A Strategy for Increasing the Use of Woody Biomass for Energy

Prepared for the

National Association of State Foresters

Forest Markets Committee

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National Association of State Foresters

The National Association of State Foresters (NASF) is a non-profit organization that represents the directors of all 50 state forestry agencies, the eight U.S. territories (American Samoa, the Federated States of Micronesia, Guam, the Northern Marianas Islands, Paiau, Puerto Rico, Republic of the Marshall Islands, and the U.S. Virgin Islands), and the District of Columbia.

Through public-private partnerships, NASF seeks to discuss, develop, sponsor and promote programs and activities which will advance the practice of sustainable forestry, the conservation and protection of forest lands and associated resources and the establishment and protection of forests in the urban environment.

State Foresters understand that having diverse and robust markets for the full spectrum of woody materials forests produce is an important prerequisite for sustainable forest management as, in their absence, generally only high values materials are harvested and the residual stand can be degraded, or harvesting may not take place at all and stands can be left overstocked - thus vulnerable to wildfires, insects and disease. This is not to say that active management is necessary or appropriate for all stands; some research areas, ecological reserves and Wilderness areas are designated for passive management.

Consistent with this understanding, the *Forest Markets Committee of NASF* seeks to maintain and expand markets for the broad array of forest products, including traditional wood products, bioenergy, and ecosystem services.

This report is a portion of the Forest Markets Committees efforts in these regards. A broader report on how to reenergize federal and state efforts to maintain and diversify markets for forest products is also being prepared.

This report was prepared for the NASF Forest Markets Committee, with funding provided by the USDA Forest Service through the Wood Education & Resource Center.

Innovative Natural Resource Solutions LLC

Founded in 1994, Innovative Natural Resource Solutions LLC (INRS) is a full-service consulting firm specializing in the forest industry, natural resource conservation, and renewable energy. INRS has worked extensively with a number of parties on the development of new biomass energy facilities around the country. The firm is currently working with developers of biomass or biofuel projects in Maine, New Hampshire, New York, New Jersey, Vermont, Massachusetts, Indiana, Virginia, Georgia, Michigan and California.

A complete description of INRS activities in biomass energy development, including a partial client listing, can be found at www.inrsllc.com.

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Introduction

The purpose of this report is to review the status of woody biomass as an energy resource, the status of the technologies for using it (particularly the new ones under development which could broaden the use of biomass), and to suggest a strategy to NASF for actions it and its members could take to increase the use of woody biomass for energy.

NASF's interest in this topic stems from its understanding that the practice of "sustainable" forestry depends on diverse and robust markets for forest products – particularly for low grade materials and its interest in helping to address global warming by replacing fossil fuels with CO_2 neutral wood.

Biomass energy refers to energy derived directly from plant or plant-derived material[i]. Biomass includes wood from the forest and mill residues, purpose-grown energy crops, and agricultural crops grown or used for energy production. This report, prepared for the National Association of State Foresters, focuses on forest-derived wood, including forest residues, mill residues, and wood harvested specifically for energy production.

Energy consumption falls into three main categories:

- *Thermal energy* – used to heat spaces or for industrial applications;
- *Electricity* – used to provide power to homes and businesses via the utility grid or directly; and
- *Transportation fuels* – used to power cars, trucks, trains and other transport.

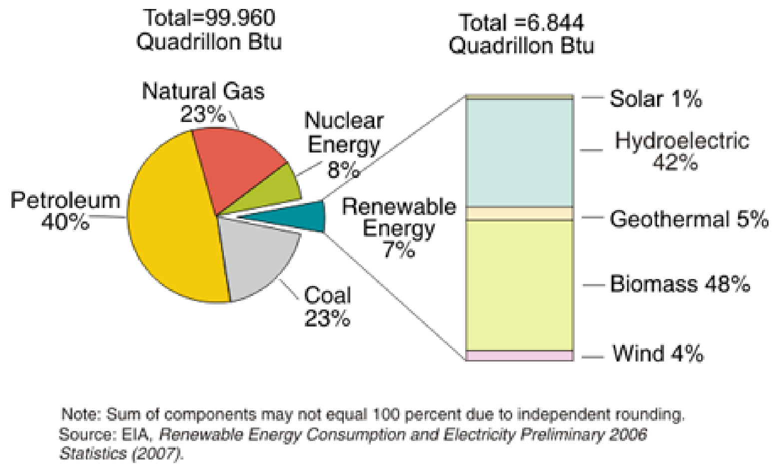
Biomass is unique among renewable fuels in providing opportunities to help meet each of these energy needs.

- *Thermal energy* – used as cordwood, pellets or chips, woody biomass can be used to generate space heat for residential, commercial and institutional application, and is commonly used at forest industries to generate process heat (e.g., biomass boilers at pulp and paper mills or wood-fired kilns at sawmills). As oil and other fossil fuel prices rise, woody biomass will in many cases become attractive for expanded industrial application, and could be used by industries with large thermal energy needs unrelated to the forest products industry.
- *Electricity* – using well-established technologies, wood can be used to create electricity for use on-site or for sale onto the regional electricity grid. Biomass electricity facilities currently exist throughout the country, with large numbers operating in the Northeast and California.
- *Liquid fuels* – the use of wood to create liquid fuels for transportation applications is an area of significant research and development activity, with some technologies entering the commercial arena. The most high-profile liquid fuel potentially derived from wood is cellulosic ethanol, but other candidate liquid fuels include pyrolysis oil, methanol, butanol, Fischer-Trophe diesel, and an organically-derived gasoline.

Energy Use in the United States

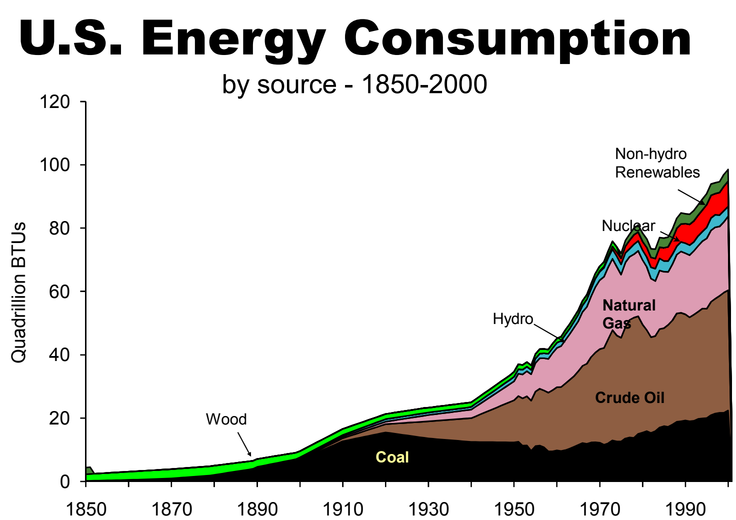
In 2006, the United States used roughly 100 quadrillion British Thermal Units (BTUs) of energy. Seven percent of this energy was derived from renewable sources, and roughly half of the renewable energy used was from biomass.

Figure 1. Energy Use in the United States, 2006[ii]



Energy consumption in the United States has risen steadily, with coal, crude oil and natural gas providing the majority of energy and product growth. Non-hydro renewable, a category that includes biomass, has historically provided modest volumes when compared to total energy consumption. However, as prices for fossil-derived energy increase and concerns about net carbon emissions influence public policy, renewable energy including biomass has significant opportunities for expanded growth.

Figure 2. Energy Use in the United State, by Source



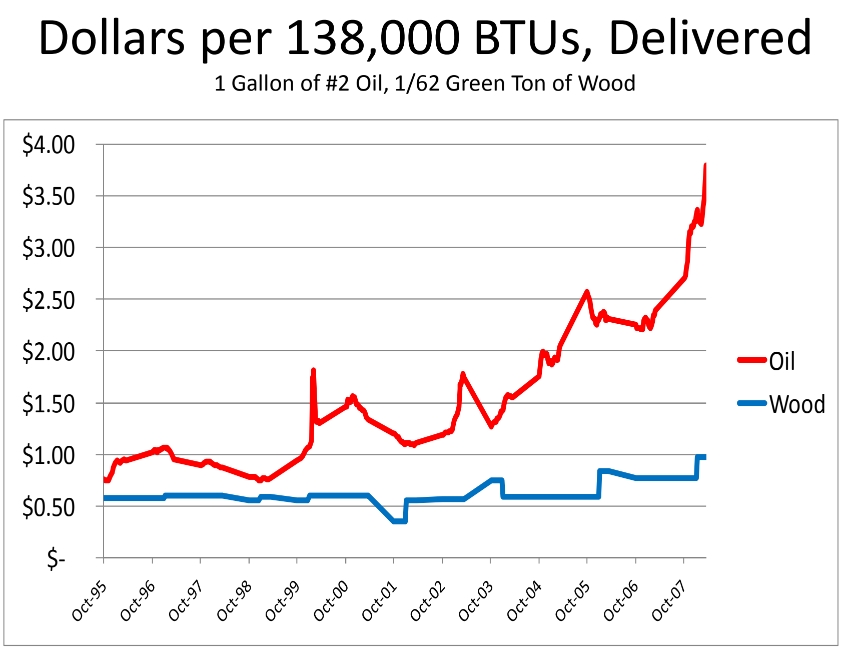
Benefits of Biomass Energy

Biomass energy provides opportunities for businesses, institutions, utilities and others to meet a range of energy needs in a cost-effective manner while supporting the local economy and environmental goals. Some of the benefits associated with biomass energy are discussed below.

Energy Prices

Prices for a wide variety of energy sources have risen significantly in the past decade, with oil showing the sharpest increase. While woody biomass prices have also risen, the rise has generally been less dramatic, and wood provides an increasingly cost-attractive alternative to other fuels. For example, the chart below shows the cost of biomass chips used for thermal energy production (e.g., school heating) in central New Hampshire, compared with the cost of No. 2 heating oil. For purposes of direct comparison, both fuels are reported in BTUs, with 138,000 BTUs being equivalent to a single gallon of No. 2 oil. ("Delivered" refers to the price of fuel brought to and unloaded at a customer's site; the cost per unit of useful heat depends upon the relative efficiency of the oil and wood heat systems.)

