculture released the National Biofuels Action Plan (USDOE/USDA 2008). This report, prepared by the Biomass Research and Development Board, outlines the state of technology development, infrastructure needs, and challenges to development of a cellulosic biofuels industry, and summarizes federal strategies for advancement and industry cooperation.

These and other initiatives have, in turn, fostered development of a myriad of federal programs, administered through a number of agencies (Table 2) that are designed to foster bioenergy and biochemicals development and production. Many of these programs are summarized in Table 3.

Table 2
Summary of Federal Agency Roles Across the Biomass-to-Bioenergy Supply Chain

Federal Agency	Feedstock Production	Feedstock Logistics	Biomass Conversion	Biorefineries and Bio-power	Biofuels Distribution	Biofuels End Use
Department of Energy	Plant and algal science; genetics and breeding; feedstock resource assessment; sustainable land, crop, and forestry management.	Sustainable logistics systems including harvesting, handling, storage, and pre-processing systems; testing logistics systems at demonstration scale.	Biochemical conversion (pretreatment/enzyme cost reductions); recalcitrance of all biomass resources; thermochemical conversion to fuels and power (gasification and pyrolysis).	Cost-shared projects and/or loan guarantees to (1) biorefineries, to demonstrate and deploy integrated conversion processes at pilot, demonstration, and commercial scale and (2) bio-power combustion systems related to biomass as a co-firing feedstock in coal-fired boilers; demonstrations of biomass co-firing.	Safe, adequate, sustainable, and cost-effective biofuels transportation/distribution systems development and deployment.	Emissions optimization/certification; vehicle emissions impact; market reporting and education to improve awareness regarding impacts of biofuels.
Department of Agriculture	Sustainable land, crop, and forest management; plant science; genetics and breeding; planting/ establishment payments to biomass crop producers.	Sustainable harvesting of biomass crop and forest residue removal; equipment systems related to planning.	Biochemical conversion (pretreatment/enzyme cost reductions); recalcitrance of forest resources; thermochemical conversion to fuels and power; on-farm biofuels systems.	Loan guarantees to viable commercial-scale facilities and grants to demonstration-scale facilities; payments to existing biorefineries to retrofit power sources to be renewable; payments to producers to support and expand production of advanced biofuels refined from sources other than cornstarch.; assessment of market impacts of biofuels production.	Loan guarantees and grants to (1) support safe and sustainable biofuel transportation distribution; (2) refineries and blending facilities development; (3) flex fuel pumps installation; and (4) support financing of transportation/distribution industry/businesses.	Market awareness and education to end users of advantages of increased biofuels use.
Environmental Protection Agency	Effects of feedstock production systems, including effects on ecosystem services (water quality, quantity, biodiversity)		Biowaste-to-energy; air, water, waste characterization of emissions and regulations/permitting; TSCA review of inter-generic genetically-engineered microbes used for biomass conversion; testing protocols and performance verification.	Health/environmental impacts of biofuels supply chain lifecycle; air, water, waste characterization of emissions and regulations/permitting; policy and research on waste-to-energy; testing protocols and performance verification.	Permitting, air emission characterization; regulation of underground storage tanks; emergency management and remediation of biofuel spills.	Engine optimization/ certification of vehicle emissions and air quality, environmental, and public health impacts; regulation of air emissions; market awareness/impact of biofuels on public health, ambient air, and vehicles.
Department of Commerce/ NIST			Catalyst design, biocatalytic processing, biomass characterization and standardization; standards development, measurement, and modeling.		Materials reliability for storage containers, pipelines, and fuel delivery systems.	Standard reference materials, data, and specifications for biofuels.
Department of Transportation	Sustainable land, crop, and forestry management.	Feedstock transport infrastructure development.			Safe, adequate, cost-effective biofuels transportation/ distribution systems development.	Promotion of safe and efficient transportation while improving safety, economic competitiveness, and environmental sustainability.
National Science Foundation	Plant genetics, algal science, and other paths to improve biofuels feedstocks and wastes as energy sources.	Basic research on modifications in processes to improve feedstock processing.	Basic and applied research on catalysts, processes, characterization for biochemical and thermochemical conversion technologies; lifecycle analysis; environmental impact amelioration.	Supportive R&D on health/environmental impacts; also bioproducts from biorefineries.		Supportive R&D on health/ environmental/safety/ social issues of biofuels use.
Department of the Interior	Forest management.	Forest management/ fire prevention (recovery of forest thinnings)	Biorefinery permitting on DOI-managed lands.			
Department of Defense	Basic R&D on feedstock processing (MSW/waste biomass)		Solid waste gasification; applied algal and cellulosic feedstock research and development.			Biofuels testing; standard reference materials, data, and specifications for biofuels.

Source: US Department of Energy (2010a), p. 1-16.

Table 3
Federal Programs that Support Development of Bioenergy and Biochemical Development and Production

Administering Agency	Program	Description	Year in Which Initiated	Funding FY 2010*	Expiration Date
EPA	Renewable Fuels Standard	Mandated use of renewable fuel in gasoline: 4.0 billion gallons in 2006, increasing to 7.5 billion gallons in 2012. Although the original requirement was for renewable fuel in gasoline, subsequent legislation expanded the mandate to include all transportation fuels.	2005, modified 2008		Ongoing
IRS	Volumetric Ethanol Excise Tax Credit	Gasoline suppliers who blend ethanol with gasoline are eligible for a tax credit of 51¢/ gallon of ethanol, reduced to 45¢/ gallon after 7.5 billion gallons produced nationally.	2005		End of 2010
	Small Ethanol Producer Credit	An ethanol producer with less than 60 million gallons per year in production capacity may claim a credit of 10¢/ gallon on the first 15 million gallons produced each year.	1990 , extended '04, '05		End of 2010
	Credit for Production of Cellulosic Biofuel	Producers of cellulosic biofuel may claim a tax credit of $1.01 per gallon. For cellulosic ethanol producers, the value of the credit is reduced by the value of the volumetric ethanol excise tax credit and the small ethanol producer credit – currently valued at 40¢/ gallon.	2009		End of 2012
	Special Depreciation Allowance for Cellulosic Biomass Ethanol Plant Property	Plants producing cellulosic ethanol through enzymatic processes may take a 50% depreciation allowance in the first year of operation, subject to certain restrictions.	2006		End of 2012
	Renewable Electricity Production Tax Credit	A per-kilowatt-hour tax credit for electricity generated by qualified energy resources and sold by the taxpayer to an unrelated person during the taxable year. Credit is 2.2¢/kwh for electricity generated from closed loop biomass and 1.1¢/kwh for open loop biomass.	1992		End of 2013
USDA	Biomass Research and Development Act	Joint program with DOE. Provides competitive funding for R&D and demonstration projects on biofuels and bio-based chemicals and products.	2000	$200M	End of FY 2015
	Biomass Research and Development Initiative	Joint program with DOE. Provides competitive grants, contracts, and financial assistance for research and development and demonstration of biofuels and biobased products, and the methods, practices, and technologies for their development.	2001	$30M (+$35M)	End of FY 2015
	Value-Added Producer Grants Program	Supports the development of business plans and marketing strategies for value-added products. Maximum award to any one individual is $300,000.	2001		Ongoing
	Rural Business Enterprise Grants	Grants to finance and facilitate development of small and emerging rural business enterprises.	2005		Ongoing
	Bioenergy Program for Advanced Biofuels	Provides payments to producers to support and expand production of advanced biofuels.	2008	$85M (+$25M)	End of FY 2012

Administering Agency	Program	Description	Year in Which Initiated	Funding FY 2011	Expiration Date
USDA	Biorefinery Assistance	Loan guarantees for the construction and retrofitting of biorefineries to produce advanced biofuels.	2008	$150M	End of FY 2012
	Repowering Assistance Payments to Elig. Biorefineries	Grants to existing biorefineries that use renewable biomass to reduce or eliminate fossil fuel use.	2008	$15M	End of FY 2012
	Biobased Markets Program	Provides for a federal procurement program and a voluntary labeling program for biobased products.	2008	$2.0M	2012
	Feedstock Flexibility Program for Producers of Biofuels (Sugar)	Authorizes the use of CCC funds to purchase surplus sugar, to be used as a biomass feedstock to produce bioenergy.	2008	Authorizes use of "such sums as necessary to ensure sugar program operates at no net cost."	Ongoing
	Biomass Crop Assistance Program	Provides financial assistance for biomass crop establishment costs and annual payments for biomass production; also provides payments to assist with costs for biomass collection, harvest, storage, and transportation to a biomass conversion facility.	2008	$400M	End of FY 2012
	Rural Energy Self-Sufficiency Initiative	Grants to enable rural communities to substantially increase their energy self-sufficiency.	2008	$5M	2012
	Rural Energy for America Program	Funds feasibility studies, renewable energy systems, and energy efficiency improvements.	2008	$70M (+$25M)	2012
	Forest Biomass for Energy	Authorizes the Forest Service to conduct a competitive research and development program to use forest biomass for energy. Priority given to projects that utilize low-value forest by-products, integrate the production of energy from forest biomass with existing manufacturing streams, develop new transportation fuels from biomass, or improve the production of forest biomass feedstocks.	2008	$15M	2012
	Community Wood Energy Program	Provides grants to state and local governments to develop community wood energy plans and to acquire or upgrade wood energy systems.	2008	$5M	2012
	Business and Industry Guaranteed Loans	Among the eligible activities is "commercially available energy projects that produce biomass fuel or biogas." (60 to 80% maximum guarantee on loans up to $10 million).			Ongoing
	Small Business Innovation Research Program: Phase I	Funding to support research and development projects for small businesses, in areas such as forests, rural development, and biofuels and bio-based products.	2009		

Administering Agency	Program	Description	Year in Which Initiated	Funding FY 2009	Expiration Date
DOE	Biomass Research and Development Initiative	Joint program with USDA. Provides competitive grants, contracts, and financial assistance for research and development and demonstration of biofuels and biobased products, and the methods, practices, and technologies for their development.	2001	$35M	End of FY 2015
	Biorefinery Project Grants	Funds cooperative R&D on biomass for fuels, power, chemicals, and other products.	2001	$179M for entire program	None
	DOE Loan Guarantee Programs	Loan guarantees for energy projects that reduce air pollutant and greenhouse gas emissions, including biofuels producers. In 2008 biomass projects made up 24 percent of all renewable energy applications submitted to the program, second only to solar at 31 percent (Gibson 2009).	2005	$10B for renewable energy and energy efficiency	None
	Loan Guarantees for Ethanol and Commercial Byproducts from Various Feedstocks	Several programs of loan guarantees to construct facilities that produce ethanol and other commercial products from cellulosic material, municipal solid waste, and/or sugarcane.	2005		Varies by program.
	Cellulosic Biofuels Production Incentives	Authorizes DOE to provide per-gallon payments to cellulosic biofuel producers until annual U.S. production of cellulosic biofuels reaches 1 billion gallons or August 15, 2015, whichever is sooner.	2005	$25B for entire program	August 2015
	Incentives for Production of Advanced, Low Impact Biofuels	As required in the Energy Independence and Security Act of 2007, DOE is responsible for administering federal incentives, laws and regulations, funding opportunities, and other federal initiatives related to alternative fuels and vehicles and advanced technologies. Program joint with USDA. (http://www.afdc.energy.gov/afdc/laws/fed_summary)	1999	$105 M in 2012	End of 2012
	Industrial Energy Efficiency	Competitive funding to support CHP, district energy systems, waste energy recovery, and efficient industrial equipment.	2009		
	Industrial Energy Efficiency Grand Challenge Grants	Funding for advancement of industrial procedures and technologies that decrease greenhouse gas emissions.	2009		
U.S. Customs and Border Protection	Import Duty for Fuel Ethanol	All imported ethanol is subject to a 2.5% ad valorem tariff; fuel ethanol is also subject to a most-favored-nation added duty of 54 cents per gallon (with some exceptions).	1980		End of 2010

* The designations M and B in the funding column refer to million and billion, respectively.

Source: Yacobucci, Congressional Research Service (2008), Capehart et al., Congressional Research Service (2008), U.S. Department of Agriculture (2008), Washington State Dept. of Community, Trade, and Economic Development (2009), Andersen (2010)

State and Regional Initiatives

State

Most of the states have enacted laws in recent years to promote the development and use of biomass energy. In addition, a number of regional coalitions of states have also been formed with the express purpose of providing incentives for biomass energy development.

Given the difficulty of locating and updating rapidly changing renewable energy legislation in the various states, no attempt has been made herein to provide a comprehensive listing of state statues relating to biomass energy. The challenge of remaining current regarding state initiatives is illustrated by estimates provided by the National Conference of State Legislatures that at least 2,000 bills related to renewable energy were introduced in state legislatures in both 2009 and 2010 (NCSL 2010, 2011). Recurrent areas of focus within state initiatives have included:

- Renewable fuel standards
- Renewable portfolio standards
- Renewable electricity standards
- Reducing/eliminating excise taxes on renewables
- Production tax credits
- Property or sales tax credits
- Investment tax credits
- Cost-sharing arrangements, grants, and rebates for renewable energy development
- Loans, bond financing
- State production requirements
- Net metering requirements for utilities
- Greenhouse gas reduction policies
- Technical assistance

A variety of resources provide frequently updated information regarding renewable fuel and biomass energy initiatives. Key sources are those of the University of Minnesota Department of Forest Resources (Becker and Lee 2008), US Department of Energy (2010b; 2011a,b), the National Conference of State Legislatures (2011), and the organization 25 x '25 (2011).

As reported by the NCSL, 38 states and the District of Columbia currently have some type of renewable portfolio standard or renewable fuel goals. Eleven of the states that have adopted renewable portfolio standards have biofuel mandates (CA, FL, IA, LA, OR, MA, MT, MN, MO, NM, WA).

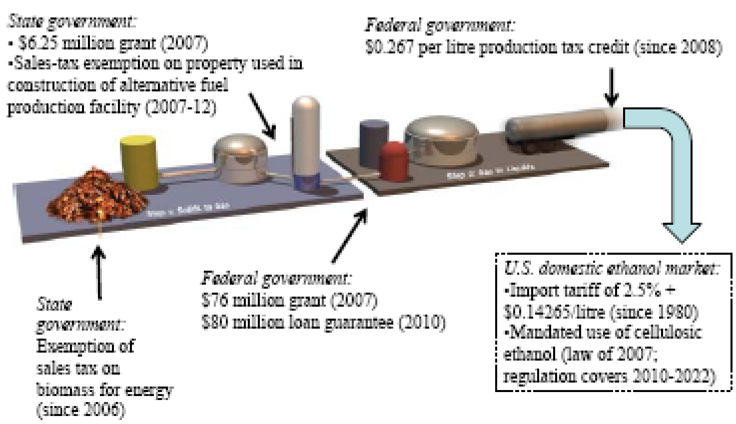
The RPS picture may change dramatically within the next several years as bills have been introduced in a number of states to overturn earlier adoption of renewable fuel targets and mandates. The impact on biomass consumption for energy production remains to be seen.