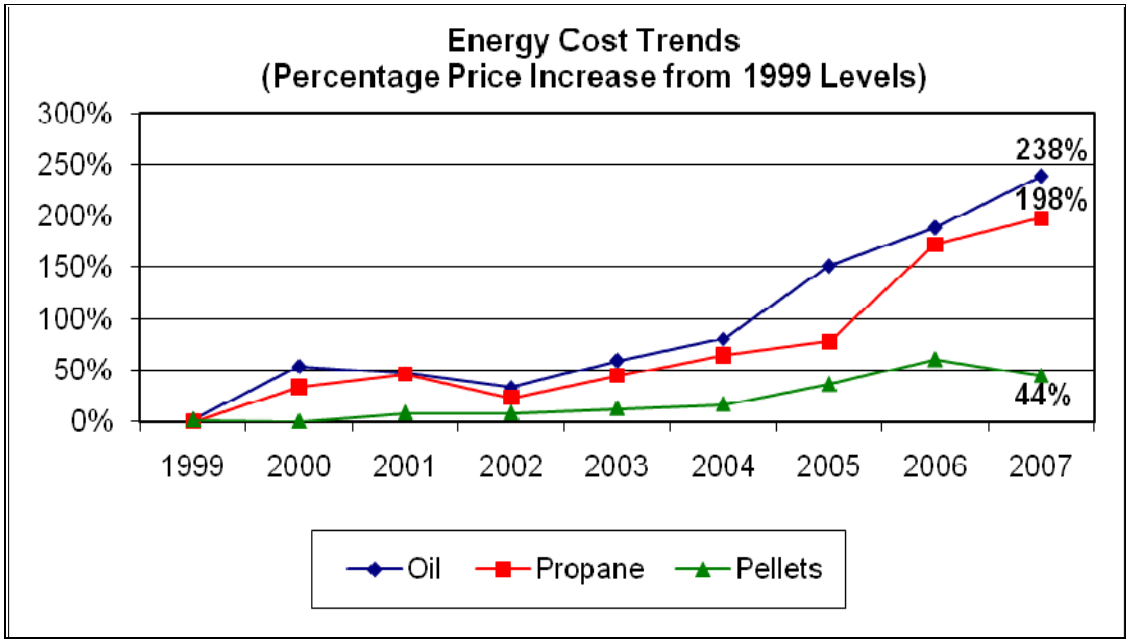
Figure 3. Wood and Oil Costs, 1995 - 2007



Cost for wood fuel is remarkably regional, including particular local factors such as physical availability, logging infrastructure, competing uses, transportation distance, and delivery requirements. The *price* information provided above is accurate for thermal biomass units in central New Hampshire, but is not necessarily true for other location in the United States. However, in INRS' experience the *price trend* information is generally consistent throughout the country, with increases in biomass prices much more modest than oil price increases.

Similarly, the percent increase for wood pellets - a biomass fuel made from mill residues and other wood – shows percent increases much lower than competing common residential heating options. The following information was developed by New England Wood Pellet[iii] using information for the Northeast.

Figure 4. Energy Cost Trends, 1999 - 2007



This biomass price trend information has a number of individuals, companies and institutions evaluating the opportunities for biomass energy installations.

Energy Security

Woody biomass is a resource available locally available in much of the United States. Woody biomass represents a fuel source that can be used to meet a wide range of energy needs.

This issue has gained importance as the public has recognized national security concerns associated with the country's petroleum use -- roughly 80% of known petroleum reserves are located in the Middle East, Venezuela, Russia, China and Nigeria. Only two percent of known petroleum reserves are in the United States[iv]. Woody biomass presents an energy option that, in many parts of the country, can be produced locally and presents a secure source of renewable energy.

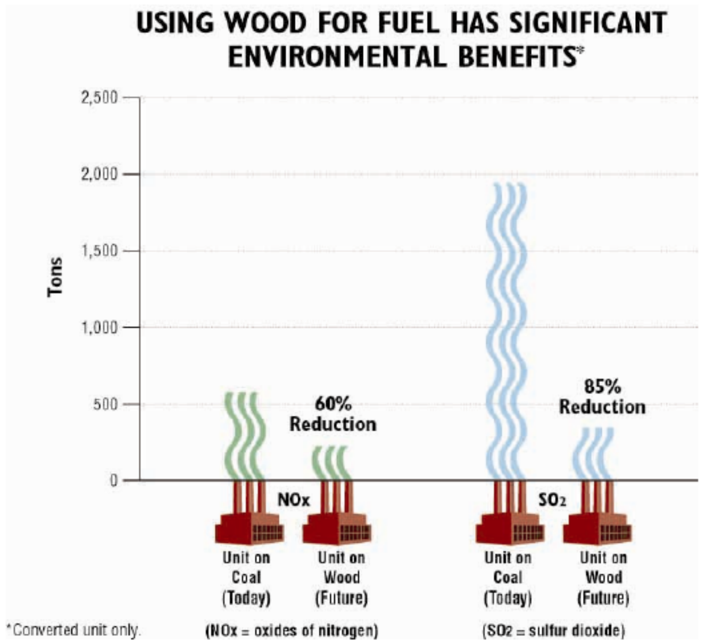
Local Economic Benefits

Biomass energy projects can provide significant economic development opportunities for the host region. Jobs are created or retained through the harvesting, processing and transportation of biomass fuel, as well as in the operations and maintenance of a biomass energy facility. Biomass electric facilities create between 2.4 and 5.0 direct jobs for each megawatt of installed capacity[v]. The use of a locally derived fuel also keeps money from leaving the local economy to pay for imported fuel.

Emissions

Depending upon the application and competing fuels, biomass energy can help achieve significant emissions reductions for a number of pollutants. For example, Public Service Company of New Hampshire replaced an operating 50 MW coal plant with a 50 MW biomass power plant in Portsmouth, NH. This fuel switch, coupled with new technology to reduce emissions, resulted in significant reductions of NO_x and sulfur[vi].

Figure 5. Emissions Reduction from Switching Electric Generation from Coal to Wood



As biomass energy displaces fossil fuel use, there are also opportunities to realize reductions in greenhouse gas emissions. Biomass harvested from sustainably managed forests[vii] is considered "carbon neutral" – the carbon that is emitted from the combustion or other use of biomass is offset through carbon captured in new forest growth[viii].

While most emissions profiles are positive, concerns have been raised about emissions of particulate matter and some toxins from smaller thermal units, such as those used in schools. Currently, most small-scale biomass heating systems in the United States emit higher levels of fine particulate matter and some toxins than the fossil fuel systems they replace. These smaller units are also below the threshold for permitting or regulation in most jurisdictions. There is a concern that in applications like hospitals and schools, if not properly installed and operated, these systems could increase exposure of sensitive populations, such as children and the elderly, to harmful emissions.

Cleaner biomass combustion technologies and emissions control options at this small scale are available in Europe and Scandinavia, and efforts are underway to make similar choices available within the United States. State Foresters understand the importance of protecting public health while working to increase the use of wood as fuel. We strongly support efforts to make cleaner technology more readily available, and particularly advocate the development of cost effective approaches that avoid pricing biomass utilization systems out of the range of feasibility.

During fire season, wildfires are a significant source of particulate matter and other emissions in the west. Smoke from wildfires tends to concentrate in western valleys, where populations tend to be centered. As forest managers implement treatments to reduce fuel loads, they are also reducing the emissions potential of future wildfires.
In addition, the slash residue that results from forest treatments often presents a disposal problem to forest managers. Much of this material is currently piled and burned, due to a lack of markets within economically feasible hauling distances. Burning slash poses a potential risk of fire escape, and creates particulate and other emissions that behave similar to wildfire smoke, often settling near population centers. Smoke management guidelines and risk management concerns are making it more and more difficult for forest managers to dispose of slash via open burning in a timely manner. However, if left on the forest floor, this material increases the wildfire risk to an unacceptable level.

Creating additional local energy markets for woody biomass would help to address the problems of timely slash disposal and wildfire risk reduction. At the same time, it would dispose of woody biomass in a manner that uses its energy instead of wasting it, and that substantially reduces emissions over what would have been produced by burning that same woody biomass in a slash pile or wildfire.

While the state foresters understand that it is very difficult to compare the human exposure to particulate matter from slash burning, wildfire, and biomass energy projects, partly because of the seasonal variation in impacts, we strongly feel that these positive air quality aspects of biomass utilization need to be recognized along with its numerous other benefits.

Major Incentives for Biomass Energy

There are hundreds, if not thousands, of programs that provide some level of support to renewable energy applications, including biomass energy. Much of this support is limited to specific geographies, technologies or applications. A detailed listing of many of these incentives and other programs can be accessed through the *Database of State Incentives for Renewable Energy*, listed in the "Information Resources" section of this report. At this time there are two primary operating incentives for biomass electricity – state-based Renewable Portfolio Standards and the federal Production Tax Credit. For liquid transportation fuels, a federal Renewable Fuels Standard has been adopted, which includes specific provisions for cellulosic ethanol. There is no major federal or state program to provide operational support to biomass thermal applications[ix], though the 2008 Farm Bill contains provisions that authorize capital support.

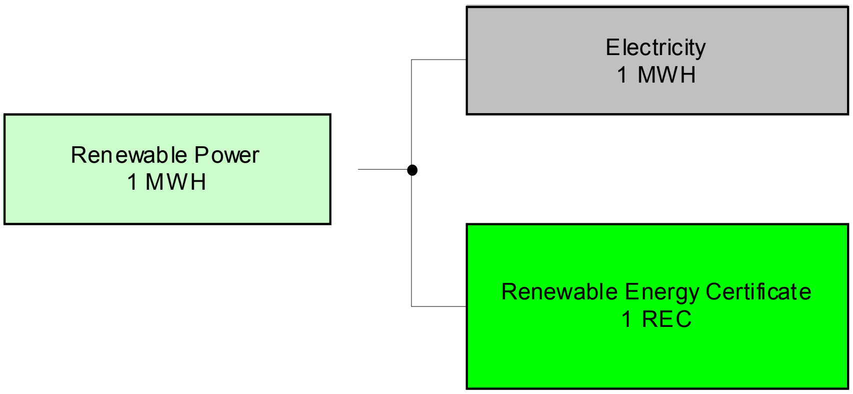
Renewable Portfolio Standards

Renewable Portfolio Standards (RPS) are becoming an increasingly popular tool at the state level to encourage the development of renewable energy generation. At this time, roughly half the states in the country have a Renewable Energy Standard or similar requirement for renewable electricity generation[x]. An RPS is a mandate that any seller of electricity operating in that state must derive a certain portion of their electricity from renewable sources. Each state defines what qualifies as "renewable" for purposes of their portfolio standard, so that generation that qualifies in one state does not necessarily qualify in other states. RPS are usually designed to provide opportunities not only for generators within the state, but also generators in other states that can import electricity.

Many firms that produce electricity using biomass power now have a new opportunity to achieve financial returns, due to state-based public policy initiatives that encourage production of renewable energy. However, these incentives entail a certain amount of risk. To meet stringent technology or emissions requirements that are part of some Renewable Portfolio Standards, investment is required in existing biomass facilities in order to qualify for these incentives.

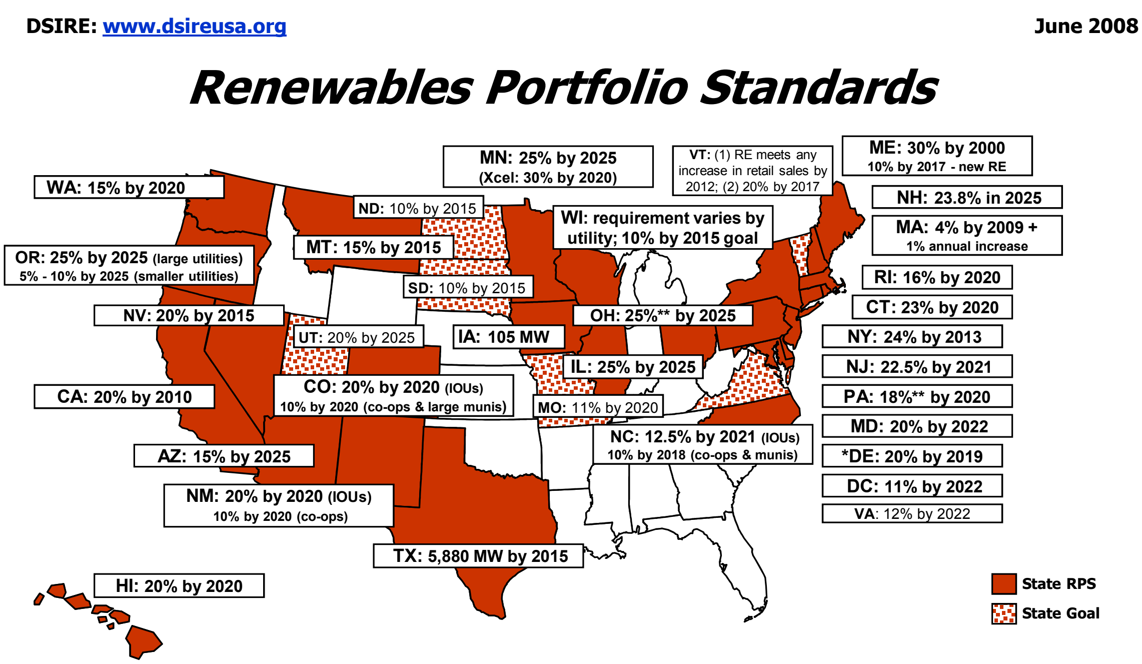
Electricity generated from renewable sources produces two separate products – first, the electricity, and, second, the "green" or renewable attributes associated with that electricity. These renewable attributes are referred to as Renewable Energy Certificates, or RECs (also known as "green tags"[xi]). For each megawatt hour (MWH) of electricity generated, one REC is created. These two products, electricity and RECs, can be separated, or unbundled, and sold individually. The value of a REC varies widely depending on the specific circumstances in each jurisdiction, but can range from essentially without value to approximately equal to the wholesale value of the electricity

Figure 6. Products from Renewable Electricity Generation



As mentioned earlier, roughly half of the states now have some form of a RPS standard, though the percentage of renewable energy required, qualification requirements for biomass energy and other specifics vary significantly state-to-state. Because biomass has a proven track record of success in providing reliable electricity production, utilities and independent developers often look to biomass as a technology to help meet renewable energy requirements.

Figure 7. States with Renewable Portfolio Standards[xii]



Production Tax Credit

At the federal level, there is a Production Tax Credit (PTC, also known as the Section 45 Tax Credit) of $0.015/kwh (inflation adjusted 1993 dollars, currently equivalent to $0.020/kwh) for some forms of renewable electricity generation, including wind, poultry waste and "closed loop" biomass.[xiii] "Open-loop biomass", the type of biomass generated through forestry activities, receives a tax credit of half this amount. "Open loop biomass" is defined by the U.S. Internal Revenue Service as including:

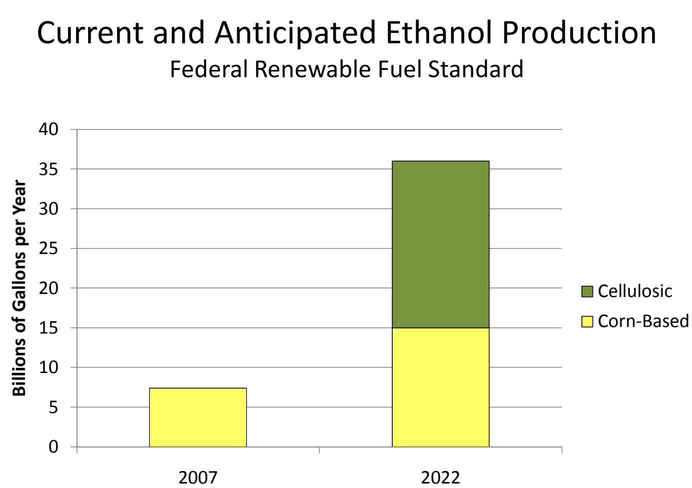
> "Any of the following forest-related resources: mill and harvesting residues, precommercial thinnings, slash, and brush".

In order to qualify for this tax credit, which runs for ten years, a biomass or other renewable energy facility must be operational by the end of 2008. Efforts are underway to extend this deadline, and the PTC has a long history of expiration or near-expiration, followed by re-authorization and extension. Uncertainty about the future of this tax credit has been a challenge for developers of biomass electric and other renewable electric generation facilities.

Renewable Fuels Standard

The Renewable Fuels Standard (RFS) is a federal mandate to increase the amount of renewable transportation fuel available in the United States. Passed in 2005 and 2007, the RFS seeks to nearly quadruple the production of ethanol and other renewable transportation fuels from current levels to 36 billion gallons per year by 2022. This will be accomplished not only by incenting more corn-based ethanol production, but mandating fuels derived from cellulosic materials, including woody biomass.

Figure 8. Required Production Levels, Federal Renewable Fuels Standard



Biomass Fuel Availability

Identifying potential sources of biomass fuel can be one of the more challenging aspects of a new biomass energy project. Potential users of biomass must answer at least two questions:

1. Is wood fuel (or feedstock) sustainably available in consistent quantity to supply a facility, and
2. Does the harvesting, processing and supply infrastructure exist to provide biomass in a consistent and timely manner?

These are often difficult questions, and developers should be prepared to clearly identify their fuel requirements prior to answering these questions. Potential fuel requirements include:

- **Fuel specifications** – what size, moisture content, composition, and other parameters apply to delivered fuel or feedstock;
- **Species requirements** – are particular species required or excluded from the process, or can the biomass unit handle a full range of species;
- **Delivery requirements** – what type of trucking is required to meet the delivery needs, including provisions for unloading (e.g., live floor trailers or truck dumps);
- **Seasonal fuel requirements** – is the fuel demand expected to be seasonal (some thermal units) or consistent year-round (e.g., electric and liquid fuel production).

Only when these fuel requirements are understood can a determination of the availability, and ultimately price, of biomass fuel be generated. Many developers of biomass energy projects come from an energy background, and thus have limited understanding of the forest industry and the complexity of biomass supply. Because biomass fuel is not a "standardized" product, with little consistency from one region, technology or application to the next, the analysis of fuel supply is complex. One area where State Foresters can be very helpful to biomass projects of all types is helping the proponents identify the specifics of their fuel needs, as described above.

Biomass fuel can come from a wide variety of sources, including but not limited to:

- Sawmill residues
- Forest harvesting residues
- Forest thinning
- Land clearing
- Dedicated (or "purpose –grown") energy crops

Each of these fuel types has unique availability and production issues. Forest residues and sawmill residues are the most common types of biomass fuel used, and are discussed in greater detail.

Forest Residues

Typical Fuel Value and Moisture
Moisture Content: 40% to 50% as-harvested
Fuel Value: ~4,625 btu/lb, 9.25 mmbtu/ton

Forest residues are the otherwise unused portion of a tree harvested for sawlogs, veneer, pulpwood, or other roundwood product. When a logger cuts a tree, the most valuable portion is generally the straight, lower portion. This portion, which can be cleanly debarked, can be used to produce lumber, pulp for paper, or other products, depending upon the species, specifications, and local markets. The portions of a harvested tree considered "forest residue" may refer to branches, tops, areas with splits or sweep, crooks, or portions of a tree with rot.

Forest residue is collected in the process of some timber harvests, particularly during harvests employing highly mechanized logging crews operating high-capacity equipment. For logging crews using chainsaws and cable skidders (as well as some other configurations of logging equipment), most forest residue is left in the woods, at the site a tree is felled. This residue can be skidded to a landing for processing, and some suppliers do this; the economics are challenging.

Once brought to a log landing, the high-value portions of a tree are separated from the parts that are "off-spec", and forest residue is piled separately. Forest residue can then be chipped directly into a logging truck, for direct delivery to market. Forest residues tend to be mixed species, as any and all residue on the log landing can be chipped and co-mingled.

Even after chipping, forest residues processed in-woods tend to have a high number of pieces that are oversized or otherwise not in conformance with traditional biomass specification[xiv]. As such, forest residues tend to be used at large facilities that can afford the equipment to screen and re-process biomass chips, typically biomass plants creating electricity or combined heat and power facilities (e.g., the energy plant at a pulp mill).

The figures below show the sorting and processing of forest residues at a logging job.

Figure 9. Wood Sorted for Chipping.