Perhaps the most significant state initiative in recent years is approval in February 2011 of a "greenhouse gas cap and trade" program by the California Air Resources Board. Regulations apply to all major utilities and industrial sources of carbon dioxide and other greenhouse gases beginning in 2012, with coverage expanded each year through 2015 (Wilent 2011).

Regional

Since thousands of bills focused on renewable and biomass energy are introduced in state legislatures every year, it is difficult to keep track of what is going on, and the cumulative effect of these and similar actions at the federal level. In fact, understanding the applicability of various initiatives to a single project can be daunting. An example how numerous programs were applied to development of a single cellulosic ethanol project is illustrated in Figure 7.

Figure 7
An Example of How Various Government Support Programs
Benefit a U.S. Cellulosic-Ethanol Plant



Source: Fliess and Steenblick (2007)

To address the coordination issue, the US Department of Energy Office of Biomass Programs has initiated five regional alliances for the purpose of encouraging the increased use of bioenergy and biobased products through coordinated federal, regional, and state outreach education and technical assistance. Regional alliances include the:

- Western Regional Biomass Energy Program of the Western Governors Alliance (an alliance of the states of Arizona, California, Colorado, Kansas, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, South Dakota, Texas, Utah and Wyoming)
- Southeastern Regional Biomass Energy Program (Alabama, Arkansas, District of Columbia, Florida, Georgia, Kentucky, Louisiana, Mississippi, Missouri, North Carolina, Puerto Rico, South Carolina, Tennessee, Virgin Islands, Virginia, and West Virginia)

- ♦ Pacific Regional Biomass Energy Program (Alaska, Hawaii, Idaho, Oregon, Montana, and Washington)
- ♦ Northeast Regional Biomass Energy Program (Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont)
- ♦ Great Lakes Regional Biomass Energy Program (Illinois, Indiana, Iowa, Michigan, Minnesota, Ohio, and Wisconsin)

Becker et al. (2011) identified 370 state policies across all of the 50 states aimed at providing incentives for forest biomass utilization. These various policies were organized by use within the biomass-to-energy supply chain, and then assessed state-by-state and region-by-region to assess how various policies interact to positively or negatively impact the supply chain. Among the conclusions were that policies relative to biomass transportation are rare, despite the fact that transportation costs have been widely documented as a barrier to biomass energy production. Another finding was that federal rules and regulations that effectively disqualify biomass from national forests for use in meeting goals of the federal renewable fuels standard have the effect of thwarting state efforts to develop biomass energy in areas where federal forests dominate. A key outcome of this research is that a framework has been established to systematically assess the effectiveness of state and regional policies and to determine interactions with federal policy; this work marks a key step in successful coordination of policies at various levels of government.

Biomass Energy Potential

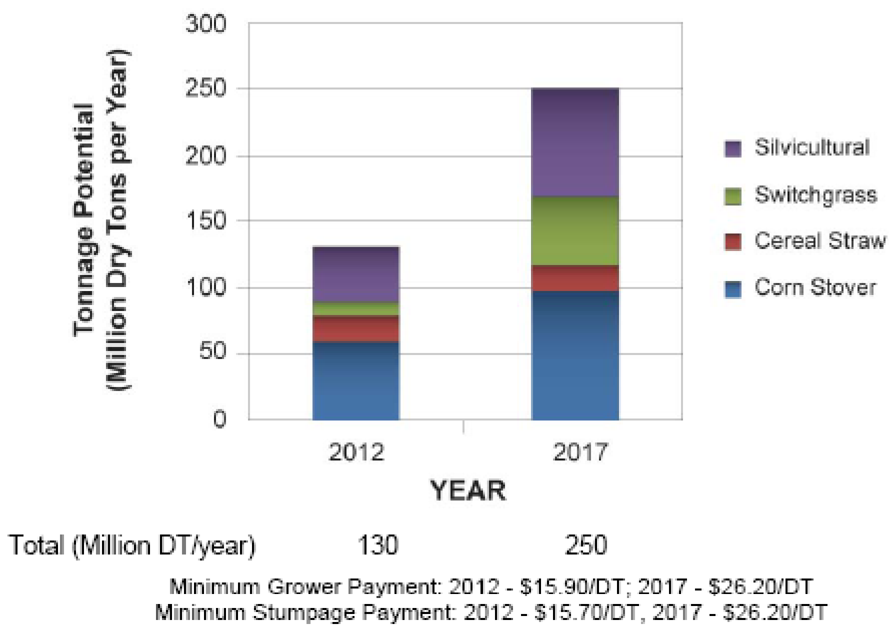
A recent joint report of the U.S. Departments of Energy and Agriculture – including the USDA-Forest Service (Perlack et al., 2005) identified a potential for annual production of over 1.3 billion dry tons of biomass in the U.S., a volume more than seven times the volume of biomass consumed for production of bio-energy and bio-based products. The report, commonly referred to as the "Billion Ton Report," pointed to the existence of 55 million acres of land in the continental United States that were not being used for food production, and that had the capacity to produce significant quantities of biomass without the need for irrigation. It was estimated that 377 million dry tons of biomass crops, such as switchgrass, reed canary grass, poplar, eucalyptus, and other species could be produced annually from these 55 million acres. In addition, it was estimated that 428 million dry tons of agricultural residues in excess of that needed for conservation tillage could be removed annually from U.S. farmland for production of bio-fuels. The joint report also pointed to 368 million dry tons of woody biomass estimated to be sustainably available annually from forest lands; a part of the woody biomass would come from non-commercial forest thinnings conducted for the purpose of reducing wildfire danger. Other forms of biomass, including manure collected at feedlot or dairy operations, organic materials recovered from wastewater, and municipal solid waste bring total estimated annual biomass availability to 1.3 billion dry tons.

Overall, the quantity of biomass identified in the Billion Ton Report as annually available in the United States is equivalent to a little over one-half of 2006 petroleum consumption.

Report authors indicated that by 2030 biomass could supply 5 percent of the nation's power, 20 percent of its transportation fuels, and 25 percent of its industrial chemicals and chemical feedstocks, equivalent to 30 percent of 2005 U.S. petroleum consumption. Not surprisingly, these estimates attracted the attention of decision-makers.

Subsequent to the Perlack et al. report, the Biomass Research and Development Board (BRDB 2008) conducted a re-evaluation of biomass availability, subtracting from the Perlack numbers the volumes already being used for production of wood and paper products and energy; over 95 percent of the 159 million dry tons of industrial wood wastes fell into this category. Also subtracted were volumes of wood in small diameter trees and forest residues judged to be non-economical to recover assuming a ceiling cost of $44 per dry ton at the forest roadside. The net result of these revisions is that the earlier estimated availability of 368 million dry tons annually was revised downward to 45 million tons, or to only 12.2 percent of the original estimate. Availability is expected to increase, however, with increased demand stemming from expected growth in production of liquid biofuels; the Department of Energy Biomass Program estimate for woody biomass availability rises to about 80 million dry tons by 2017 (labeled in Figure 8 as "Silvicultural).

Figure 8
Projected Bioenergy Feedstock Availability at Specified Minimum Grower Payments



Source: U.S. Department of Energy (2010a, p. 2-17).

Regarding production of woody biomass in bioenergy dedicated plantations, the BRDB report projects that this kind of material, along with perennial grasses, is likely to play a major role in the cellulosic biofuel mix. Woody material would come from short-rotation tree plantations established on cropland, as well as from biomass plantations established on grasslands, timberland, or other lands not classified as croplands. Under the revised estimate, wood from bioenergy plantations would constitute a significant part of projected production of 145 to 236 million dry tons per year by 2022.

Displayed prominently in the Billion Ton Report, is a list of assumptions on which biomass availability projections were based. Among these assumptions are the following:

- Yields of corn, wheat, and other small grains will increase by 50%.
- Harvest technology is capable of taking 75% of annual crop residues (when removal is sustainable).
- All cropland is managed by no-till methods.
- 55 million acres of cropland, idle cropland, and cropland pasture will be dedicated to production of perennial energy crops, including grasses and trees.

These are obviously non-trivial assumptions. Conversion of assumptions to reality will require substantial investment in research, development, education and technology transfer, and mobilization of investment capital. Strategic planning, and actions to ensure that biomass supplies match projected biomass availability, are essential.

Forms of biomass that have attracted the most attention over the past several years are mill residues - sawdust, shavings, and sander dust. These forms of biomass are far easier to collect than forest or agricultural residues or, in the short run – dedicated energy crops – although the long history of use of these materials in producing value added products translates to significant competition for their use, at least until recently. The marked downturn in the North American forest products industry that began in 2007 led to both reduced production of mill residues, and reduced demand for them from traditional users such as the particleboard industry. During the same period, however, the bioenergy industry continued to grow. The result was a marked reduction in the long-running surplus of mill residues (Table 4 and Figure 9).

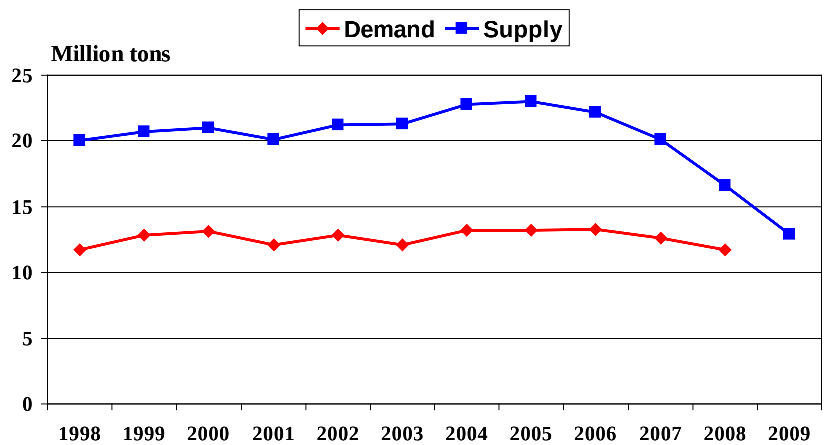
Table 4
Wood Residue Supply and Demand in the United States and Canada

	SW Lbr	SW Plywd	HW Lbr	Sawdust, shavings, sander dust	Wood pellet use in stoves	Sources of Demand (x 10^6 tons)				
	x10^9 bd ft.	x10^9 ft.^{2}	x10^9 bd ft.	x10^6 bd tonnes	x10^3 tonnes	Pellets	MDF	Particleboard	Pulp	Total
1998	63.2	19.8	14.7	20.0	114	0.3	2.5	7.5	1.4	11.7
1999	65.6	20.0	15.2	20.7	132	0.4	2.8	8.1	1.5	12.8
2000	67.4	19.7	14.6	21.0	163	0.5	2.8	8.0	1.8	13.1
2001	64.9	17.4	13.7	20.1	217	0.8	2.7	7.1	1.5	12.1
2002	68.7	17.7	14.2	21.2	251	0.9	3.0	7.7	1.2	12.8
2003	69.0	17.2	14.4	21.3	299	1.1	2.9	7.1	1.0	12.1
2004	73.8	17.3	15.7	22.8	367	1.3	3.3	7.5	1.2	13.2
2005	74.9	17.0	15.4	23.0	486	1.6	3.4	7.2	1.1	13.2
2006	72.3	16.0	14.9	22.2	619	2.0	3.4	6.8	1.1	13.3
2007	65.1	14.6	13.8	20.1	673	2.1	3.4	6.0	1.1	12.6
2008	52.8	12.2	12.2	16.6	814	2.3	3.0	5.4	1.0	11.7
2009	42.0	10.0	8.7	12.9						

Source: Spelter and Toth (2009)

As lumber and plywood markets and production begin to regain steam, which a panel of experts recently predicted would rebound spectacularly between 2012 and 2013 (Random Lengths 2011a), sawdust and shavings production will increase. At the same time, demand from pellet, MDF, particleboard, and pulp industries is likely to increase as well. Going forward, how quickly and to what extent will the pellet industry grow? Will the forest industry seek to expand consumption of residues for energy, releasing lesser volumes for use by other industries? Will new sources of demand for wood residues develop, such as for cellulosic biofuels? The answers to these questions will have major implications for future residue availability and costs.

Figure 9
North American Residue Supply from SW Lumber and Plywood and HW Lumber, and Demand from Pellets, MDF, Pulp, and Particleboard



Source: Spelter and Toth (2009)

A very recent development that will help to answer some of the questions posed above is the May 4, 2011 announcement by the Department of Agriculture that it would designate 50,000 acres in 39 counties of Missouri and Kansas as the first Biomass Crop Assistance Program Project Area in the U.S. (Reuters 2011). Those acres will be planted with switchgrass and other perennial energy crops for use in manufacturing biomass pellet fuels and other bioenergy products.

Potential Impacts of Energy and Climate-Related Public Policy on Established Industries

Operating Costs and Global Competitiveness

From a federal perspective, the greatest concerns about increases in industrial energy prices focus on impacts on global competitiveness. A recent report in this regard dramatically illustrates how changes in energy prices can impact industrial concerns, and how well-intentioned governmental initiatives can devastate even large and well-established industries. Halpern et al. (2007) point to sharp increases in natural gas and oil prices through the 1990s up to 2006, indicating that rising natural gas prices were "in many ways a product of well-intentioned government policies that . . increased demand for natural gas in the electric power sector." They further noted that "Over the past two decades, power producers, seeking to limit emissions in response to U.S. and state environmental regulations, have turned to natural gas as a fuel." However, the domestic supply of natural gas remained flat, leading to domestic natural gas prices that were far higher than in most other nations[5]. Electricity rates also increased significantly from the mid 1990s through the middle of the last decade, rising 40 to 50 percent to exceed energy costs in other countries.

The effects were sobering. For example, the U.S. aluminum industry – an industry that relies on electric power for over 80 percent of its energy needs – was paying 41 percent more for electricity by 2004 than in 1997, a development that led to a one-third reduction in domestic production and a shift in market share to China, Russia, and Canada. The domestic chemicals industry – an industry that relied heavily on natural gas as a fuel and feedstock – was decimated. With energy costs one of several factors that negatively impacted competitiveness of this industry, the export value of industrial chemicals (excluding pharmaceuticals) fell from $16.8 billion in 1997 to $218 million by 2006. The paper industry was similarly affected, with a number of recent mill closures attributed in part to the rise in natural gas prices relative to other nations.