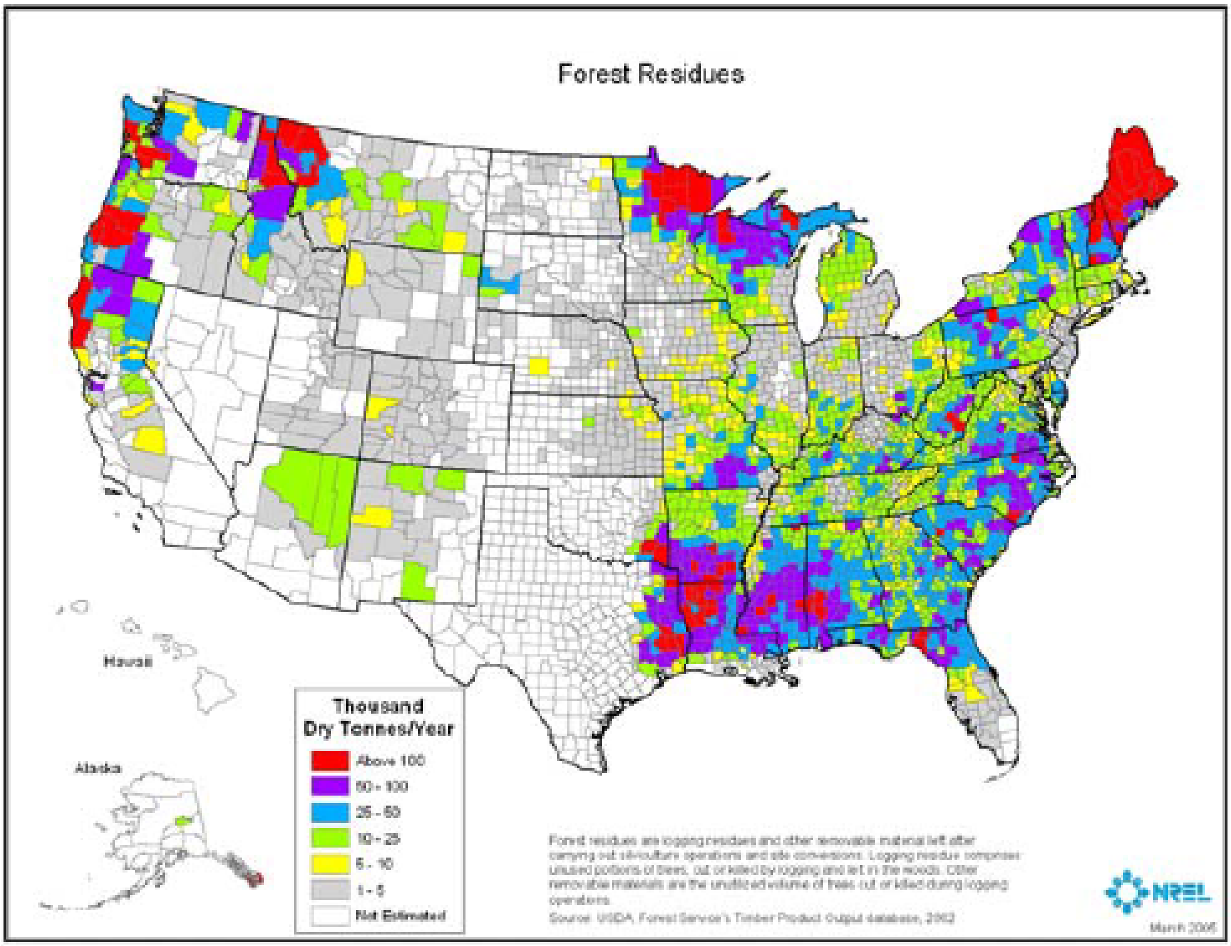
Figure 10. Close-up of Chipper on Log Landing

Figure 11. Forest Residue Chips Being Emptied at a Biomass Electric Plant

Figure 12. Forest Residue Contains High Levels of "Off-spec" Pieces

The National Renewable Energy Laboratory (NREL), using information developed by the USDA Forest Service – Timber Products Output analysis, has developed information on the volumes of forest residue available in the United States on a county basis[xv].

Figure 13. Forest Residue by County, Estimated[xvi]



Nationally, INRS estimates that there are roughly 93 million green tons of logging residue available annually[xvii]. This volume of wood can generate 56 million megawatt hours of electricity, enough to meet the combined electricity needs of Wyoming, Montana, Delaware, the District of Columbia and Vermont for one year[xviii].

Similarly, assuming 80 gallons of cellulosic ethanol per dry ton of forest residue, this is enough wood to produce 3.8 billion gallons of ethanol, roughly equivalent to the combined energy value of all gasoline used in Delaware, the District of Columbia, Maryland, New Jersey and Pennsylvania annually[xix].

Sawmill Residues

Typical Fuel Value and Moisture
Moisture Content: 50% as-delivered
Fuel Value: 4,500 btu/lb, 9.00 mmbtu/ton

When sawmills cut cylindrical logs into rectangular boards, residue is produced - including bark, sawdust and mill chips. Actual residue generation varies by species and mill equipment, but a general rule of thumb is that a log in a sawmill produces 60 to 70% of useful timber as boards, 20 to 30% as wood chips, and 10% as sawdust[xx]. Due to high concentrations of wood from the outside of the tree, the part that carries water from the roots to the leaves, sawmill residues are generally high in moisture, often as high as 50% moisture.

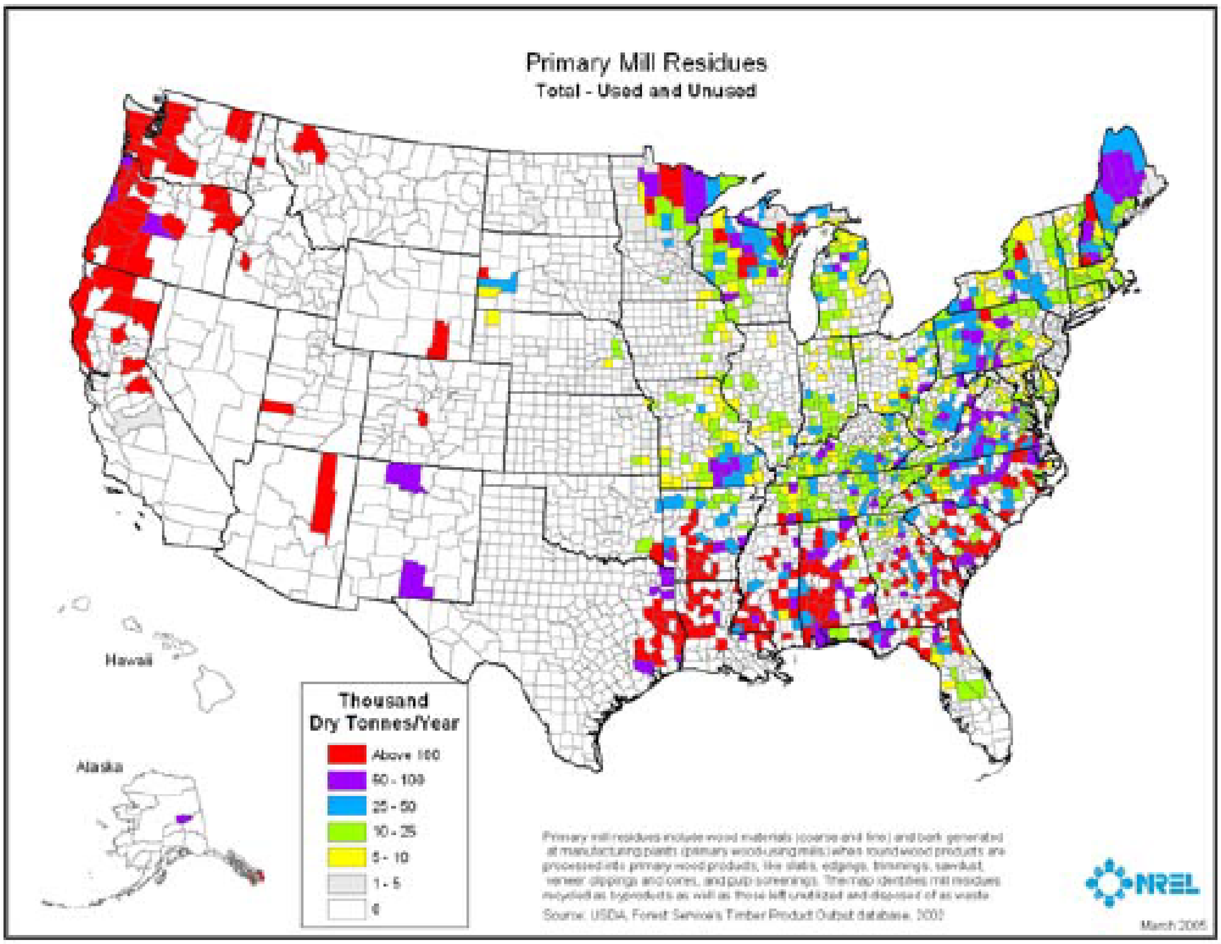
Sawmill residue, while a possible biomass fuel, has other potential uses as well. Bark is often sold for landscaping uses, sawdust is sold for animal bedding, and sawmill chips are often sold to pulp mills.

Figure 14. Residue Production at Sawmill

Sawmill residue relies on the production of lumber at a mill. This makes sawmill residue availability closely tied to overall lumber production – in the United States this is often a function of housing starts. While sawmill residues have long been and will likely remain an important biomass fuel source, some facilities that rely primarily upon sawmill residue for fuel have faced fuel supply challenges in the current lumber market downturn.

The National Renewable Energy Laboratory (NREL), using information developed by the USDA Forest Service – Timber Products Output analysis, has developed information on the volumes of sawmill (primary mill) residue available in the United States on a county basis[xxi].

Figure 15. Sawmill Residue by County, Estimated[xxii]



Nationally, data from the National Renewable Energy Laboratory suggests that there are 139 million green tons of sawmill residue generated annually[xxiii]. This volume of wood can generate 82 million megawatt hours of electricity, roughly enough to meet the electricity needs of Missouri or South Carolina or Washington for one year[xxiv].

Similarly, assuming 80 gallons of cellulosic ethanol per dry ton of forest residue, this is enough wood to produce almost 5.6 billion gallons of ethanol, roughly equivalent to the combined energy value of all gasoline used in Alaska, California, Hawaii, Nevada, Oregon and Washington annually[xxv].