Ho et al. (2008) examined the likely effects on an array of U.S. industries of increases in energy costs resulting from a $10 per ton tax on carbon. Examining impacts over very short, short, medium, and long-run time horizons, they found that great care would be needed in implementing any kind of carbon policy because of the potential to cause significant adverse impacts to domestic industries while simply shifting emissions impacts to nations with weaker or nonexistent GHG mitigation policies. The greatest risk arises from policy that is not mirrored by that of global competitors and trading partners. Not surprisingly, the greatest risks are to energy and carbon intensive industries, with the degree of risk linked to the degree to which specific industries can pass on costs to consumers, the potential for customers to shift to less carbon intensive products through product substitution, and the strength of competition from imports. Judged to be at greatest risk in both the very short and longer time horizons are the petroleum refining, chemicals and plastics, primary metals, and nonmetallic metals industries. In this study, pulp and paper was not identified as a high-risk industry.

Several additional studies have focused on the effect of increased energy prices on energy-intensive industries (Bassi et al. 2009; Yudken and Bassi 2009, 2010) and all have concluded that climate policies that put a price on carbon, if enacted by the U.S. alone or non-uniformly worldwide, could have substantial impacts on the competitiveness of U.S. energy-intensive manufacturing industries in the relatively near term, especially if not accompanied by effective energy efficiency investments. As in the Ho et al. study, energy intensive industries were seen as facing the likelihood of increased production costs, reduction of operating surpluses and margins, and erosion of their domestic and global market shares, with iron and steel, petrochemicals, aluminum, and pulp and paper

[5] Natural gas prices have subsequently declined substantially in response to discovery of new supplies and implementation of new extraction technologies.

industries identified as facing the greatest challenges. From a policy standpoint, researchers warn that care must be taken in crafting climate policies so as to not encourage energy intensive industries to simply shift operations to some other region of the world that may not have comparable greenhouse gas emissions reduction commitments. At the same time, it is noted that there are technology investment and policy options that could serve to mitigate policy-related operating cost increases while improving energy efficiency and enhancing long-term economic performance and competitiveness.

It is apparent that care must be taken in development of public policy that has the effect of raising energy prices. Even well intended actions can profoundly and adversely affect individual firms, industry sectors, and even entire industries.

Bassi et al. (2009) point out that the extent of impacts and challenges, as well as opportunities vary across industries depending upon energy intensities, their energy mix, and how energy and energy feedstocks are used in production. The forest products industry would appear to have something of an advantage in this regard. For instance, while the paper industry faces challenges as indicated above, it nonetheless obtains much of its energy from biomass, and moreover has considerable expertise and the infrastructure in place to procure and handle biomass resources. Thus this industry not only has significant opportunities to increase its energy efficiency (as noted above) but to potentially become a provider of power, biofuels, and/or biochemicals.

<u>Impacts on the Forestry/Wood Products Sector</u>

Sector-Wide Observations

In 1998, a time when thinking about significant bioenergy development was just beginning to move into the mainstream, the Department of Energy examined the forest products industry from a wood energy perspective. Several excerpts from the final report (Mayes 1998) capture the essence of findings - interesting in that they almost perfectly describe current situation and nature of discussion:

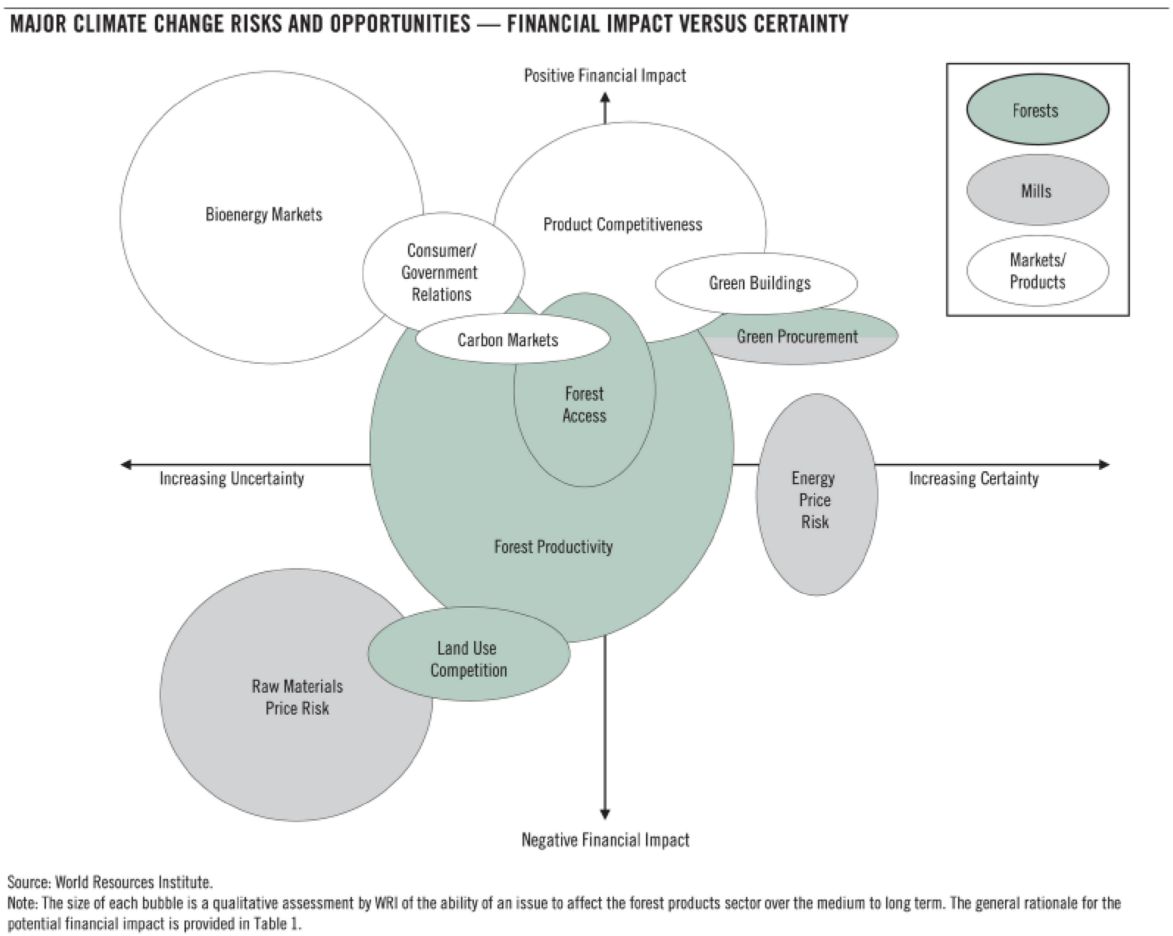
> " . . . *The challenge of broader implementation of biomass for energy* [beyond use by the forest products industry itself] *is to gain the wider involvement of those entities most able to participate, as well as to stimulate new industry.*
>
> *Although certain sectors of the Forest Products Industry would indeed resist diverting more biomass resources for energy, the fact is that the majority of timber grown in the United States is available to the winning bidder. Forest product industry members are generally not self-sufficient in supply, so they purchase needed biomass products from producers or other intermediaries. Generally, these resources are non-industrial private landowners not under long-term contract. Further, current forest removal (i.e., utilization) rates are such that a substantial supply of logging residue is available. Therefore, at a sufficient price, energy interests could obtain additional biomass resources."*
>
> *" . . . Considering all viewpoints, two key questions relating to the area of governmental policy seem to be emerging:*

1) Will renewable energy mandates, if enacted, stimulate the birth of a new renewable-based generating industry, with survival qualities yet to be determined?

2) Will the Forest Products Industry overall be a formidable obstacle or a willing participant in additional biomass energy generation?

In short, the Department Energy in 1998 described bioenergy development as both a potential risk and potential opportunity for the U.S. forest products industry, and questioned how the industry might respond. Ten years later the World Resources Institute produced a graphic representation of risks and opportunities facing the forest products industry (Figure 10); in this case the focus was not bioenergy development, but instead climate change. Realistically, risks identified relate not only to climate policy, but to energy policy as well. Risks identified include impacts of rising energy prices, the potential for raw materials price increases due to competition from a growing bioenergy industry, and increasing land use competition linked to both bioenergy production and

Figure 10
Major Climate Change Risks and Opportunities in the Forest Products Industry



Source: Aulisi, Sauer, and Wellington (2008) public interest in forest carbon reserves. Another identified, though largely uncertain risk is loss of productivity due to increasing incidence of drought, disease, insect infestation, and fire – and over the longer term – shifts in the historic range of forest tree species. The same factors were identified by the European Commission (2009) as threats to the pulp and paper industry.

The risk of increased raw material prices for mills (lower left, Figure 10) is seen as large, though the prospects for increasing prices are seen as uncertain. A good part of that uncertainty hinges on what happens in the public policy arena. The same is true of risks posed by land use competition. The recently established Biomass Crop Assistance Program (discussed in greater detail in the following section) provides an example of how public policy can raise raw material prices for the forest products industry.

WRI researchers envision not only risks associated with climate policy, but opportunity as well. Actions on the part of both industry leaders and policy makers are likely to have substantial influence on the risk/opportunity balance. Nonetheless, opportunities envisioned for the forest products industry include:

- The potential for increases in forest productivity (with a probability roughly equal to the risk of loss of probability. The potential for increased growth rates in a carbon-rich atmosphere, and greater intensity of management in response to expanded market opportunities could both contribute to increases in forest outputs.
- The emergence of bioenergy markets.
- Increased competitiveness of wood products with fossil fuel and energy intensive products.
- Market opportunities linked to the green building movement and green procurement.
- Improved relationships with government regulators and consumers.
- Opportunities in carbon markets, although the potential here is judged to be both modest and uncertain.
- A positive (as well as negative) impact of fossil fuel price increases. Positive aspects relate to increasing interest in biofuels and relatively greater impacts of fossil fuel costs on energy intensive competitors.

One thing that is abundantly clear is that from this point forward the price of wood in any form must at least reflect its energy value, in addition to costs of growing, harvesting, transporting, and processing. Roberts (2007) posits that markets for fuel, food, and fiber (e.g., wood) will converge over time in the sense that their primary feedstocks will tend to trade on the basis of their energy equivalency. In his view, the world price for oil will become a support price for farm and lower quality forest products.

Regarding the risk of price increases for raw materials used in producing forest products, Table 5 illustrates the relationship between the price of a barrel of oil and the equivalent energy value of a variety of various forms of energy and feedstocks used in generating energy. If these various energy products and feedstocks were perfectly interchangeable, then they could be expected to be priced at levels reflecting their energy content; the substantial disparity in price values is indicative of the difficulty in substituting fuels and,

Table 5
Value of Different Energy Products and Feedstocks Based on Net Heat Value and Various Prices per Barrel of Petroleum

	Petroleum	Equivalent Value	#2 Fuel Oil	Propane	Natural Gas	Electricity	Bituminous Coal	Wood Pellets	Hardwood Chips/Shavings (Price/odt)	Softwood Chips (Price/odt)
Btu – Net heating value	5,576,000/Bbl		115,000/gal.	71,900/gal.	820,000/M ft^3	0.0034/kwh	26,000,000/t*	13,600,000/t	13,800,000/t	6,060,000/t
	($/Bbl)	($/Million Btu)	($/gallon)	($/gallon)	($/1,000 ft^3)	(¢/kwh)	($/ton)	($/ton)	($/ton)	($/ton)
	50	8.63	1.00	0.62	7.09	2.94	224.38	117.65	119.37	52.30
	75	12.94	1.49	0.93	10.60	4.40	336.44	175.70	178.30	78.42
	100	17.26	1.99	1.24	14.18	5.88	448.76	235.50	238.74	104.60
	125	21.57	2.48	1.55	17.70	7.33	560.82	293.50	297.82	130.71
	150	25.88	2.97	1.86	21.19	8.80	672.89	351.43	356.66	156.83
	200	34.52	3.98	2.48	28.36	11.76	897.52	470.60	477.48	209.19
	250	43.14	4.96	3.10	35.40	14.66	1121.64	587.00	595.64	261.43
	300	51.76	5.94	3.72	42.38	17.60	1345.71	702.86	713.32	313.67
Mid 2009 Price (Avg. U.S.)	61.66	11.06	2.39	2.03	Ind. 5.33 Res. 12.12	Ind. 6.81 Res. 11.51	58.76	244.00	--	PNW 82.58 South 64.43
Feb./Apr. 2011 Price (Avg U.S.)	99.21	17.12	3.39	2.38	Ind. 5.56 Res. 10.01	Ind. 6.73 Res. 10.99	67.60	249.00	--	PNW 60-160 South 60-70

Table 5 (Continued)

Value of Different Energy Products and Feedstocks Based on Net Heat Value and Various Prices per Barrel of Petroleum

	Petroleum	Equivalent Value	Southern Pine Pulpwood (Delivered)	Southern Pine Chip-N-Saw Logs	Southern Pine Sawlogs (Delivered)	Western Softwood Sawlogs (Delivered)	Hardwood Sawlogs (Delivered)
Btu – Net heating value	5,576,000/Bbl		9,160,000 Btu/Cord	10,345,000 Btu/Cord	6,966,000 Btu/M Bdft Scribner	6,670,000 Btu/M Bdft Scribner	8,300,000 Btu/M Bdft Scribner
	($/Bbl)	($/Million Btu)	($/cord)	($/cord)	($10^3 Bdft Scribner)	($10^3 Bdft Scribner)	($10^3 Bdft Scribner)
	50	8.63	79.05	89.28	60.12	57.56	71.63
	75	12.94	118.53	133.86	90.14	86.31	107.40
	100	17.26	158.10	178.55	120.23	115.12	143.26
	125	21.57	197.58	223.14	150.26	143.87	179.03
	150	25.88	237.06	267.73	180.28	172.62	214.80
	200	34.52	316.20	357.11	240.47	230.25	286.52
	250	43.14	395.16	446.28	300.51	287.74	358.06
	300	51.76	474.12	535.46	360.56	345.24	429.61
2009 Price (Avg. U.S.)	61.66	11.06	23.58	42.19	333.35	359.38	151.00-271.00
Feb./Apr. 2011 Price (Avg U.S.)	99.21	17.12	29.13	43.88	340.00	567.00	#2 Sawlogs (oak, ash, maple) 200.00-350.00

- Prices for various energy products from Energy Information Administration (2011).
- Gross heating values and efficiency estimates from USDA-Forest Service Fuel Value Calculator (2008).
- Conifer chip prices from Random Lengths Yardstick (2010, 2011b), and converted from oven dry metric tons (odmt) to oven dry tons (odt).
- Volumes per cord as per Dobie and Wright (1975); wood volumes assumed for southern pine pulpwood – 85 cubic feet/cord; C-N-S logs 96 cubic feet/cord.
- Net Btu values for pulpwood determined based on wood volume per cord, calculated mass of dry wood based on average specific gravity of 0.47, average dry basis moisture content of 65%, and efficiency factor in energy conversion of 0.67. (wet basis moisture content – (100*65/100 + 65 =39.4%; wood substance = 60.6%; 85 ft^3/cord*.47*62.4 lb/ft^3*.606*8600 Btu/lb*.67 = 8,705,000 Btu/cord); Wiirhout the .67 efficiency factor – 85 x .47 x 62.4 x .606 x 8600= 12,990,000
- Net Btu values for sawlogs determined based on weights per board foot of logs per Page and Bois (1961), adjusted for specific gravity; specific gravity of logs assumed as 0.47 for SYP, 0.45 for western softwood species, and 0.56 for hardwood species. In all cases, average dry basis moisture content of 65% and efficiency factor in energy conversion of 0.67 assumed.
- Pine pulpwood and CNS log prices from LSU Ag Center (http://www2.lsuagcenter.com/agsummary/narrative.aspx)
- Hardwood Sawlog Prices from Northeast Timber Exchange (http://northeasttimberexchange.com/?page_id=4)
- Though not shown, the energy values of switchgrass, corn stover, and other forms of energy crops and agricultural residue are very similar to those of wood. On a moisture-free basis, switchgrass and corn stover have net heating values at 80% efficiency of 12.4 and 14.1 million Btu per ton, respectively.

in some cases, of relative abundance. What the numbers show is that at the current (April 2011) petroleum price (yellow shaded line) and at current prices for various energy products and feedstocks, several forms of raw material currently used in producing forest products are selling at prices well below their equivalent energy values; these include southern pine pulpwood, southern pine Chip-N-Saw logs, conifer chips, and even some species of hardwood sawlogs. Figures also suggest that if energy prices were to rise 50 percent over current levels, current sawlog prices for some preferred species would be below equivalent energy value. Given the current and expected long-term emphasis on bioenergy, over any extended period of time, disparity between price and energy value is not likely to persist.