Forest Thinnings

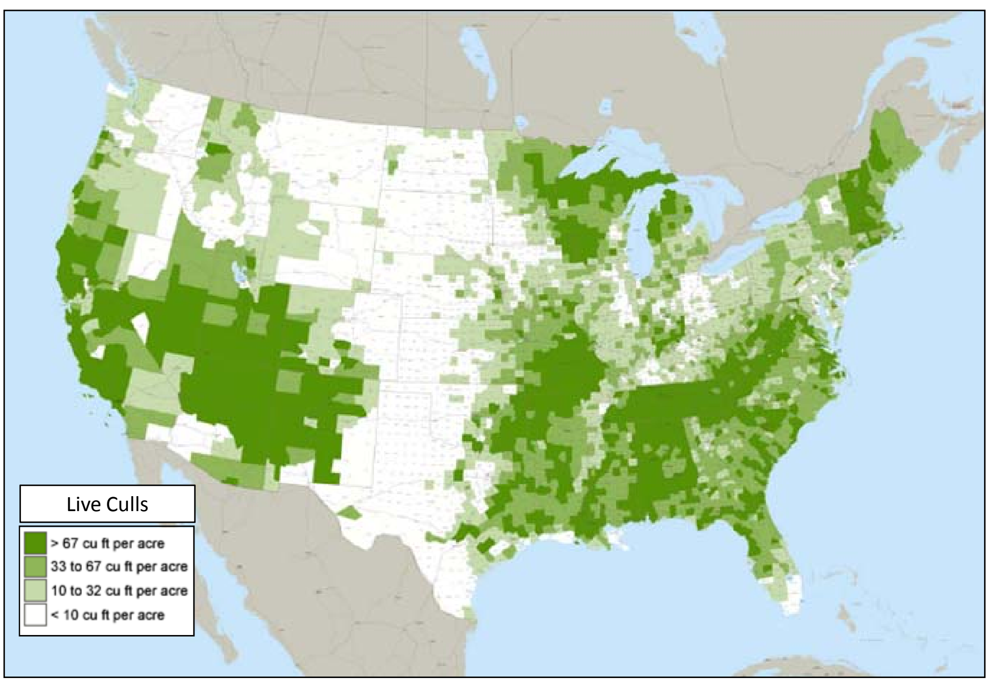
Typical Fuel Value and Moisture
Moisture Content: 40% to 50% as-harvested
Fuel Value: ~4,625 btu/lb, 9.25 mmbtu/ton

Forest thinning refers to the selective removal of trees as part of a forestry operation in order to improve the health of the remaining stand[xxvi]. Thinning may be conducted to increase growth and thus improve the marketability of the remaining stand, for ecological reasons, or in many parts of the country to decrease fuel loading and mitigate the threat posed by wildfire.

Stems removed during a forest thinning may include live cull, standing dead trees, and low-grade trees that do not meet the specifications for higher value local markets. Biomass energy may provide an important outlet for this material, and provide landowners and land managers an additional tool for managing forests, improving forest health and productivity.

Data on the availability of wood potentially available from forest thinning is more difficult to accurately assess at the national level than forest residues or sawmill residues, as availability depends upon local market conditions. Historically, thinning and removing cull trees has not been commercially viable in many areas of the country. The development of markets for biomass and improvements in equipment may make some operations economically feasible, or at least reduce their cost. The figure below shows the per-acre density of live cull trees, by quartile.

Figure 16. Live Cull Density by County, Estimated [xxvii]



Increasing Productivity of Forest Stands

More intensive silviculture can increase the growth rate of forest stands and their productivity for forest products, including but not limited to, biomass. Investments in increasing natural forest productivity through planting, controlling competition, and developing trees which are genetically superior are common in certain areas of the country (e.g., the Southeast and Pacific Northwest), but are not commonly practiced everywhere. These practices make the most sense on sites which are the most productive. Various researchers have evaluated the potential for increased productivity, and concluded that productivity could be doubled or better on good sites.[xxviii] The total amount of additional biomass that could be produced nationwide is unknown, but undoubtedly substantial.

Conversion of Biomass to Energy Products

Once collected, biomass can be used to create thermal, electric and liquid energy products. The following section discusses technologies currently in use or under development that utilize biomass to generate energy products. The following descriptions contain generalized statements that may not apply to all installations and applications. Information includes:

- *Products* – a description of the energy types produced;
- *Size Range* – the typical size range for this type of installation;
- *Efficiency* – the percent of BTU input to captured BTUs. For liquid fuels, it is important to note that the product is really an intermediate product – the final efficiency of BTU input to useful energy will depend upon the efficiency of the final consumer (e.g., a vehicle);
- *State of Technology* – a description of the current commercial status of the technology group;
- *Market Drivers* – the external factors that have the greatest impact on the commercial success of this technology; and
- *Biomass Types* – the type of woody biomass typically used as a fuel or feedstock.

Description	Large-Scale Stand-Alone Biomass Electric Facilities - Combustion
Product(s)	Electricity
Size Range	5 MW to 80 MW (Facilities smaller than 10 MW tend to be uneconomic, and facilities have to draw wood from larger supply radiuses as they get bigger. Proposals exist to build biomass plants in excess of 80 MW in the U.S., but to date 80 MW is the largest stand-alone biomass facility in the country.)
Efficiency	Biomass electric plants currently operating are roughly 30% efficient, varying slightly with size, technology and configuration. This is comparable to the efficiency of steam turbine generation plants using other fuels, such as coal.
State of Technology	Stand-alone biomass electric units have a history of over two decades in the U.S., with the largest number of installations in the Northeast and California. In addition to the existing plants, there are dozens of facilities that are in some state of development around the country. Biomass is one of the few renewable electricity technologies well suited to "base load" applications, providing electricity to the grid on a continuous bases. Existing biomass power plants use roughly 1.5 to 1.8 green tons of wood for each megawatt hour (MWH) of electricity generated. For a biomass electric facility operating at a 95% capacity factor, this means that annual wood use will be roughly: • ~133,000 green tons for a 10 MW facility • ~333,000 green tons for a 25 MW facility • ~650,000 green tons for a 50 MW facility Facilities currently in the design phase claim higher efficiency, but these technologies are not yet demonstrated at full commercial scale. Biomass electric plants constructed to date utilize either a stoker grate or a fluidized bed boiler to efficiently and uniformly combust wood chips, using this heat to generate steam and spin an electric turbine. These are well proven technologies, sharing significant technology advancements with other thermal electric generators, notably coal.

Market Drivers	In addition to the cost of electricity, biomass electric currently enjoys a number of incentives at the state level. Many states have adopted a Renewable Portfolio Standard (RPS), which requires that suppliers of electricity purchase a certain percentage of electricity from renewable sources. While the exact rules and implementation vary by state, all states allow either existing or new biomass facilities to participate in these programs. Incentives are structured by state and by technology, but in some instances can provide more than $50 per MWH of qualifying biomass generation, in addition to payment for the electricity. At the federal level, a Production Tax Credit provides plants with a tax credit for each MWH of electric generation they sell. This tax credit, at roughly $10 per MWH (half of the credit provided to wind and solar), can be used for five years for existing facilities and ten years for new facilities. The tax credit is currently set to expire at the end of 2008, though facilities operating by that time can receive the credit for its full applicable period. Congress has a history of last-minute extensions to the Production Tax Credit, and many observers believe that it will be extended beyond 2008.
Biomass Types	Biomass electric plants can and do take a variety of biomass types, including forest residues, urban wood and sawmill residue. Because a combustion technology is used, there is little concern regarding species mix or homogeneity of the feedstock. Agricultural residues can potentially be collected and used, but given the technologies in use and the location of most existing facilities in heavily forested areas, agricultural residues have not been a meaningful part of the fuel supply for any of these plants.

Description	Combined Heat and Power Facilities - Combustion
Product(s)	Electricity and thermal energy (process heat)
Size Range	500 kW to 60 MW, with useful heat as an additional product
Efficiency	40% to 80%, depending upon technology choices and the amount of heat captured and used. Increased efficiency over electricity-only applications comes from the capture and use of heat that would otherwise be unutilized. Thermal loads that are consistent and year-round provide the best economics for these applications.
State of Technology	Biomass combined heat and power applications have a long history in the U.S. forest industry, where a large number of pulp mills or sawmills have traditionally used their residues to generate both electricity and process heat. For larger applications (e.g., a pulp mill), the technology used is very similar to what is described for stand-alone biomass electric facilities. Biomass CHP is now moving beyond the forest industry, and industries with high heat and electricity demand are looking at biomass as one legitimate alternative. Greenhouses, breweries, ethanol production facilities and other large industrial users of steam and electricity are all potential applications of biomass combined heat and power.
Market Drivers	CHP enjoys efficiencies due to the capture of both electricity and heat. Depending upon the quality and volume of heat needed, the thermal load may diminish the amount of electricity that can be produced. At present, the thermal component of a combined heat and power project is not eligible for any non-market operational support. The electric generation can participate in regional Renewable Portfolio Standards and gain Production Tax Credits, as described in the biomass electric section above.
Biomass Types	Biomass CHP plants can and do take a variety of biomass types, including forest residues, urban wood and sawmill residue. Because a combustion technology is used, there is little concern regarding species mix or homogeneity of the feedstock. Some smaller facilities only take screened biomass chips or other highly processed fuels. This is not due to combustion limitations, but smaller facilities are unable to justify the expense of robust fuel handling systems, and as such are likely to limit their fuel types.

Description	Institutional Scale Thermal Energy
Product(s)	Thermal energy
Size Range	25 to 1,500 horsepower (1 to 50 thousand pounds of steam per hour) • Can be built smaller or larger, but the majority of projects fit within this size range
Efficiency	60% to 90% depending upon technology choices and thermal load characteristics.
State of Technology	Biomass thermal applications are well proven, and a number of facilities around the country have installed biomass thermal technologies. Early adopters have been schools and other public institutions, as well as the forest products industry. The "Fuels for Schools and Beyond" program focuses on thermal applications. For example, the state of Vermont has public policy that provides capital incentives for schools and other institutions to install thermal energy projects, and this program has been successful in achieving significant market penetration. Today there are roughly 50 institutional scale thermal applications in Vermont (includes installations at industrial sites), and most facilities use between 500 and 1,000 green tons of wood annually. To date, biomass technology at the institutional scale has focused on combustion boilers and small gasifiers, using wood chips as the feedstock. These technologies are proven and work well, but put limitations on the type of facilities that can or will use biomass thermal. For example, the need for space to back up a truck full of wood chips, and the need to facilitate large storage volumes, discourages some potential users with high thermal loads from evaluating biomass. Technologies are now coming to market that facilitate the use of wood pellets for institutional scale thermal applications. These technologies hold significant promise to allow the installation of thermal biomass at locations previously considered challenging. This is because pellets provide an opportunity to bring biomass in using smaller vehicles (similar in size to a traditional oil delivery truck used for home delivery), and storage of this dry fuel can be accomplished in silos or other formats that limit the footprint. Biomass thermal also includes district heating, where heat is provided to a number of customers in a compact area from a centralized plant. Successful biomass district heating projects are located in St. Paul, MN, Concord, NH and Montpelier, VT, with a number of other small cities around the nation evaluating the opportunity. District heating allows construction of one centralized facility, instead of facilities at the site of every user. The economy of scale and coordinated purchasing that district heating presents makes it an option worth evaluation for many densely populated areas.
Market Drivers	The cost of heating spaces has become a major challenge for many