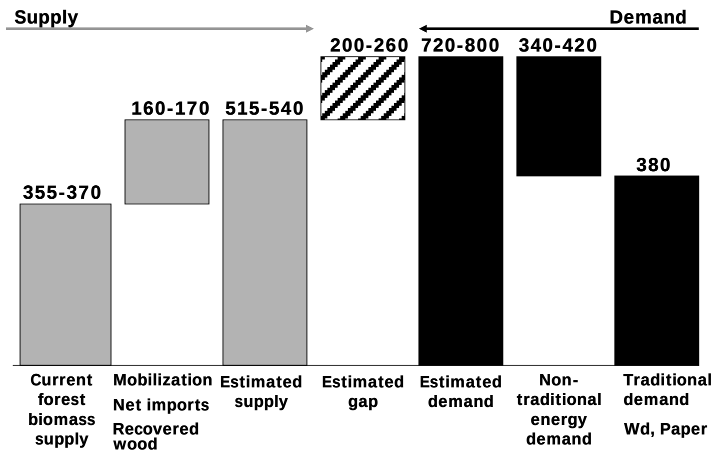
Energy Policy and the Paper Industry

There has been considerable discussion in recent years of the positive implications of bioenergy and biochemicals development for the pulp and paper industry. Conversion of chemical pulp and paper mills to full biorefineries and adapting new technologies for conversion of black liquor and hemicellulose to energy and chemicals holds the promise of expanding product options, boosting profit margins, and improving environmental performance. However, it is increasingly apparent that the promise of bioenergy/ biochemicals development could be derailed by casual government intervention aimed at stimulating such development.

An assessment of how bioenergy development without careful implementation might affect established industries was completed in late 2007 for the European Commission. That study, the result of a McKinsey/Pöyry Forest Industry Forestry Consulting team analysis commissioned by the Confederation of European Paper Industries (Mensink 2007, CEPI 2007), examined European bioenergy targets in the context of available biomass. Those targets are relatively aggressive and include significant growth in production of electricity from biomass, a more than doubling of the use of renewable fuels (and particularly biomass) in heating and cooling, and pursuit of cellulosic ethanol and other transportation fuels. The conclusion of the McKinsey/Pöyry study was that demand for biomass will exceed supply (i.e. a supply gap will develop – Figure 11) if efforts to mobilize additional volumes of biomass do not accompany pursuit of biomass energy targets as part of the goal to obtain 20 percent of energy from renewable sources.

The implications of a biomass supply gap as presented in Figure 11 were outlined by the McKinsey/Pöyry team in the form of three scenarios (Figure 12). The first scenario represents an ideal case in which there is no mismatch between demand for and supply of woody biomass. In this case some price increases for woody biomass are likely, primarily due to regional mismatches between supply and demand and related transportation issues, but overall the outlook is for only a limited impact on Europe's pulp and paper industry.

Figure 11
Projected Gap Between Woody Biomass Supply and Demand
in Europe Without Efforts to Bolster Supply



Source: McKinsey/Pöyry Forest Industry Consulting, 2007 (Mensink 2007; CEPI 2007).

Figure 12

Three Possible Scenarios Regarding Efforts to Reach 20%
Renewable Energy Supply

1	No mismatch between demand for and supply of wood biomass -Increased biomass supply -other RES technologies	* Some cost increase (regional mismatches/ transportation) * Limited effect on PPI
2	Mismatch between demand for and supply of wood biomass Current subsidy levels and structure	* Significant increase in cost of bio-mass (incl. pulpwood and logs) * Some risk to paper industry competitiveness. * Significant risk of bio-energy targets not being met.
3	Enforcing RES target without closing demand-supply gap.	* Large increases in wood cost. * Large part of EU PPI non-competitive * Rough cost of additional bio-energy incentives 8-11X

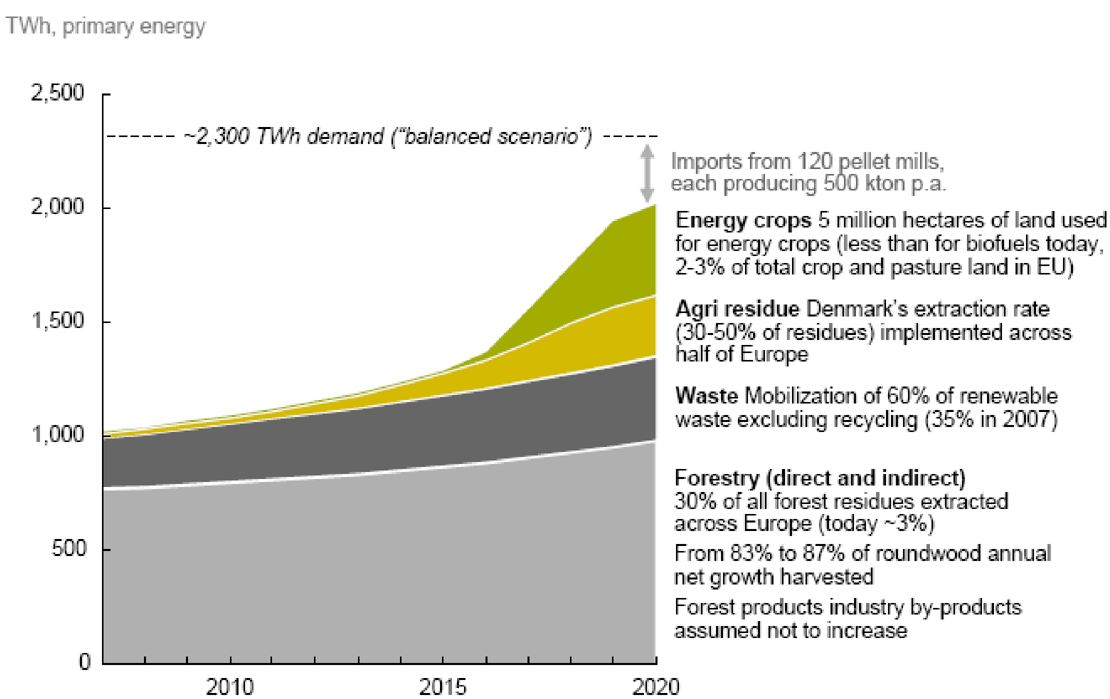
Source: McKinsey/Pöyry Forest Industry Consulting, 2007 (as reported by Mensink 2007; CEPI 2007).

In the second scenario the impact of a mismatch between demand for and supply of woody biomass brought about by a continuation of current subsidy levels and policies was considered. The likely result here is a significant increase in the cost of biomass, including pulpwood, and a risk to global competitiveness of Europe's pulp and paper industry. In addition, there is significant risk of bioenergy targets not being met. A third scenario examined what might happen if public policy focuses on renewable energy mandates absent success in matching biomass supply to demand; this combination of factors is expected to lead to large increases in the costs of woody biomass and bioenergy incentives as well as severe impacts to the established pulp and paper industry – generally a lose-lose situation.

That concerns identified were not theoretical is evidenced by the recent history of raw material prices for European wood-based panel manufacturers. Raw material costs for this industry increased four-fold between 2002 and 2007, with wood cost increases attributable in part to rising demand for wood fuel pellets (Eastin and Hendrickx 2007). More recently Sommerauer (2009) reported that pulpwood is now regularly being chipped for energy uses in Sweden, either for heat and power or pellet manufacture, and that similar trends are underway elsewhere. While noting that pulpwood is normally outside the reach of energy buyers, Sommerauer reported that the recent drop in pulpwood prices has stimulated the interest of bioenergy interests and that growth in energy wood demand is changing the fundamental nature of pulpwood and chip markets such that changes will not simply be reversed when pulp, paper, and sawn timber demand recovers. In his words "Energy wood is creating a floor beneath the pulpwood market, and given the scale of . . . renewable energy targets – and the need to mobilize more costly sources of energy wood – it is a floor that is far more likely to rise than to fall in the future."

A recent report (European Climate Foundation 2010) indicates that the majority of the potential for bioenergy growth in Europe is based on use of agricultural and forest residues and establishment of energy crops on idle or abandoned cropland (Figure 13).

Figure 13
Biomass Sources Under an Aggressive EU Supply Mobilization Scenario



Source: European Climate Foundation (2010)

The report goes on to say that ". . . current momentum in the industries involved does not suggest that this potential is materializing . . . and there are few signs of the agriculture or forest industry starting to capture residues at a significantly larger scale." Report authors point out that the lead-time for required investments and changes is 5 to 10 years and they call for urgent action to develop a European biomass supply that is significantly higher in 2020 than today.

Figure 13 is interesting in several respects. First, considering the relatively modest increase in biomass demand that has occurred within Europe over the past four years, reports of marked increases in pulpwood and wood fiber prices that have already been experienced are somewhat surprising (Ekstrom 2008a, 2008b). Also of note is a sharp upswing in wood pellet consumption – a favored form of raw material input for bio-energy production. Both the prices of wood pellets, and the raw material needed to make them, have risen substantially (Ekstrom 2009a); pellet fuel production growth has also led to increased competition for fiber with pulp manufacturers (Ekstrom 2009b, 2009c).

Another interesting aspect of Figure 13 is that in order to meet mandated 2020 biomass energy targets under what is described as a "balanced scenario" requires that the EU be supplied by annual imports of 60 million tons of wood pellets (500,000 tons annually from each of 120 pellet mills). Today, a significant portion of wood European pellet imports come from North America, a situation that has contributed to increasing competition among pellet producers and pulp manufacturers in the US and Canada (Ekstrom 2009c).

Concerns about European biomass supplies to this point are based largely on mandates relative to production of biomass electricity and heat. However, steady advances toward commercialization of 2^{nd}-generation biofuels from lignocellulosic raw materials are raising the level of concern. A recent report from the *elobio* (effective and low disturbing biofuel policies) team at the Energy Research Centre of the Netherlands (Uslu et al. 2010) points out that under the EU Renewable Energy Directive greenhouse gas (GHG) emissions savings from 2^{nd}-generation biofuels will be counted as twice their real contribution across the EU, translating to a very high level of subsidy as compared to other energy products. The potential impact on competition for feedstocks in lignocellulosic markets is described as "intense" in coming decades, and it is anticipated that feedstock costs for a number of wood products manufacturers will increase. Those seen as potentially impacted in the relatively near term include manufacturers of products made from sawdust, wood residues, and low-grade timber, including pulp and paper, panels, and some other manufactured wood products. It is noted that demand for biomass from 2^{nd}-generation biofuels is negligible at present, but that commercialization of 2^{nd}-generation technologies is likely to increase the price that such plants can pay for biomass since the feedstock cost share for such plants is less than for 1^{st} generation biofuel plants; analysts believe that this phenomenon will be accentuated as the scale of 2^{nd} generation biofuel plants and the price of petroleum increases.

Major concerns about casual adoption of biomass targets and incentives in the E.U. surfaced several years before similar actions in the U.S. Publicity regarding adverse impacts to established industries also came to light well in advance of initiatives mounted across this country. Yet, it appears that such concerns and problems escaped the attention of policy makers on this side of the Atlantic. In the myriad of U.S. programs and incentives, a similar inattention to potential unintended consequences can be seen.

The North American pulp and paper industry raised concerns about unintended consequences of renewable energy incentives in 2005. In an American Forest and Paper Association report (AF&PA 2005), it was noted that a subsidy of 1.1¢ per kilowatt-hour through the Renewable Electricity Production Tax Credit (DSIRE 2011) to encourage production of electricity from biomass was already impacting pulpwood prices, and thus paper industry competitiveness, in one state – South Carolina – and that implementation of biomass-to-energy subsidies of this magnitude in at least six other paper-producing states would likely have a similar effect. The law was subsequently reauthorized several times, retaining the 1.1¢ per kilowatt-hour provision for electricity produced using open-loop biomass and including a parallel provision authorizing a payment of 2.2¢ per kilowatt-hour for generation using closed-loop biomass.

A pair of recent studies conducted by the School of Public Policy at Georgia Tech University (Brown et al. 2008, 2009) examined likely impacts on the forest products industry, and on the pulp and paper industry in particular, of various governmental energy and climate policies. Examined in the first study were potential impacts of adoption of a 25-percent renewable portfolio standard (RPS) and a 25-percent renewable fuels standard (RFS), each with 2025 implementation goals, and implementation of a national GHG cap and trade system. Findings point toward significant impacts of RPS and cap and trade implementation including increased prices of biomass, diversion of significant quantities of biomass toward production of energy rather than paper, and an erosion of markets as a result of increased production costs. Near-term impacts of implementation of a renewable fuels standard were viewed as minimal, since technologies for production of biofuels from cellulosic feedstocks had not been (and still aren't) commercialized. Kimbell et al. (2009), in fact, argue that a RFS is unlikely to ever have much impact on wood prices since feedstocks other than wood are likely to dominate in a cellulosic biofuels industry even should one become viable. Brown et al. (2008) and Sedjo and Sohngen (2009) are more cautious in their assessment of this issue; both warn that a scientific breakthrough could lead to substantially increased demand for biomass for this purpose over the longer term.