	institutions, and colleges, schools, industries, office buildings and others are likely candidates for thermal biomass. Due to the high efficiency of thermal projects, many can be justified purely on economics, and move forward without extra-market support. Some campuses are already pursuing biomass-based district heating, such as the University of Idaho and the University of Montana – Western Campus. There are some localized and site specific funds for capital (the Vermont example above, for instance). There are currently no major operational public policy incentives for thermal energy from biomass.
Issues with Technology	Institutional scale biomass thermal using green chips and hog fuel faces a number of challenges. One emerging challenge is concerns regarding particulate matter emissions from institution scale biomass thermal projects, particularly those sited at schools. In recent years, air regulators have raised concerns that not enough is known about the emissions profile of the technology as operated, and note that this is a particular concern around young children. Air regulators and others are now in the process of evaluating the "as used" emissions from these systems, which should add clarity to this concern and help identify a path toward resolution. For example, some new biomass thermal applications have added post combustion emissions controls, which may minimize concerns in this area. Physical space has also been a concern for institutional-scale biomass thermal applications. To date, the need to have space to back up a live floor truck and store one to two trailer loads of wood has limited locations where biomass thermal is attractive. Many existing facilities have limited space available, and the footprint of a fuel bunker or other storage can be impractical to accommodate. Perceived fuel availability and fuel price risk also present challenges for small thermal biomass facilities. These sites, which are not large enough to justify dedicated supply infrastructure, have to date relied upon suppliers that have a core business outside of biomass supply. While the route to buy oil, natural gas or other thermal fuels is fairly clear and straightforward, supply of biomass often involves significant work on the part of the buyer. Similarly, concerns about long-term supply and pricing can discourage investment in biomass thermal. Some of these concerns have been recognized by the industry, and new products (such as wood pellets) are coming to market that address some of these concerns. Similarly, a new business model is developing, where third party ownership of the biomass thermal unit is coupled with management of fuel supply. This allows a customer to simply buy heat, and have a company in the business of purchasing / delivering fuel, and evaluating / owning technology to concentrate on wood supply and technology.

Biomass Types	Most biomass thermal units can handle a wide variety of fuels. However the fuel handling systems on institutional scale systems tend to favor smaller, uniform, processed chips that run smoothly and present minimal risk of jamming equipment. Due to this limitation, many types of biomass considered residue (e.g., forest residues and urban wood residues) are challenging fuels for these projects, due to fuel handling and operational challenges that residues can present. Biomass thermal equipment manufacturers are working to address these challenges. Sawmill residues are often an ideal fuel source for thermal projects. Pellet manufacturing facilities have traditionally received their feedstock from sawmill residues, particularly sawdust and clean chips. As this feedstock becomes harder to acquire, given changes in the sawmill industry and competing uses, facilities are now purchasing roundwood for pellet production. To date, wood pellet manufacturers do not generally seek to use forest residues or mixed urban wood residues for pellet production, due to concerns about ash content, equipment wear and consistency of quality.

Description	Biomass Gasification
Product(s)	Gasification creates syngas, which is essentially hydrogen (H_2) and carbon monoxide (CO), with a variety of impurities. Syngas can be combusted directly in a boiler or used in a gas turbine to generate electricity. The hydrogen from syngas can be isolated and used to power fuel cells. In terms of value added fuels and chemicals, syngas has the potential to produce a wide range of commercial fuels and chemicals, including: ▪ Synthetic diesel, ▪ Acetic acid (used in the chemical processing industry and as a food additive), ▪ Methanol (CH_3OH), or "wood alcohol", used to produce formaldehyde, other chemicals, as a fuel additive, or in other applications, ▪ Mixed alcohols (ethanol, propanol, butanol, etc.) to be further isolated and processed into discrete fuel and chemical alcohols, and ▪ Dimethyl Ether (CH_3-O-CH_3), propane substitute.
Size Range	Varies widely, depending upon technology and application
Efficiency	As high as 75%, depending upon technology and application. Some applications are intermediate technologies, meaning that the efficiency depends upon the final use (e.g., automobile mileage for ethanol).
State of Technology	When biomass is rapidly heated in a reduced oxygen environment, the plant matter does not combust but rather becomes a synthetic gas (syngas), a combination of hydrogen (H_2) and carbon monoxide (CO). Because gaseous fuels such as syngas mix more easily with oxygen than either liquid or solid fuels, combustion of syngas is more efficient and cleaner than direct combustion of the fuel from which it was made. Because of this, most gasification projects to date have concentrated on supplying thermal heat, and in some cases electricity generation. However, significant promise exists for the use of gasification as an intermediate process in the production of fuels and chemicals from biomass feedstocks. Just as syngas mixes easily with oxygen for combustion purposes, it also interacts efficiently with chemical catalysts. This provides the opportunity to use syngas to create, through catalytic conversion, a range of value-added fuels and chemicals. To date, production of liquid fuels and chemicals at the commercial scale has not been proven for biomass gasification, but many experts believe this area holds great promise. One of the significant challenges is the clean-up of syngas, removing impurities that can foul a catalyst. Range Fuels has been awarded funding from both the U.S. Department of Energy and the State of Georgia to build a commercial scale facility utilizing gasification to produce liquid fuels from biomass feedstocks. This facility, in

	Soperton, Georgia, has broken ground on a facility expected to make 20 million gallons of ethanol from forest residues.
Issues with Technology	One of the significant challenges to date for biomass gasification has been the cleanup of syngas. The syngas produced from biomass can have tars and other impurities which can foul equipment and create emissions challenges.
Market Drivers	Gasification hold promise as a technology that can handle a wide variety of feedstocks and convert biomass into a number of forms of useful energy more efficiently than other common technologies. A large number of firms are pursuing projects along this path, and technical advancements are being achieved for thermal, electric and liquid fuel applications.
Biomass Types	Gasification is an incredibly flexible conversion technology, and can accommodate a wide range of feedstocks. In addition to a full range of wood (chips, sawdust, bark, etc.), gasification feedstocks can include paper mill waste, agricultural residues, animal waste, and other carbon-based feedstocks. Some gasification technologies can use coal or crude oil as well. Many gasification technologies require feedstock that is highly processed (particles the size of sawdust) and with low moisture content. These rigid specifications can require additional processing of feedstocks prior to conversion to energy products.

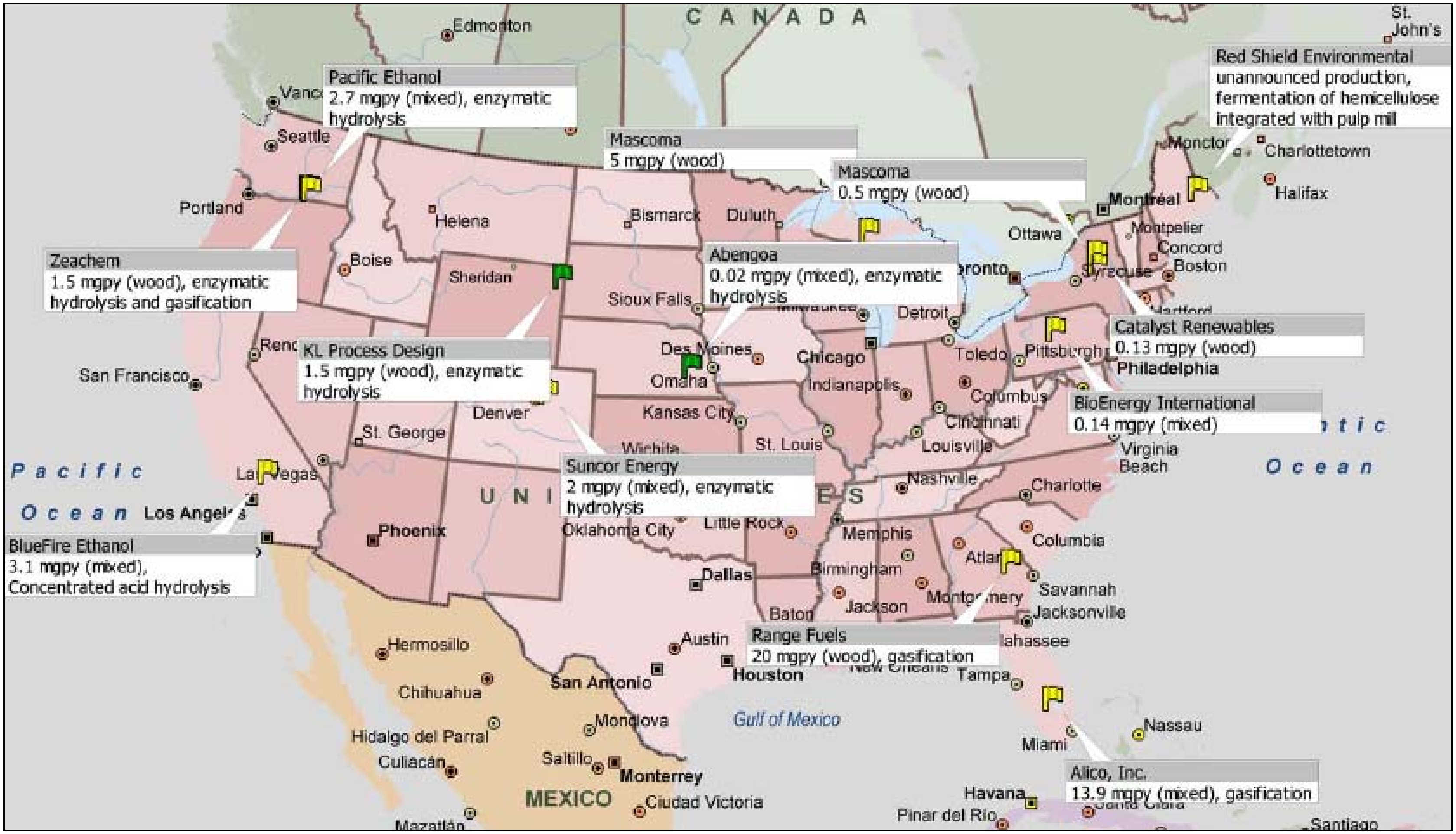
Description	Pyrolysis
Product(s)	Fast pyrolysis provides a mechanism to convert solid biomass, such as wood, into a liquid fuel that can be stored and transported. Pyrolysis oil, with roughly half the heating value of oil on a volume basis, can be used in thermal energy applications with modest changes to existing equipment designed for oil. Pyrolysis oil can be used in direct combustion applications, and has been successfully tested or demonstrated in engines, turbines and boilers for the production of heat or electricity. However, many observers believe that the potential for pyrolysis oil lies not in combustion applications but in upgrading to transportation fuels and chemicals. Much of this is already occurring, in both the lab and at the commercial scale. One company, partnering with the National Renewable Energy Laboratory, has developed a process to convert pyrolysis oil to transportation grade fuels, to be used in place of or as additives to gasoline and diesel. Another firm has developed a substitute for phenolic resin, used as an adhesive in engineered wood products (Oriented Strand Board, for example). A food flavoring, liquid smoke, is extracted from pyrolysis oil at a facility in Wisconsin. Pyrolysis oil can also be used in some gasification and fractionation processes, essentially serving as a way to turn bulky, high moisture biomass into a product that can be handled and transported for further processing at a centralized site, presumably improving the economy of scale. Bio-oil has been identified as a potential feedstock for "green gasoline", a biomass-derived product chemically identical to petroleum-based gasoline.
Size Range	From 15 tons per day to 250 dry tons per day of input
Efficiency	Claims as high as 75% (intermediate product). Pyrolysis oil is an intermediate product, and its ultimate efficiency is impacted by the efficiency of the application using the fuel.
State of Technology	Pyrolysis (fast pyrolysis or flash pyrolysis) is a thermal process that rapidly heats biomass in an oxygen-free environment[xxix] to a controlled temperature (generally around 500°C), then quickly cools the volatile products formed during the reaction. This process creates three distinct products – pyrolysis oil, char, and gasses. Pyrolysis oil (also referred to as bio-oil), the primary product of pyrolysis, can be used as a fuel, and some researchers believe it holds great promise as a "platform intermediate" for the production of high-value chemicals and materials. Fast pyrolysis is a technology with a significant history, primarily in Europe and Canada. Several reactors have shown yields of liquid product as high as 75% (based on starting weight of the biomass), and companies are pursuing new applications for the product. Pyrolysis companies have developed operating facilities, with one in the U.S.