The second Georgia-Tech study (Brown et al 2009) analyzed, through use of the National Energy Modeling System, potential impacts to the pulp and paper industry of a shift to 25 percent renewable electricity (as promised by President Obama in his 2008 election campaign), implementation of a federal carbon cap and trade program, and aggressive pursuit of federal industrial energy efficiency program. It was noted that such policies are attractive to decision-makers since the combined effect of the three policies would be to reduce electricity sector carbon emissions by over 40 percent. Findings indicate that a shift toward renewable electricity without a parallel program to increase industrial energy efficiency could increase the price of biomass for electricity production by 160 percent by 2030, a figure that drops to 67 percent if energy efficiency is pursued concurrent with a cap and trade initiative; the magnitude of increase in both cases would clearly impact pulpwood prices. A cap and trade program alone would raise the price of biomass for electricity production by an estimated 28 percent by 2030. A second problem was identified – that being that the price of industrial electricity (and likely other forms of energy) would rise as well; this analysis suggested increased electricity costs of 6 to 18 percent as a result of joint implementation of all three policies. Thus, both raw material costs and the costs of energy would likely rise for the pulp and paper industry.

It is worth noting that both of the Brown et al. studies, as well as several others, have identified the potential for energy efficiency gains in the pulp and paper industry that could at least partially offset the deleterious effects of increasing raw material prices. In fact, a recent study found that the pulp and paper industry is one of the two industries (the iron and steel industry being the other) having the greatest potential for reduction of energy consumption; potential energy savings of 25 percent by 2020 through implementation of proven technologies and process improvements were identified (Brown et al. 2008, p. 8). Ruth et al. (2000) had earlier projected the potential for a 2.1 percent annual decrease in paper industry energy intensity in response to a carbon price of as little as $23 per ton, in comparison to a 0.84 percent decrease under a business as usual scenario; a marked reduction in paper industry carbon intensity was also said likely in the face of carbon reduction initiatives.

Beyond energy efficiency gains, the idea of pulp and paper mills becoming integrated biorefineries that produce not only paper, but also biofuels and other forms of energy and a range of biochemicals has gained momentum over the past decade following initial work in Sweden. It is envisioned that integrated biorefineries of the future, based within what are now paper mills, will cost effectively convert biomass into variety of end products, could greatly enhance profitability and adaptability to changing economic conditions (USDOE 2007).

The effects on the paper and wood products industries of increasing electricity production from biomass, and associated tax credits, were the subject of another study recently commissioned by the Florida Department of Agriculture and Consumer Services (Hodges et al. 2010). In that study, the impact of increasing biomass fuel supply for electric power generation in Florida was simulated over a range of 1 to 80 million green tons annually; the upper end of the range represents about 26 percent of current electricity generation in Florida and roughly 21 percent by the year 2025. It was concluded that at the 40 million green ton per year level, prices for forest commodities may increase by up to 18 percent in the short run, but by a lesser amount over the longer term based on an expected reallocation of capital resources to bio-power production over time. The study also projected substantial increases in revenue for forest landowners and forestry companies, but higher prices (2.4 to 4.6 percent higher) for paper and wood products and a corresponding decline in output for the forest products sector of about 6.7 percent. Regarding subsidies, such as a renewable energy production tax credit, it was concluded that such a measure would likely significantly boost bioenergy production as well as competition within the state for biomass resources. A key finding was that the forest products manufacturing sector, including the pulp and paper industry, would be adversely affected by marked expansion of bioenergy production as a result of increased competition for wood resources and higher prices for material inputs. Not assessed was the possibility of increased production of bioenergy by the forest products industry itself, including associated revenue potential – a prospect is widely viewed as probable.

Effects of increased competition for raw materials are already affecting wood markets. In an interview focused on rising wood costs (Austin 2009) Hakan Ekstrom, of Wood Resources International, pointed out that wood costs typically account for about 50 percent of the production costs of a pulp mill, and that average pulpwood prices increased by about two-thirds in the period 2002-2008. He also predicted that expanding demand for renewable energy would potentially drive wood fiber prices higher in the near future. Ekstrom went on to say that with the near-term supply of biomass relatively inelastic, at least in the near term, the new markets for wood biomass would likely "push wood prices to unprecedented new heights." In a recent post Ekstrom (2011a) notes that wood fiber costs for pulp mills, after falling dramatically during the recent recession, rose for three consecutive quarters beginning in mid-2010, placing early 2011 pulpwood prices close to the record levels posted in 2008.

Pulp and paper manufacturers are not the only entities impacted by rising biomass consumption. With a several year time lag to similar developments in Europe, wood-based panel manufacturers in North America began to see marked increases in their raw material costs in response to a policy-driven wood pellet market in Europe and often domestically subsidized increases in the use of biomass for energy production. Wood costs have risen substantially in recent years for North American manufacturers of fiberboard, and core stock and underlayment grade particleboard, doubling between 2005 and early 2007 (Roberts 2007), and rising another 40 to 50 percent since then. The cause: rising demand for wood pellets and declining sawmill activity (the source of sawdust and shavings for many composite manufacturers). As long ago as 2007, Roberts observed that the pellet industry needed to begin utilizing fiber sources other than sawdust and shavings in order to expand.

Energy Policy and Building Materials Manufacturers

Cross Industry Competition

The wood-based building materials industry should be relatively well positioned (with a few notable exceptions) to compete in a carbon and energy constrained world. It is well known, for example, that the energy consumption linked to wood products manufacturing is low compared to energy requirements for competing products. This is especially true for delivered energy. As shown in Table 6, whether measured in terms of energy consumption or costs of energy consumed, delivered energy (that for the most part is fossil fuel-derived energy) comprises a smaller component of wood products manufacturing than of cement, iron and steel, or aluminum. Not included in Table 6 is on-site generated energy, something that is very prominent in wood products manufacturing and, increasingly, cement production. Inclusion of on-site generated energy would roughly triple the wood products consumption numbers while also slightly raising energy costs. Nonetheless, it is clear that increases in the cost of fossil fuels, resulting from events in global markets or from public policy actions, would have greater impact on the fossil-energy-intensive sectors than on the wood products sector. Less clear is how the wood products industry would fare in a situation defined by parallel increases in the costs of all fuels, including biomass. A key reason for the lack of clarity is that for some segments of the wood products industry, a rise in the cost of biomass fuels may also translate to an increase in the cost of basic raw materials used in making the products themselves.

Table 6
Sector Delivered Energy Intensity in 2002 for Selected U.S. Industries

Sector	Energy Consumption per Dollar of Value Added (kBtu)	Energy Consumption per Dollar Value of Shipments (kBtu)	Energy Cost per Dollar of Value Added (Share - %)	Energy Cost per Dollar Value of Shipments (Share - %)
Cement	95.5	56.0	24.5	15.1
Iron and Steel	66.5	27.8	20.4	8.0
Aluminum/Alumina	34.3	12.2	21.0	6.9
Wood Products	10.6	4.2	4.7	1.9
Pulp and Paper	31.1	15.2	8.8	4.3

Source: USEPA (2007)

In addition to questions regarding potential impacts of rising energy costs on competing industries, there are questions as well as to how various industries might fare under a program of carbon taxes. Some clarity is provided by statistics from the Environmental Protection Agency (Table 7) that show CO_2e emissions per unit of value added for basic materials; per long-standing protocol, the carbon emitted from biofuels used in providing energy in wood and paper products manufacturing is not counted in emissions statistics; were it counted, the 0.85 number would become approximately 3.5. In either case, wood products are competitively well positioned should carbon taxes become a reality. Again, however, the situation is not altogether clear because of recent questions about the carbon neutrality of biomass energy.

Table 7
Emissions Intensities for Key Industrial Sectors in the U.S., 2002

Sector	**Metric tons CO_2e/$1000 Value Added**
Cement	18.20
Iron and Steel	6.29
Aluminum	6.14
Forest Products	0.85

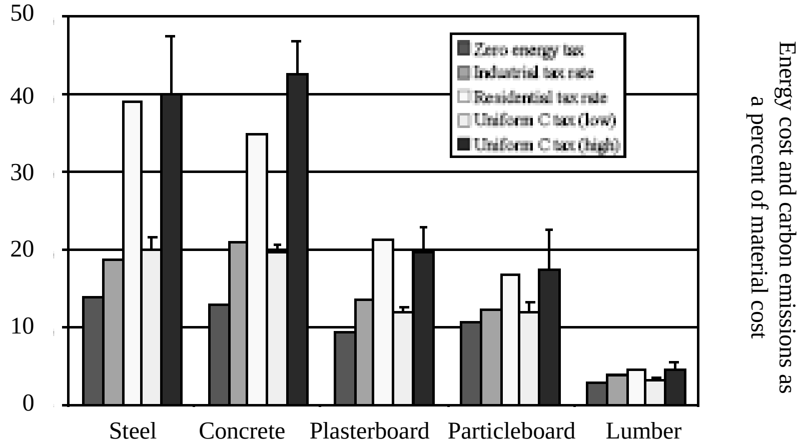
Source: USEPA (2009a)

A recent Swedish study (Sathre and Gustavsson 2007) provides one indication of how climate-related public policy may impact manufacturers of competing construction materials (Figure 14). In this study the focus was on the impact of carbon and energy taxes on the cost of building materials production.

The first step in this study involved determination of energy costs as a percentage of prices of finished materials used in building construction. Although analyses were based on prices of energy and finished products within Sweden, with prices expressed in Euros (€), findings are informative. With zero energy or carbon taxes (descriptive of the current situation in the U.S. today) energy costs were found to comprise 13.8, 13, 9.4, 10.6, and 3.0 percent of finished material costs for steel, concrete, plasterboard, particleboard, and softwood lumber, respectively.

Whereas energy consumed in the production of steel, concrete, and plasterboard was found to be dominantly derived from fossil fuels, lumber and particleboard production was largely powered by biomass-derived energy – a situation that again parallels current U.S. practice.

Figure 14
Costs of Energy Inputs and Carbon Emissions of Materials Production, Expressed as a Percentage of Finished Materials Cost Under Different Tax Regimes



(The main bars for uniform carbon taxes assume electricity produced by natural gas-fired condensing plants; the smaller error bars show the effect of electricity production from coal-fired plants)

Source: Sathre and Gustavsson (2007)

Based on initial findings, study authors then evaluated the potential impacts of energy, carbon, and sulfur taxes on relative prices of these various materials (Table 8). One tax evaluated was a carbon tax of 78€ per ton of carbon on end-use fossil fuels and energy taxes on diesel fuel and electricity use, reflecting the actual level of Swedish industrial taxes in effect on January 1, 2005. This program was accompanied by a residential carbon taxation program, with tax rates of 371€ per ton of carbon on end-use fossil fuels

Table 8
The Effect of Various Energy, Carbon, and Sulfur Taxes on Total Energy Costs

	Coal	Fuel Oil	Diesel	Natural Gas	Biofuel-Forest	Biofuel-Processing	Biofuel-Waste	Electricity
Base energy price (€/GJ)	1.7	5.3	11.1	6.3	3.7	3.4	2.2	12.7
Energy tax (€/GJ)								
Zero tax rate	0	0	0	0	0	0	0	0
Industrial rate	0	0	3.1	0	0.15	0.03	0.03	0.15
Residential rate	1.3	2.1	3.1	0.73	0.15	0.03	0.03	7.8
Uniform carbon tax (low)	0	0	0	0	0	0	0	0
Uniform carbon tax (high)	0	0	0	0	0	0	0	0
Carbon emissions tax (€/GJ)								
Zero tax rate	0	0	0	0	0	0	0	0
Industrial rate	2.0	1.6	8.1	1.3	0.40	0.08	0.08	0
Residential rate	9.3	7.6	8.1	6.0	0.40	0.08	0.08	0
Uniform carbon tax (low)	2.3	1.6	1.7	1.2	0.08	0.02	0.02	2.4/ 5.7
Uniform carbon tax (high)	10.8	7.7	8.0	5.8	0.40	0.08	0.08	11.5/ 27.0

	Coal	Fuel Oil	Diesel	Natural Gas	Biofuel-Forest	Biofuel-Processing	Biofuel-Waste	Electricity
Total energy cost (including sulfur tax) (€/GJ)								
Zero tax rate	1.7	5.3	11.1	6.3	3.7	3.4	2.2	12.7
Industrial rate	4.3	7.3	22.3	7.6	4.3	3.5	2.3	12.9
Residential rate	12.9	15.4	22.3	13.1	4.3	3.5	2.3	20.6
Uniform carbon tax (low)	4.6	7.3	12.8	7.5	3.8	3.4	2.2	15.1/ 18.4
Uniform carbon tax (high)	13.2	13.4	19.2	12.1	4.1	3.5	2.3	24.3/ 39.7

Source: Sathre and Gustavsson (2007)

combined, the same tax on diesel as the industrial rate, and substantially greater tax rates than the industrial rate on electricity use. The combined taxation programs were designed to encourage shifts to less carbon intensive industrial production and, over the longer term, changes in consumption patterns to products with lower fossil fuel and carbon intensity. Within both tax programs, tax rates were highest on carbon intensive fuels such as coal, coal-fired electricity, fuel oil, and diesel, and lower on fuels such as natural gas and biomass.

Also evaluated in the Swedish study were the potential impacts of what were described as uniform low and high carbon taxes of 78€ and 371€ per ton of carbon, and a tax based on the sulfur content of fuels. Under the uniform low carbon tax rate scenario with taxation of sulfur emissions, energy prices for fossil fuel-derived energy increased 15 to 45 percent (and 175 percent for energy from direct combustion of coal), and 0 to 3 percent for biomass-derived energy. The uniform high carbon tax rates, again including sulfur taxes, effectively raised energy prices 70 to 210 percent (and 675 percent for energy from direct combustion of coal), and 3 to 11 percent for biomass energy.

Not surprisingly, the relative impact on fossil fuel and carbon intensive industries and their products was found to be substantial. For example, imposition of the full suite of energy, carbon, and sulfur taxes had the effect of dramatically raising energy costs as a percentage of finished material costs for steel and concrete, while the effect on lumber was far smaller. In the high uniform carbon and sulfur tax scenario, the energy cost as a percent of finished material cost rose from 13.8 to 40 percent for steel (48 percent when electricity was derived from coal), from 13 to 43 percent for concrete (47 percent when electricity was derived from coal), but only from 3 to 4.3 percent for softwood lumber. The impact on particleboard was greater than for lumber because of the higher energy intensity of this product; in this case, instituting the full suite of energy, carbon, and sulfur taxes had the effect of raising energy costs per cost of finished product from 10.6 percent to over 17 percent (and to 23 percent when electricity used was derived from coal).

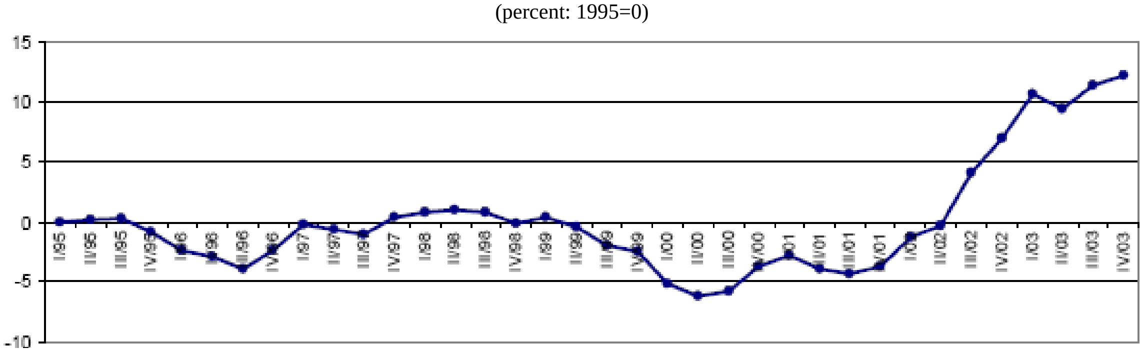
In summary, the Sathre/Gustavsson study conclusively shows that increases in prices of energy derived from fossil fuels (whether due to market pressures or public policy) will negatively impact the cost structure of those industries whose products are fossil fuel intensive. The effect is to increase production costs relative to industries producing products with lower fossil fuel intensity. In the case of wood vs. non-wood construction products, the impact is dramatic, and highly favorable to wood products.

Impacts on Specific Wood Industries

An issue not considered in the Sathre/Gustavsson study was the potential for increased competition for woody biomass as a result of favorable tax policy for bioenergy. This issue was considered in a recent examination of impacts of increased energy prices and use of wood for energy on the forest industry of Norway (Trømborg and Solberg 2010). This study considered effects on profitability and domestic production for specific industry segments, with findings showing that a 40 percent rise in the price of energy would increase competition for biomass for bioenergy, impacting various forest products industry segments in different ways. Using a regionalized partial equilibrium model that considered the forest sector, forest industries, and the bioenergy sector, impacts on the pulp and paper industry were found to be minimal, in large part because Norway's pulp and paper industry primarily relies on spruce pulpwood which is infrequently used in bioenergy production. A four percent decline in paper industry output was projected over the five year modeling period. The sawmill industry was also impacted, mainly due to an increased price of electricity, but this increase was found to be offset by higher prices received for chips, sawdust, and bark - which in turn negatively impacted the particleboard industry. The particleboard industry was found to suffer the greatest impact from the increase in energy costs, with a 12 percent drop in production projected.

The risks from changes in domestic energy policy and increasing energy costs are especially significant for the particleboard industry. This industry faces all of the risks of other industries from increased energy costs, but as pointed out by Trømborg and Solberg (2010), the industry today finds its primary raw material increasingly sought, and even subsidized, as an energy resource for use by a developing bioenergy industry. The record of wood costs in the EU-15 in 2001-2002 illustrate the dramatic increases faced by the wood industry in the early years of the past decade (Figure 15).

Figure 15
Wood Cost History in the EU 15 in the Period 1995-2003
(percent: 1995=0)



Source: Van Riet (2004)

It was earlier noted that raw material prices for European wood-based panel manufacturers increased four-fold between 2002 and 2007, with wood cost increases attributable in part to rising demand for wood fuel pellets. Much the same scenario is now unfolding in North America. By mid 2007 particleboard producers across North America were reporting substantial increases in price for wood raw materials over a period of three to four years, with increases ranging from about 40 percent to more than

100 percent in some regions. A price of $64 per oven dry metric ton (odmt) for sawdust was reported for the 3rd quarter of 2009 in the U.S. Northwest (Ekstrom 2009d). Spelter and Toth 2009 reported similar prices for the same period, with values for shavings and sawdust ranging from $38 to $56 per green metric ton (about $49-73 per odmt) across the nation in 2009, with the highest prices in the Northwest. Average prices had been about $28 per odmt five years earlier (Ekstrom 2009d). What this meant is that wood prices, which had historically ranged from 15 to 20 percent of particleboard selling prices (Spelter 1996) became 30 percent and more of the market price. Much of the increase in wood pellet demand in North America was the result of subsidies and mandates in the EU that created import markets for wood pellets in various European countries. Then came BCAP.

The Biomass Crop Assistance Program (BCAP), introduced in the 2008 Farm Bill (USDA 2011), was (and is) intended to encourage investment in development of new biomass resources, and/or utilization of unused biomass resources such as crop residues, for use in bioenergy production. The program specifically provides for reimbursement of up to 75 percent of the cost of establishing a bioenergy perennial crop, as well as up to 5 years of annual payments for annual or perennial grassy crops, and up to 15 years of annual payments for woody crops. One provision of the program provides financial payments of up to $45 per ton for the collection, harvest, storage and transportation of biomass materials to a biomass conversion facility.

Though intended to stimulate the development of new biomass feedstocks, the program, at least in the short run, simply served to increase competition for already available materials. FarmEnergy.org recently reported that the more than $200 million initially spent under BCAP vastly outstripped Congressional projections of $70 million for the entire program through 2012; more notably it was reported that few BCAP dollars were spent to develop new biomass feedstocks, despite Congressional intent for the program. Christianson (2010) indicated that approximately two-thirds of the initial spending was directed to current biomass sources instead of new sources; he also reported that the subsidy approximately doubled the current market value for wood fiber used by member mills of the North American-based Composite Panel Association, creating a serious threat to procurement of wood fiber used in making particleboard and medium density fiberboard. The BCAP program was subsequently amended to remove residual materials used in value added production processes from qualifying for the $45 per dry ton subsidy. However, as pointed out by Sedjo (2010), and as discussed subsequently in this report, this modification may be insufficient over the longer term in preventing diversion of wood from “value-added” products manufacture to bioenergy production.

In addition to the risks posed by increases in prices of fossil fuels, and increasing wood raw material costs, all wood composite manufacturers also are experiencing increased resin costs – costs that are directly related to the market price of petroleum. Winchester (2005) documented the 170-200 percent rise in the market price of urea and the doubling of phenol market prices during the period 1999-2005, citing the 250+ percent rise in the price of crude oil and the 160 percent rise in the price of natural gas that occurred during that period. Spelter et al. (2010) focused on resin costs, chronicling the resin cost history for the U.S. oriented strandboard (OSB) industry in the six-year period 2000-2006; these prices rose 61 percent during that time frame.

As illustrated in Table 9, the effect of a continuation of these various trends is likely to affect specific industries within the forest products sector quite differently. For instance, the energy intensities of all of the particle-based panel industries (particleboard, medium density fiberboard (MDF), and OSB) are substantially greater than those of the softwood plywood industry; the energy intensity of resins used is also much greater in the particle-based panel industries, posing greater risk for future price and availability issues. The plywood industry is also insulated from increasing competition for wood raw materials stemming from rising bioenergy demand. The plywood industry is also better positioned should a carbon tax come into effect. Thus, should energy prices rise significantly, either as a result of market forces or public policy, or should carbon be taxed, or should policy mechanisms continue to provide incentives for increased use of bioenergy, then the plywood industry could conceivably begin to regain market share lost earlier to OSB. On the other hand, for the same reasons, the OSB industry may find new opportunities in decking, underlayment, and other markets to the detriment of the particleboard industry.

Table 9
Cradle-to-Gate Cumulative Energy Requirements to Manufacture Various Products (MJ/m^3), Wood Raw Material Needs, and Carbon Liberation in Manufacture

	Particleboard	MDF	OSB	Softwood Plywood	
				PNW	SE
Wood collection and transp. to mill	3,504	1,683	1,342*	812	865
Resin	3,105	3,924	3,392	329	408
Catalyst	88	--	--	--	--
Wax	26	266	Included in resin	--	--
Urea scavenger	16	33	--	--	--
Wood fuel	561	7,718	4,197	1,550	2,290
Fossil fuel	3,564	7,083	3,389	1,273	2,707
Nuclear				10	55
Hydro-electric				307	8
Total energy input	10,865	20,707	12,320	3,140	5,060
Wood in product	672 kg/m^3	793 kg/m^3	620 kg/m^3	504 kg/m^3	625 kg/m^3
Carbon (CO_2 equiv.)	392kg	621kg	488	216	345

Source: Particleboard – Wilson (2010b); MDF – Wilson (2010a); OSB – Kline (2005); Plywood – Wilson and Sakimoto (2005); Wood harvest and transport data for plywood production from Johnson et al. (2005); Plywood resin energy data – Wilson (2010c).
* Based on figure for MDF and weighted by wood mass.

Within the plywood industry itself, policy resulting in increased prices of energy or increased taxation of carbon emissions, without some kind of modification for regional variation, would favor the Pacific Northwest where energy intensity is lower, in part due to species differences and where hydro-electric generation is more common.

It is clear that all of the composite panel industries, and especially the particle-based panel industries, would face stiff competition from foreign competitors should domestic energy prices rise absent similar increases in competing regions. It will be extremely important for policy makers to keep in mind that even seemingly straightforward measures may have unintended and detrimental consequences for long-established well-paying domestic industries, including serious erosion of global competitiveness. Policy measures can also tilt the playing field so as to create winners and losers among domestic competitors.

While studies consistently show the lumber industry to face less risk than other forest sector industries from energy price increases, and climate policy that may impact energy related costs, almost all research has based such conclusions on studies of softwood sawmills. It has long been recognized that hardwood sawmills have higher electricity costs in sawing than softwood mills because of typically slower processing rates linked to greater wood density, production of thinner lumber, and the need for greater care in producing grade lumber. Thermal energy consumption is also greater due to longer drying times linked to lower moisture content requirements and slower drying rates

Table 10
Comparison of Hardwood to Softwood Lumber Energy Use

	Overall Energy Consumption [1,2]			
	Electrical Energy		Thermal Energy	
	MJ/m^3	kWh/MBF	MJ/m^3	kWh/MBF
Hardwood Lumber	597	297	5,400	9.6 million
Softwood Lumber	335	151	3,600	5.5 million

[1] All values provided in actual dimensions
[2] Final dry planed lumber dimensions of 19.1mm (0.75 in) thick by 14.0mm (5.5 in. wide.
[3] 1.76 m^3 per 1.0 nominal MBF (thousand board feet) dry planed lumber and includes walnut steaming and plant heating.
[4] 1.623 m^3 per nominal MBF (thousand board feet) planed dry lumber; 3.6 MJ per kWh, 1054 per million BTU

Source: Bergman and Bowe (2007)

needed to avoid drying defects (Bergman and Bowe 2007). Electrical and thermal requirements have been shown to be 97 and 75 percent greater, respectively, in hardwood lumber production as compared to softwood. Based on an extensive survey of hardwood sawmills, Espinoza et al. (2011) documented that energy accounted for 7.9 percent of annual operating budgets of U.S. hardwood mills in late 2010, a figure that is almost double that of softwood mills as reported by Sathre and Gustafson (2007) and others. Espinoza and company also found that increasing energy costs are already affecting cost structure and profit margins in U.S. hardwood mills; energy expenditures as a percent of total costs rose in 58 percent of U.S. hardwood mills over the previous five years, with corresponding adverse impacts on profits. Consequently, rising energy costs pose a greater challenge to the hardwood lumber industry than to its softwood counterpart.

Another part of the forest sector that appears to face greater climate policy related risks than others is the logging industry. It is generally accepted that the logging industry will benefit from widespread development of a bioenergy industry, since this will potentially lead to increased forest activity and provide increased diversification and perhaps protection from the ups and downs of the economic cycles that affect the forest products industry. On the other hand should national climate and energy policies, which are the driving forces behind bioenergy development, result in substantially higher energy prices – and particularly prices of liquid fuels – then this industry would be significantly impacted. Over the past 15 years, logging costs have risen 50-67 percent, with small to medium-sized firms at the upper part of this range; the greatest component of change has been the cost of consumables (principally fuel costs) that have almost doubled during this period (Stuart et al. 2008). About a quarter of costs are accounted for by fuel and lubricants. As noted by Stuart et al. (2003), loggers do not benefit from industrial rates for energy, but instead must pay market rates at the time commodities are used. The same is true for services. Moreover, this industry does not have the option of switching to coal, biomass or (easily) to natural gas should costs of traditional sources of energy rise inordinately.

Scenarios

Assessment of the potential future of the U.S. bioenergy industry, and the impact of the growth of this industry on the forest products industry, was done in the context of the following scenarios, all fundamentally based on the price of petroleum and informed by findings reported herein. Four petroleum price levels were selected based on historical West Texas intermediate crude prices (EIA 2011b): 1) a "low" price corresponding to the 2000-2009 average of $51.18 (rounded to $50), 2) a "medium" price close to the 2007-2010 average of $78.86 (rounded down to $75), 3) a "high" price corresponding to mid-May 2011 ($100), and 4) a "record" price based on the July 3, 2008 high benchmark of $145.32 (rounded to $150). In all cases the impacts of various climate and bioenergy policies and incentives are considered. A "no climate policy" is used in describing a situation in which a carbon cap and trade system, carbon tax, or similar system is implemented, in contrast to the term "climate policy" that assumes enactment of carbon trading, carbon taxation, or like measures.

Five scenarios are examined, reflecting various combinations of energy prices and climate policy. The fourth scenario – that in actuality is two scenarios (encompassing with adoption and without adoption of climate policy) is developed based on the conclusion that outcomes, for purposes of assessing impacts on the forest industry, would be essentially the same with and without adoption of a formal climate policy.

<u>Scenario #1 – Low Petroleum Prices and No Climate Policy</u>: Petroleum prices drop to around $50/bbl and remain there, suggesting relative long-term abundance. Interest in climate change issues on the part of U.S. policy makers remains tepid to nonexistent, but Europeans maintain focus on reduction of carbon emissions. The U.S. economy and housing market experience a steady recovery.

Carbon taxes or government caps on carbon emissions remain off the federal agenda, but continue to develop as state and regional initiatives in the West and Northeast. Without attention to competitiveness issues, industries in these regions may be adversely impacted in global markets and in domestic regions not affected by carbon initiatives.

Under this scenario, with apparent energy supply certainty and lack of commitment to addressing climate issues, interest in biofuels wanes. Support for biofuel related incentives diminishes, as does support of continued subsidies for development of energy crops – currently seen as the foundation of a domestic biofuels program. The relative abundance of domestic supplies of natural gas and coal, combined with lack of concern for carbon emissions linked to coal combustion, serve to temper demand for wood residues for use in electric generation, district heating, and residential use. However, export markets for fuel pellets and other forms of biomass remain strong, translating to growing markets for wood products mill residues and wood chips in regions close to port facilities. Export markets for mill residues and chips exert upward pressure on raw material prices for pulp and paper, particleboard, and medium density fiberboard mills, and for the landscape mulch and bedding industries. However, interest in wood as a feedstock for electrical generation wanes, tempering local impacts of rising export demand. Increased production of sawdust and shavings resulting from increasing sawmill production also reduces export market impacts on domestic biomass prices and supply availability.