	and several in Canada. Ensyn has constructed six pyrolysis reactors, including an 80-ton per day facility in Renfrew, Ontario, and is reportedly pursuing a number of new opportunities in North America. Dynamotive has operating commercial facilities in Guelph and West Lorne, Ontario. Renewable Oil International has taken a different approach; instead of seeking to build large pyrolysis oil facilities, this firm has developed units that can be constructed remotely, transported in container-size pieces, and quickly installed on-site. Renewable Oil International is currently constructing a 15-ton per day demonstration facility in Massachusetts.
Issues with Technology	While bio-oil has established conversion sites and processes, this technology has not yet gained widespread adoption. Issues that need to be addressed for this technology to gain increased market acceptance include: ▪ The handling of pyrolysis oil once produced, including ways to address concerns regarding separation; ▪ The consistency of the properties of bio-oil over a range of feedstocks; ▪ Refinement and continued development of extraction processes to allow highest value-added use of the product
Market Drivers	Pyrolysis has enjoyed limited commercial success in the U.S. While a proven technology conversion platform, the intermediate product created – pyrolysis oil – does not have ease of entry to existing markets. For most applications – including existing thermal and electric generation – modifications are needed to existing infrastructure to accommodate pyrolysis oil.

Description	Fermentation
Product(s)	Ethanol is the primary product of fermentation, though the process can be tailored to produce various quantities of other alcohols. Ethanol is attractive because it has an existing and known market, transparent pricing, and increasing demand (much of which results from government price support mechanisms).
Size Range	Once commercial, expected to be 20 million gallons per year of production or greater at each individual facility.
Efficiency	Claimed conversion rates of 1 dry ton of biomass into 65 – 110 gallons of ethanol, depending upon technology, feedstock, and other variables. At 80 gallons of ethanol per dry ton of wood feedstock, this is a conversion efficiency of roughly 33%. Ethanol is an intermediate product, and its ultimate efficiency is impacted by the efficiency of the vehicle or other application using the fuel.
State of Technology	Fermentation is a long-understood biological process in which enzymes produced by microorganisms catalyze chemical reactions that convert simple plant sugars into alcohol. . Fuel-grade ethanol, a gasoline additive and substitute often made from corn and grains, is made through this fermentation process. The technology by which plant feedstocks, including wood, can be converted into ethanol ("cellulosic" ethanol) holds great promise. Ethanol can be produced through fermentation from any plant-based substance, and was produced using wood as a feedstock during both World War I and World War II. However, the process is not as straightforward as converting high-sugar crops such as corn or sugar cane into ethanol, and cellulosic ethanol production through fermentation has not yet proven to be economical at the commercial scale. Spurred by the rising cost of gasoline, historically high prices for ethanol on the spot market, increasing concerns about diversion of food crops to fuel use, and public policy incentives, a number of firms are seeking to develop fermentation-based cellulosic ethanol facilities. Some firms currently have demonstration or pilot facilities and are seeking to move this technology to the commercial scale. Most fermentation for ethanol production practiced today converts six-carbon sugars, such as glucose. While wood is high in these sugars (39% - 50% for hardwoods, 41% to 57% for softwoods), it also has high concentrations of five-carbon sugars, such as xylose (18% - 28% for hardwoods, 8% to 12% for softwoods). Recent advances have improved yields from five-carbon sugars, but these require additional enzymes, and add complexity to feedstock processing.

	In the Northeast, New York state has funded two demonstration projects, one by Mascoma Corporation using a technique developed at Dartmouth College and another by Catalyst Renewables using a technology developed at the State University of New York College of Environmental Science and Forestry at Syracuse. These projects will use wood, and potentially other biomass, to produce ethanol. The goal of these projects is process improvement to move toward full commercial scale facilities. Potential also exists for the extraction of hemicellulose, a component of wood, for ethanol production, leaving behind the cellulose and lignin for the creation of traditional forest products – for example, pulp and oriented strand board. This extraction process, aqueous extraction, is the subject of research at the State University of New York and the University of Maine, and may provide commercial opportunities for integration into existing forest industries. A cellulosic ethanol project at Red Shield Environmental's pulp mill in Old Town, Maine using the University of Maine's new technology was recently awarded $30 million by the U.S. Department of Energy.
Issues with Technology	A US DOE estimate of capital costs for a commercial scale cellulosic ethanol facility, constructed on a stand-alone basis to utilize woody biomass or agricultural residues is $250 - $300 million. Due to the relative complexity of cellulosic fermentation, the capital costs for this process are higher than for a comparably sized corn-to-ethanol facility. A number of technology experts indicated that, for stand-alone facilities at least, this will always be the case. However, this also means that existing infrastructure, such as that which can be found at operating or idle pulp mills and biomass energy facilities, may be valuable assets for firms looking to construct cellulosic ethanol operations. To date, the high cost of capital has reportedly served as a deterrent to commercialization of this technology. Significant advances have recently been made in enzymes tailored to breaking down cellulosic material. The National Renewable Energy Laboratory, in partnership with enzyme companies, was recently recognized for significant reductions in the cost of enzymes designed for cellulosic ethanol production. However, even with these advances, cellulosic ethanol enzymes have not been proven in a process-relevant way, including how the microorganisms that create the enzymes survive over time in a commercial environment. Wood is highly recalcitrant, or difficult to break down, when compared to other potential cellulosic feedstocks such as agricultural residues. For that reason cellulosic ethanol may be produced through fermentation from feedstocks other than wood initially, or "pre-treated" woody feedstocks such as pulp and paper mill residue or aqueous extractions may gain favor.

Figure 17. Location of Operating and Proposed Cellulosic Ethanol Facilities Using Wood Feedstocks[xxx].



Strategy for Increasing the Use of Woody Biomass

The following recommendations are suggested for action by the NASF, and/or in some cases, individual State Foresters. They are intended to promote the increased use of woody biomass and promote sustainably managed forests.

1. **Assure sustainability of the forest resource –** Work to make certain that biomass fuels derived from forestland are harvested as part of sustainable forest management efforts, and assure State Forester participation in development of any state, regional or national standards for "sustainable biomass".

2. **Support the existing forest industry –** Biomass markets are relatively low-value, and take a wide range of products. In order for loggers, mills and landowners to produce and deliver biomass fuel (or feedstock) at a reasonable cost, other parts of the forest products industry must be functioning. The ability to market wood for lumber, veneer, engineered wood products and pulp can provide the economic support to conduct a timber harvest. The markets provided by biomass energy provide opportunities to sell a greater variety of products, or offer additional market choices for lower value products. However, in many regions of the country biomass markets alone are sufficient to support a timber harvesting operation. As such, the State Foresters, acting individually and collectively, should continue their leadership role in supporting a diverse forest products industry, recognizing that this is a cornerstone of a robust biomass energy market. This includes implementing the report of the NASF Markets Committee on maintaining and diversifying markets that allow sustainable forestry[xxxi].

3. **Develop a national community energy program –** Biomass has the potential to meet the energy needs of a number of state and community institutions, such as government buildings, schools, hospitals, prisons and campuses. Building on the successful "Fuels for Schools" program, the National Association of State Foresters should support a national effort to develop community-scale biomass applications. In addition to the obvious energy and environmental benefits, such a program would have the effect of re-introducing forest product utilization to many citizens, and could support broader forestry efforts. The action steps recommended to develop a community action program are detailed subsequently. States should consider development of similar programs.