It is worth noting that even at these energy price levels, the energy values of some biomass raw materials are markedly higher than current market prices (Table 5). Over time, energy markets for these materials could be expected to develop.

A reduced focus on biofuels and bioenergy in general and tepid interest in atmospheric carbon mitigation also leads to less interest in developing new bioenergy crops and using forest residues as energy feedstocks. One result is reduced land use competition for the established forest sector.

Prices of basic raw materials fall from present levels under this scenario, benefiting the steel, aluminum, concrete, and plastics industries more than the wood industry; thus, these products become more competitive with wood.

<u>Scenario #2 – Moderate Petroleum Prices and No Climate Policy:</u> Petroleum prices retreat to an average of about $75/bbl, fluctuating periodically in a $10-15 range above and below the average, and occasionally spiking in response to world events. Relatively high petroleum prices, and price instability, and a measure of supply uncertainty serve to maintain interest in development of petroleum alternatives including biofuels. Interest in climate change issues on the part of U.S. policy-makers remains tepid, but waxes and wanes with election cycles. Europeans maintain focus on reduction of carbon emissions. Carbon taxes or government caps on carbon emissions remain off the federal agenda, but continue to develop as state and regional initiatives in the West and Northeast. Without attention to competitiveness issues, industries in these regions may be adversely impacted in global markets and in domestic regions not affected by carbon initiatives. Generally low priority of climate issues erodes support for development of alternatives to fossil energy, other than in the transportation fuels arena.

Under this scenario, the present array of alternative energy policies and incentives for biofuels development, at both state and federal levels, is likely to persist and perhaps expand, although the price of petroleum remains low enough that the economics of unsubsidized production of transportation biofuels continue to be marginal. Incentives for development of energy crops and crop and forest residues (such as the BCAP program) continue, as do financial incentives for development of bioenergy facilities. Absent concerns about carbon emissions, enthusiasm for development of alternatives to fossil energy (other than transportation fuels) diminishes, and solutions involving greater use of coal and natural gas to supply energy needs gain traction. Export markets for mill residues, pellets, chips and other forms of biomass remain strong, driven by climate policy in the EU and elsewhere. Domestic biomass fuel exporters are given a boost by federally financed bioenergy feedstock export assistance linked to rural economy development goals. Export markets for mill residues and chips exert upward pressure on raw material prices for pulp and paper, particleboard, and medium density fiberboard mills and for the landscape mulch and bedding industries. Increased production of sawdust and shavings resulting from increasing sawmill production helps to modify impacts of export markets on domestic biomass prices and supply availability.

Using the petroleum price as a guideline, at this level the energy values of sawdust and shavings, southern pine pulpwood, southern pine Chip-N-Saw logs, and some species of hardwood sawlogs (hickory, beech) are higher, and in some cases markedly higher, than current market prices even without any form of subsidy (Table 5). Over time, energy markets for these materials could be expected to develop, driving up raw material costs to the forest products industry.

Prices of basic raw materials fall from present levels under this scenario due to lower than current energy expenditures associated with raw material extraction, transport, and primary processing, benefiting the steel, aluminum, concrete, and plastics industries more than the wood industry; thus, these products become more competitive with wood.

Scenario #3 – Moderate Petroleum Prices and Climate Policy: Petroleum prices retreat to an average of about $75/bbl, fluctuating periodically in a $10-15 range above and below the average, and occasionally spiking in response to world events. Relatively high petroleum prices, and price instability, and a measure of supply uncertainty serve to maintain interest in development of petroleum alternatives including biofuels. Global pressure to act to reduce carbon emissions begins to influence U.S. policy-makers to take action, with state and regional initiatives in the West and Northeast helping to overcome inertia at the federal level. Europeans maintain focus on reduction of carbon emissions. Relatively high petroleum prices and price instability serves to maintain interest in development of petroleum alternatives including biofuels.

This scenario is the same as described in scenario #2 except that domestic support for carbon management is now assumed to exist. Under this scenario, the present array of alternative energy policies and incentives for biofuels development, at both state and federal levels, is likely to persist and perhaps expand, although the price of petroleum remains low enough that the economics of unsubsidized production of transportation biofuels continue to be marginal. In the face of concerns about carbon emissions, enthusiasm for development of alternatives to fossil energy is accentuated, perhaps giving rise to new forms of incentives and subsidies, including financial inducements, tax benefits, coverage or write-down of capital costs, subsidies, carbon taxes or emissions limits, or other incentives. Incentives for development of energy crops and crop and forest residues (such as the BCAP program) continue, as do financial incentives for development of bioenergy facilities.

Export markets for mill residues, pellets, chips and other forms of biomass remain strong, driven by climate policy in the EU and elsewhere. Domestic biomass fuel exporters are given a boost by federally financed bioenergy feedstock export assistance linked to rural economy development goals. Upward pressure on raw material prices resulting from growing export markets is reinforced by similar pressures stemming from initiatives to reduce carbon emissions. As noted earlier, sharp increases in the price of biomass would likely result from aggressive pursuit of increased electricity production from biomass, a carbon tax, and/or implementation of a carbon cap and trade program. Sawmills and planing mills would benefit from increased prices for mill residues, but industries that rely on mill residues, chips, and low-grade logs as raw material – pulp and paper, particleboard, and medium density fiberboard – would face sharp price increases, the impact of which could be blunted by concerted efforts within these industries to increase energy efficiency. Increased availability of sawdust and shavings resulting from increasing sawmill production helps to modify impacts of export markets on domestic biomass prices and supply availability.

Using the petroleum price as a guideline, at this level the energy values of sawdust, chips, and shavings, southern pine pulpwood, southern pine Chip-N-Saw logs, and some species of hardwood sawlogs (hickory, beech) are higher, and in some cases markedly higher, than current market prices even without any form of subsidy, tax, or related policy measure (Table 5).

Without intervention in energy markets in the form of carbon management initiatives, prices of basic raw materials would fall from present levels under this scenario, allowing steel, aluminum, concrete, and plastics industries to become more competitive with the wood products industry. However, as noted earlier, implementation of policies aimed at reducing carbon emissions, such as carbon taxes or cap and trade programs, have the potential to completely reverse this situation, raising operating costs for energy intensive, and particularly fossil-fuel intensive, industries and shifting the competitive balance back toward industries having lower fossil fuel and energy intensity. The cement industry is particularly impacted as high energy intensity is accompanied by problems and financial liabilities related to high carbon emissions resulting from conversion of calcium carbonate to lime in the cement kiln. Under this scenario, implementation of at least some carbon mitigating measures is assumed, but it is also assumed that accompanying actions will be taken to soften adverse impacts on key industries, at least in the short term, to provide time for improvements in energy efficiency, energy switching, and adoption of energy conservation measures.

Within the forest products sector, energy intensive industries will be challenged under this scenario to adapt to the new reality. The paper industry faces significant pressure to accelerate energy efficiency improvements, including capture of a greater portion of the energy value of biomass now used in supplying a portion of energy requirements. At the same time, composite products industries would face severe challenges not only with respect to costs of biomass feedstocks, but with regard to energy-intensive petroleum-based resins, the prices of which would also be impacted by carbon management measures.

In all cases, unilateral action to address carbon concerns results in major international competitiveness issues without policy mitigation.

Scenario #4 – High Energy Prices With and Without Climate Policy: Petroleum prices remain near the $100/bbl level (the mid-May 2011 market price), with world events feeding future supply uncertainty concerns. Climate issues gain traction among policy makers. Interest in stimulating alternative energy development, and in reducing carbon emissions, drives energy policy development and stimulates support for incentives and inducements.

Under this scenario, the present array of alternative energy policies and incentives for biofuels development, at both state and federal levels, is likely to persist and perhaps expand, but at this point the price of petroleum is high enough that unsubsidized production of transportation biofuels becomes economically feasible. With sustained petroleum prices at this level it is assumed that biofuels move from the pilot scale to commercial production, resulting in substantial increased demand for biomass feedstocks. Economic signals also support private sector commercialization of many alternative energy technologies with the result that the rate of innovation accelerates, boosted by infusion of private capital. Innovation, in part, creates uncertainty as entirely new technologies (energy from algae, Kior, genetically modified energy crops) become part of the energy equation and competitive environment. In addition, a number of alternative energy alternatives become economically attractive without incentives or subsidies.

As in scenario #3, in the face of concerns about carbon emissions, enthusiasm for development of alternatives to fossil energy is accentuated, with a shift in emphasis to carbon taxes or implementation of emissions limits, or other incentives for carbon emissions reductions. At the same time, incentives for development of energy crops and crop and forest residues and public financing programs for development of bioenergy facilities are allowed to sunset as bioenergy industries become established. A carbon tax alone would create strong incentives for a shift away from coal in electricity generation (or at least incentives for co-firing with wood), creating another potential source of strong demand for biomass.

Regarding woody biomass, at this petroleum price (as highlighted in yellow in Figure 5) the energy values of all wood residues, pulpwood in some markets, and small diameter southern pine sawlogs become greater, and in some cases substantially greater, than current prices without any kind of carbon management subsidy or policy inducement to shift away from fossil fuels. Moreover, the energy values of lower grade hardwood sawlogs of some species (hickory, beech) rise significantly above current market prices, again without any form of subsidy or inducement; energy values approach hardwood sawlog prices for lower grade logs of some preferred species.

At this price level the lumber industry continues to enjoy competitive advantage over fossil-fuel intensive industries. Moreover, the high value of mill residues increases the profit margin of lumber manufacturers, except in instances in which mills rely on small diameter and/or low grade logs as raw materials.

Under this scenario there is increased motivation for sawmills to use more of their own residues for heat and power generation that could result in less residue availability to industries that rely on mill residues as raw material. As in scenario #3 energy intensive industries will be challenged to adapt to high energy prices, but in this case even without the existence of policy measures intended to discourage the use of fossil fuels. The paper industry again faces significant pressure to accelerate energy efficiency improvements, including capture of a greater portion of the energy value of biomass now used in supplying a portion of energy requirements, but benefits from federal programs to assist with energy efficiency improvements. Also as in scenario #3 composite products industries face severe challenges not only with respect to costs of biomass feedstocks, but with regard to energy-intensive petroleum-based resins; at these market prices, pressures arise even in the absence of carbon mitigation related policies. Raw material availability for use as mulch and bedding is substantially reduced under intense competition from higher value-added industries.

In developing this scenario, it was concluded that for purposes of this analysis outcomes would be essentially the same both with and without climate policy implementation. However, from a broader perspective a major difference would likely be substantial increases in the use of coal in the absence of a climate policy relative to what would happen with a carbon mitigation policy in place.

<u>Scenario #5 – Record Energy Prices and Abandoned Climate Policy:</u> Rising consumption coupled with supply constraints drives petroleum prices to $150/bbl and higher (Figure 5, blue line and below), putting pressure on prices of all energy resources. Energy supply issues push climate concerns to the sidelines, bringing coal back into the energy equation and stimulating renewed interest in nuclear power. Energy prices stimulate massive new investment in alternative energy, bringing the full suite of emerging energy technologies into play.

Market prices send strong signal to all sectors to improve energy efficiency and adopt energy conservation measures, and public energy policy broadens beyond the singular focus on large industrial users to encompass commercial and residential sectors. Energy efficiency and demand reduction improvements occur across all sectors, but not without considerable economic disruption. Energy and fossil intensive industries that cannot adapt quickly enough fade, while those better positioned increase market presence.

Regarding woody biomass, at petroleum prices of $150/bbl and up the energy values of all wood residues, pulpwood, and small diameter southern pine sawlogs are greater, and in some cases substantially greater, than current prices, without any kind of carbon management subsidy or policy inducement to shift away from fossil fuels. Moreover, the energy values of lower grade hardwood sawlogs of some species (hickory, beech) rise significantly above current market prices, again without any form of subsidy or inducement; energy values approach hardwood sawlog prices for lower grade logs of some preferred species such as oak, ash, and maple.

As in scenarios #3 and #4 energy intensive industries will be challenged to adapt to high energy prices. All industries face significant pressure to accelerate energy efficiency improvements. Industries using biomass energy as a source of heat and power, including all players in the forest products industry, face strong competition for biomass resources and have strong incentives to maximize the efficiency with which biomass residues are converted to energy and used in manufacturing processes. Also as in scenarios #3 and #4 composite products industries face severe challenges not only with respect to costs of biomass feedstocks, but with regard to energy-intensive petroleum-based resins; however, potential competitors face the same challenges. Market signals trigger renewed efforts to replace fossil-fuel based resins for all composite products manufacturers. Industries whose supply chains are designed based on just-in-time delivery are forced to rethink market strategies based on maximization of energy efficiency in delivery systems.

Problem Areas in Current Bioenergy Policy and Suggestions for Modification to Reduce Impacts on Established Industries

Lack of Policy Focus

Participants in a recent forest biomass policy conference sponsored by the Pinchot Institute (2009) identified a key problem in current energy policy - "policy ambivalence." Stated objectives of present policies range from displacement of reliance on foreign oil and reduction of greenhouse gas emissions to providing new markets to foster forest health and sustainability and jobs in rural economies. A significant problem with this approach is that the lack of a clear policy focus increases the likelihood of policy conflicts and inattention to key concerns.

Regarding the former, consider the following:

A 2006 Report to Congress on the National Biomass Research and Development Initiative (USDA/USDOE 2006), the last year for which an annual report was required, lists the following objectives of the program:

1. Increased domestic energy security
2. Enhancement of the environment and public health
3. Job creation and enhanced economic development of the rural economy
4. Diversity markets for raw agricultural and forestry products.

Pursuit of objectives 1 and 2 would logically involve development of bioenergy production facilities within the United States, and commercialization of unused biomass resources and development of new biomass resources for domestic use in energy production. As pursuit of these objectives may well be compatible with objectives 3 and 4, the result might often turn out to be a "win-win" situation. Suppose, however, that pursuit of objectives 3 and 4 involves development of export markets for bioenergy feedstocks? While perhaps good for rural jobs, this strategy would be in direct conflict with objective number one; such a strategy might well also work against the interests of established value-added biomass-based industries.

Now, however, export of bioenergy feedstocks is being actively pursued as a job creation and market diversification strategy through the Renewable Energy and Energy Efficiency Export Initiative, implemented in 2010. The new initiative involves eight federal agencies, including the Departments of Energy, Commerce, and Agriculture, and is managed by the International Trade Administration. While mostly focused on development of export markets for renewable energy technologies and equipment, the initiative also supports assistance for export of biomass feedstocks (International Trade Administration 2010, p. 19). In a recent webinar promoting the initiative, a senior international trade specialist for the U.S. Department of Commerce's International Trade Administration, reportedly referred to steadily increasing U.S. wood biofuels exports, questioning why even greater volumes aren't being exported (Gibson 2011).

The attempt to satisfy a number of interests appears to be undermining pursuit of a coherent strategy. Re-examination of the inclusion of export assistance for biomass feedstocks is recommended, with consideration of reallocation of funds devoted to this part of the program toward development of domestic markets for biomass energy. Such a modification should not adversely impact the rural jobs potential, but would have the benefit of better aligning outcomes with national energy security goals; promoting local use of biomass and thereby reduced energy efficiency losses through transportation; and making more transparent potential tradeoffs between established local enterprises, job creation programs, and overall community well-being.

Diversion of Raw Material from Established Value-Added Industries

That woody raw materials should not be diverted from long established value-added forest products industries was underscored in a report prepared for the American Forest and Paper Association by RISI (2010). A study of employment and economic impact across a number of industries showed that the U.S. combined forest products industry creates 5 times as many jobs as the alternative energy sector for the same volume of wood consumed; the multiplier rises to 9 times when upstream and downstream jobs are considered. For the pulp and paper industry specifically the core and broader rations in comparison to bioenergy were found to be 4:1 and 8:1, while the same comparison relative to the non-paper forest products industry yielded ratios of 6:1 and 11:1.

According to White (2010) increased use of woody biomass for bioenergy can be expected to create what are described as ripple effects in the forest and agricultural sectors. He goes on to say that "Increased use of mill residues for bioenergy will likely decrease their availability for their current use (e.g., oriented strandboard, bark mulch, and pellet fuel)." In White's view, the likelihood of milling residues being drawn away from existing production uses to bioenergy production will increase as biomass prices increase. Sedjo (2010) expressed the same view, pointing out that even in the absence of the BCAP subsidy, there were high levels of entry into traditional wood markets by wood pellet producers. He also pointed out that electrical power producers in the southern U.S. are proceeding with plans to increase their use of biomass largely from traditional industrial wood markets based on findings that freshly harvested wood is more suitable to their equipment than forest residues that contain dirt and grime.

Sedjo observes that avoiding the diversion of materials from existing production processes already occurring in the marketplace will be difficult. He posits that the conflict for resources will be greatest between traditional wood industries, such as pulp and paper and composite products, and bioenergy producers. He further notes that:

> *" . . . because wood is fungible, it can readily be shifted between traditional industrial purposes and energy purposes, which includes biofuels and combustion for energy both as raw wood and processed wood, such as wood pellets. To prevent the redirection of industrial wood, a substantial "wall" would have to be placed between the two wood uses to ensure that the subsidy is not used to redirect commercial wood to energy uses. . . The notion of implementing an effective wall between energy and traditional wood markets is daunting. Separating markets for very similar products is very difficult and rarely successful. . ."*

A takeaway here is that programs that provide direct support for collection, transport, and delivery of biomass to bioenergy facilities, if in place for a significant period, will inevitably undermine established biomass users, even if barriers are erected to prevent support payments from being applied to diversion of traditionally used forms of biomass. **A solution is to focus support programs on increasing the supply of biomass and in assisting the design of development of logistics guidelines, but to minimize or avoid direct per unit volume subsidy initiatives.**

Creation of Biomass Demand that Exceeds Supply

As discussed in a previous section of this report, a significant gap in biomass supply is developing in Europe, as a result of aggressive incentives for bioenergy production and insufficient attention to biomass supply. A similar situation may be developing in the United States.

It was noted earlier that the Department of Agriculture in early May 2011 designated 50,000 acres in Missouri and Kansas for production of energy crops. This is the kind of action needed to align biomass supplies with demand created by promotion of bioenergy opportunities and subsidized research and development of bioenergy production facilities. That program relies on financial assistance to farmers to establish perennial energy crops, since a year or more is required before such crops begin to produce marketable yields. However, current proposals in Congress appear likely to result in termination of the Biomass Crop Assistance Program through which financial assistance would flow. It remains to be seen whether significant areas of energy crops can be developed without some kind of program to reduce risk for entrepreneurial biomass suppliers.

With respect to woody biomass, Stokes (2010) recently examined the future demand/supply equation for the southeastern U.S. and concluded that prospective significant increases in biomass supply may be needed to meet developing demand. He indicated that while there are opportunities to increase both availability and supply, both incentives and markets will be needed before this can occur. Galik et al. (2009) also looked at this issue and identified risks to users of forest resources stemming from the possibility of demand exceeding supply for woody biomass. They pointed to the likelihood of a spike in resource pricing should a shortage in supply develop, noting that there are not excess undeveloped supplies of biomass that can simply be added to what is now being drawn from southeastern forests. They reported that all forest users would be affected, and especially industries that depend upon residues of other industries for raw material supplies. A central conclusion was that "Policy makers must have a strong understanding of the available resource base and be aware of these tradeoffs when considering incentives or programs to encourage increased levels of forest biomass for bioenergy or biofuel." In the western United States an obvious problem regarding bioenergy feedstock supplies is the exclusion from qualification for the biofuels renewable fuels standard of biofuels made from biomass obtained from most federal lands – thus making associated investment ineligible for the myriad of federal bioenergy development support programs. Regarding existing forms of woody biomass that could be a source of bioenergy and that are largely unused, such as forest residues, the central issue is not one of increasing supply, but of development of a supply system.

Creation of situations in which demand exceeds supply can also occur when financing is provided to establish bioenergy facilities without exercising due diligence to ensure that adequate biomass supplies are available. Citing several examples in which this has occurred, the Pinchot Institute (2010), recently expressed the view that "investor grade" feasibility analyses are needed before financing individual projects, and that it is essential to ensure that the resource assessment account for future competition during the 30 to 40 year service life of a given facility.

Adverse Impacts on Global Competitiveness of Biomass-Based Industries

As discussed previously, U.S. particle-based panel industries would face stiff competition from foreign competitors if domestic energy prices were to rise without similar increases in competing regions; problems would be similar regardless of the cause of increased energy costs. Difficulties would be magnified if domestic wood raw material prices were to rise in response to non-market forces such as energy policy. While there is a clear recognition of this reality on the part of the Department of Commerce and other federal agencies, there is a clear need to base policy development on finely-tuned rather than broad brush information. After evaluating the Waxman-Markley bill (HR2454) that proposes output-based rebating to certain energy and carbon intensive sectors as a means of softening the negative impacts of a carbon tax or cap and trade program, Morganstern (2010) concluded that more refinement is advisable in identifying program recipients. Instead of using the six-digit North American Industrial Classification Scheme (NAICS), as proposed in the Waxman-Markley bill, Morganstern suggested that a much more refined approach, based on perhaps a 7- or 8- digit NAICS and focused on the sub-industrial categories having the greatest emissions and/or the most cost-effective potential to reduce their emissions, would be preferable. He noted that this kind of information would allow the EPA to potentially include certain industry sub-sectors not currently recognized in Waxman-Markley. This kind of refinement is potentially important to the particleboard, hardwood lumber, and logging industries since specific industry figures are hidden with larger industrial classifications at the six-digit level.

Lack of Recognition of the Sustainability Benefits of Biomass

As reported by Research Reports International (RRI) (2006), production costs for biomass feedstocks are higher than production costs for fossil fuels; moreover, the price of biomass is likely to increase as demand increases. The authors noted that although infrastructure has been developed to support the existing biomass industry (agriculture and forest products), additional infrastructure, including new harvesting, handling, and processing technologies, will be needed as feedstock types are added and use increases. Biomass costs are further increased by attention to sustainability concerns – concerns that are focused on biomass energy only. In the words of RRI, "The lack of policy to credit the distinct sustainability benefits of biomass or to require sustainable use of natural gas and other fossil resources makes the cost of biomass energy to appear high. In order for biomass-fueled generation to be able to compete effectively on a large scale with other renewable and fossil fuel alternatives, its environmental benefits must be realized." Participants in a Pinchot Institute hosted workshop (2010) also recently observed that climate and energy policy does not recognize avoided GHG emissions, a recognition that would favor the use of both wood products and biofuels; in this regard, some participants expressed concern that this could lead to competition between carbon-for-storage (no harvesting) vs. carbon-for-bioenergy, another area yet unresolved in the policy arena.

How Energy and Climate-Related Policies and Initiatives Might be Modified to Reduce Impacts on Established Industries

Based on findings linked to development of this report, the following modifications to energy and climate-related policies and initiatives are recommended:

- Ensure that government initiatives relative to biomass supply keep pace with efforts to encourage biomass consumption for energy production.
    - Maintain a focus on new sources of supply.
    - Move toward certification of federal forests.
    - Remove restrictions on eligibility under the federal Renewable Fuels Standard of bioenergy products derived from biomass harvested from federal lands.
    - Eliminate programs and provisions that provide direct support or subsidies for collection, transport, and delivery of biomass to bioenergy facilities.
    - Rather than direct support or subsidies for woody biomass as indicated above, support the development of:
        - guidelines for responsible collection that protects forests and woodlands.
        - systems to improve collection system logistics and economics for small woodland and woodlot owners, perhaps including
            - assistance in formation of landowner cooperatives for biomass collection.
            - incentives to encourage establishment of concentration yards.
            - extension/outreach programs that increase awareness of opportunities for increased income and improved woodlot

management on the part of farmers and small woodland owners.

- Ensure that incentives for establishment of large-scale bioenergy facilities are not provided without careful assessment of biomass resource availability and established uses within a material procurement region. Avoid endorsement of any facility based primarily on pursuit of economies of scale.

- In regions with well established competition for biomass resources provide greater emphasis on small-scale bioenergy development (district heating, mill-scale CHP) than large-scale development.

- Reconsider bioenergy program objectives and eliminate conflicting goals and associated initiatives.

- Consider experience within the European Union when developing any kind of energy or climate policy initiative relative to bioenergy development; the EU has been wrestling with implementation of climate policy for a considerable period (i.e. Alexeeva-Talebi et al. 2008), and careful assessment of policy successes and failures there can help to avoid adverse impacts to established industries and other policy failures and shortcomings on this side of the Atlantic.

- Expand the current policy focus of EPA Clean Air Act carbon initiatives, and Waxman-Markley and related legislation to include industries beyond those deemed most critical. Refine and expand industry databases to increase knowledge of energy consumption and carbon emissions of industry sub-sectors not commonly considered in policy development.

- Credit the distinct sustainability benefits of biomass energy in policy initiatives and/or implement penalties for non-sustainable use of natural gas or other fossil fuel resources.

- Recognize that industries potentially facing not only increasing energy costs, but also increased competition for primary raw materials, as a result of energy and climate policy deserve particular attention with regard to policy alleviating measures. Well financed assistance programs aimed at increased energy efficiency and conservation concurrent with bioenergy development initiatives is one example of the kind of measure that could be employed. In addition, initiation of a program of targeted research to identify raw material options and potential product modifications in particleboard manufacture is recommended as the particleboard industry faces critical survival issues as a result of increased demand for biomass,

What Industries Can Do to Proactively Address Potential Problems/Opportunities

In view of the large impact that public policy can have on the health and ultimately survival of industries it is perhaps obvious that industries individually need to keep abreast of policy discussions that might affect them. In addition, the dual risks posed to many forest products industry sectors by climate and energy policy on the one hand, and rising market-driven energy prices on the other, suggest a need for proactive action on an industry-by-industry basis to assess risks, and to identify and implement strategies to alleviate these risks.

Perhaps most obvious is the need to continually and aggressively seek improvements in energy efficiency and conservation, and to understand the carbon footprint of industry operations. For industries that rise to the level of "critical industries" based on employment, value added contribution to the economy, and susceptibility to foreign competition, such as the pulp and paper industry, much of the work in determining what steps need to be taken has already been done (Francis et al. 2002, Kramer et al. 2009). In addition, pathways for movement toward conversion of pulp and paper mills to integrated biorefineries have been identified, and extensive research and development efforts are ongoing. A comprehensive assessment has also been conducted of the logging industry through a cooperative in Canada led by FP Innovations (Forest Innovation Partnership 2011). In both cases, extensive lists have been prepared of actions that could be taken to improve energy efficiency and reduce energy consumption. They deserve immediate and ongoing attention.

Other industries have received less attention. One industry that is just beginning to be examined regarding energy use and efficiency is the U.S. hardwood lumber industry. As indicated previously, over the past year a team at Virginia Tech University (Espinoza et al. 2011) has begun to assess the impact of rising energy prices on this industry, finding via an extensive survey of sawmill owners that energy expenditures as a percent of total costs rose in 58 percent of U.S. hardwood mills over the previous five years, with corresponding adverse impacts on profits. Shockingly, however, they also found that energy audits have been conducted by only one-eighth of companies responding to the survey, that very few had any kind of energy management program in place, and that less than two percent had someone within the company with assigned responsibilities as an energy manager. For this industry the opportunities, and need, are obvious.

For both softwood and hardwood lumber manufacturers the majority of energy consumption occurs in the lumber drying process, and this is therefore a logical target of opportunity in any energy efficiency program. For the hardwood industry, where drying times are longer and care needed in drying greater, there may be opportunities in scaling up small-scale solar kilns for use in dehumidification systems.

As discussed throughout this report, the particleboard industry faces greater challenges than any other industry as a result of bioenergy development, rising energy prices that have inspired the bioenergy phenomenon, and rising resin costs that are linked to increases in energy prices. For this industry, a critical examination of alternative raw material options would seem to make sense (i.e. alternatives to both wood and fossil-based resins); consideration of product redesign so as to minimize raw material inputs may also be warranted. A well-funded, targeted program of research focused on this issue is among the policy recommendations in the next section; given government investment to date in developing competing demand for the raw material used by the particleboard industry, a bit of investment in exploration of options for the industry most affected would seem to make sense. Among options that might be investigated are the full range of lightweight panel options developed in recent years at the U.S. Forest Products laboratory using both traditional and non-traditional raw materials, including honeycomb core and foam core panels.

GHG emissions have only recently begun to be studied. One report that will be valuable to the forest products industry is a 2009 report from EPA. With a perhaps somewhat misleading title "Potential for Reducing Greenhouse Gas Emissions in the Construction Sector," the report deals with primary materials used in construction, and sets forth a number of ideas and strategies for beginning to manage carbon emissions.

Summary

Current and proposed climate and energy policy, and specifically incentives for the development of bioenergy have the potential to negatively impact established biomass-based industries through increased costs, competition for supplies, and perhaps other unidentified cause and effect relationships. Long-term implications of rising energy prices – whether resulting from market forces or public policy – for the domestic wood products industry point to similar potential.

Based on findings linked to development of this report, a number of modifications to energy and climate-related policies and initiatives are recommended, including changes to ensure a focus on increasing biomass supply rather than on expanding biomass markets; elimination of programs and program provisions that provide direct support or subsidies for collection and delivery of biomass; assistance in organizing landowner cooperatives for biomass collection; and crediting the distinct sustainability benefits of biomass energy in policy initiatives and/or implement penalties for non-sustainable use of natural gas or other fossil fuel resources.

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