4. **Provide support for federal operating incentives to encourage biomass energy** – At the federal level, the Production Tax Credit (Section 45 Tax Credit) serves as the primary incentive for biomass electricity production; incentives exist for wood-based ethanol, but given the state of the technology are largely unused. No operating incentives exist at the federal level to support thermal biomass applications, though capital support is authorized through the 2008 Farm Bill. State Foresters should clearly communicate to policy makers at the federal level:
    a. Support for biomass electric provided by the Production Tax Credit (PTC) should be continued, and open-loop biomass (biomass generated through sources other than dedicated energy crops) should be continued.

i. The PTC for open-loop biomass, currently set at half of the amount provided for wind and solar, should be on par with other renewable generation sources;
ii. The PTC should be extended for co-firing with fossil fuels, utilizing existing infrastructure and providing incentives for the direct displacement of oil, coal and other fuels with biomass;
iii. The PTC should be authorized for an extended period of time, and not be allowed to expire or come close to expiring. The current system of reauthorization for one or two years at a time does not provide project developers with adequate time to identify, permit and construct a biomass project.

b. Existing capital and operating incentives for cellulosic ethanol should continue, providing incentives for this promising family of biomass conversion technologies;
   i. The existing definition of "renewable biomass" contained in the federal Renewable Fuels Standard excludes biomass from federal lands and some plantations. NASF should support efforts to develop a more inclusive definition of "renewable biomass".
c. Biomass thermal projects currently enjoy no operating support at the federal level. These are the projects that can most often provide for community needs or support manufacturing activities. Given the scale and difficulty in verifying output, capital funding and technical support, as proposed for a *National Community-Scale Biomass Program*, may be the most appropriate way to support these projects at the federal level.
d. The 2008 Farm Bill contains multiple opportunities for federal support of forest-derived biomass. State Foresters should work to fully capture the potential benefits of this legislation:
   i. Assure that federal procurement rules for biobased products fully recognize the value of wood products;
   ii. Work to secure funding for the Energy Title of the bill;

5. **Incorporate biomass energy as a carbon-preferred energy use as federal carbon limits are considered.** At the federal level, there is growing support for limits on carbon emissions; either through a "cap and trade" system, a carbon tax, or both. While the approach to carbon limits will vary significantly by state and by region, State Foresters share a recognition that:
   a. Biomass presents opportunities to reduce carbon emissions while supporting forestry activities;
   b. Biomass can meet thermal, electric, and transportation fuel energy needs;
   c. Biomass should be fully recognized and rewarded as a carbon-preferred fuel source in any federal program that seeks to limit, tax, or otherwise manage carbon emissions.

   In addition to advocating for these principals at the national level, State Foresters should also seek opportunities to influence carbon limit policies at the state and regional level.

6. **State foresters should serve as biomass energy leaders at the state and regional level.** In addition to support for biomass at the federal level, State Foresters are well positioned to serve in a leadership role in the development of energy policies that support biomass at the state and regional level:

a. Renewable Portfolio Standards that place sustainable biomass energy production on par with other renewable energy generation sources;
b. Capital and operational support for biomass thermal systems that serve community, institutional and manufacturing needs;
c. Identification of locations of a state or region where sufficient biomass supply and processing infrastructure exists to support new wood energy ventures;
d. Identification of existing members of the forest products industry – landowners, loggers, mills and others – that can serve as part of a biomass energy supply chain;
e. In states with significant amounts of state-owned forestland, and subject to other land management objectives, encourage and contribute volumes of biomass material to the marketplace;
f. Support efforts to provide operational support for biomass thermal applications, including appropriate inclusion in state Renewable Portfolio Standards.
g. Advocating for increased investment in electrical transmission lines in regions here biomass electric generation can provide significant generation.

7. **Support development of reliable information on current and future biomass supplies.** Reliable data is critical to assuring project developers that investment in biomass projects is warranted and sustainable.
    a. Support increased funding for the USFS's Forest Inventory and Analysis (FIA) program. The FIA program is not yet fully implemented across the US. Additional funding is needed to complete implementation across the landscape and to strengthen analytical components of this critical program.
    b. Allow integration across all land ownership types, and scale appropriately to allow for appropriate intrastate sub-regional modeling and analysis;
    c. Support improvements in modeling capability to reliably predict future supply.

8. **Promote opportunities for long-term biomass supply from well managed sources**. Biomass energy projects are often capital intensive, and require developers to have assurances that supply will remain available for the life of a facility. State Foresters, acting individually or collectively, can:
    a. Support, where appropriate, agreements for long-term fuel supply from public lands, particularly where forest thinning may improve forest health, reduce fire risk, or serve other stewardship goals;
    b. Support public policy that supports active management by private land owners and timber harvesting;
    c. Assure that federal land management programs are adequately funded to deliver biomass material in reliable and consequential volumes;
    d. Identify and work to address local, state and national policy, legal and market barriers related to woody biomass utilization; and
    e. Facilitate direct dialogue between biomass project developers and community or tribal owned forests, large landowners, landowner cooperatives, land owned by conservation organizations, or other groups positioned to enter into long-term supply arrangements to help source a biomass energy facility.

9. **Address emissions from biomass boilers.** It is critically important to protect public health at the same time wood to energy projects are pursued. EPA does not have data nor the authority to establish industry standards for smaller boilers (under 10 million BTU). NASF needs to work with EPA and other parties to establish industry standards, best management practices and approved technology which is available, affordable and effective at protecting public health. There are barriers to new, highly efficient and low-emission European technology being adopted in the US and NASF needs to work to remove those barriers. Using appropriate technologies, it should be possible to increase the use of wood for fuel and protect air quality.

10. **Support continued and increased funding to improve technologies to use woody biomass more efficiently, as well as funding for technologies that better harvest, process and transport biomass feedstocks.** Funding for the research, development and deployment of such technologies should encourage demonstration, pilot and early-stage commercial applications. Funding should also be devoted to technology transfer, encouraging shared information on ways that commercial-scale applications can be most successful. Harvesting equipment which can be operated efficiently in small diameter and low-value stands is also needed.

11. **NASF and its members must be cognizant of the impacts, both positive and negative, that biomass energy markets can have on existing forest industries.** To the extent possible, NASF and its members should advocate for programs and policies that build biomass energy opportunities that are compatible with and complimentary to existing wood industries.

12. **When this report and its recommendations are adopted by the National Association of State Foresters, a more specific action plan to implement these recommendations will be developed.** This action plan will identify who is responsible, what resources are necessary, and when implementation is to occur.

Action Steps for a National Community-Scale Biomass Program

Goal: Develop a national program to support community-scale biomass energy projects, modeled after the successful "Fuels for Schools" program.

Issue: Biomass energy presents opportunities for communities around the country to use a native, renewable resource to help meet the thermal energy needs (e.g., space heat) of community institutions. Possible suitable locations for biomass energy installations include:

- Schools
- Universities
- Town and city offices
- State office buildings
- Hospitals
- Community centers
- Industrial parks
- Prisons
- Other buildings that serve the shared needs of a community

Biomass energy, in appropriate locations, has the potential to help communities meet a number of social, environmental and economic goals, including:

- Economic savings when compared to fossil fuel use;
- Support for the economy through local procurement of an indigenous and renewable resource;
- Integration of forestry and the forest products industry into the community;
- Energy security through displacement of fossil fuels;
- Demonstration of the benefits of renewable energy projects;
- Reduction in greenhouse gas emissions; and
- Support for responsible forest management and the development of markets for low-grade wood.

Action Steps

1. The existing "Fuels for Schools" program serves as a model, which can be greatly expanded to allow more communities to evaluate and implement projects in response to the recent increase in energy prices.

2. The USDA Forest Service and the National Association of State Foresters (NASF) should identify six to eight "regions" of the country to serve as locations for the development of intellectual and technical infrastructure to support community-scale biomass projects.
   a. The identified regions should encompass the entire nation;
   b. Provide funding for one person in each of these regions of the country to serve as a coordinator for community-scale biomass energy projects. This person should be housed within a state forestry agency, but equally available to all states within the identified region. This person would be the initial point of contact for biomass

energy projects, and would serve to coordinate information resources, financing, technical assistance and event coordination. This individual would work with Utilization & Marketing foresters in each state in the region, and be responsible for developing relationships with state-based air regulators, biomass suppliers, technology vendors, project engineers, and others critical to a biomass energy project's success.

   c. Provide funding for resources in each state to assist biomass energy project promoters understand, evaluate and initiate projects.

3. Provide funding for a national "clearing house" of information, publications and expertise on community-scale biomass systems. BERC, the Biomass Energy Resource Center (a non-profit located in Montpelier, Vermont) has been identified as a possible location.

4. Fund the development of tools that can be used across the country to help communities evaluate biomass energy projects, including:

   a. A budget estimation tool
   b. A life-cycle cost analysis tool
   c. A template / checklist for facility managers evaluating biomass thermal projects
   d. Development of business models / funding strategies for biomass projects based upon type, location, etc.

5. Provide funding for feasibility analyses for biomass thermal energy programs. The federal government, working through the USDA Forest Service, should provide funding directly to communities to conduct these analyses. Such funding would be overseen by the regional coordinator (discussed above) to assure that tasks were not replicated, and that existing knowledge was shared broadly.

6. The federal government should provide loans to communities to capitalize new biomass energy facilities, with payments based upon estimated savings in the feasibility study (above). This will provide communities with a "no net cost" method to implement biomass energy projects.

7. The USDA Forest Service and the Environmental Protection Agency should jointly develop information on technology choices and emissions control that will protect air quality for community-scale energy projects, and the loans above will provide sufficient capital to purchase, install and operate the emissions control identified in this best practices document.

8. The federal government and state agencies will be encouraged to provide small long-term wood supply contracts in support of biomass thermal energy projects.

9. Provide funding for one-day events in every state that provide potential biomass users an introduction to the opportunity and the resources and contacts necessary to evaluate a project and take next steps.

Information Resources

The selected websites offer information on biomass feedstocks, technologies, and policies. This list is not meant to be comprehensive, but provides a sample of resources that can provide additional information, perspective, links and resources on biomass energy opportunities.

Bioenergy Technology Selection Matrix, a tool to allow users to match available feedstocks and desired energy products (e.g., electricity or ethanol) with a description of available biomass conversion technologies. http://www.nrbp.org/bioenergy/default.aspx

Biomass Energy Resource Center, non-profit organization working to develop community scale biomass, www.biomasscenter.org

Biomass Magazine, a for-profit magazine from BBI International Media that covers the biomass industry, including but not limited to woody biomass, www.biomassmagazine.com

BioWeb, a project of SunGrant, designed to help users identify what biomass is, where it is, and how much is available; the ways it can be converted to biofuels, biopower, and bioproducts; and biomass economics and policy. This site has a significant component of agricultural biomass application, but contains relevant information on woody biomass as well. www.bioweb.sungrant.org

California Biomass Collaborative, a state-based effort to identify the availability, applications, harvesting methods and other items of interest for a wide range of biomass feedstocks, including woody biomass, http://biomass.ucdavis.edu/index.html

Community Forest Resource Center, a project of a non-profit organization aimed at building markets to promote responsible land management and provide opportunities for private landowners, www.forestrycenter.org

Database of State Incentives for Renewable Energy. A comprehensive state-by-state listing of incentives for a wide variety of renewable energy applications, including biomass. www.dsireusa.org

Forest Bioenergy is a website that is designed for information sharing among natural resource management and extension professionals as well as community planning and development professionals. www.forestbioenergy.net

Forest Engineering Research Institute of Canada (FERIC), a non-profit that has done extensive work on systems for biomass harvesting, collection and processing, www.feric.ca

Fuels for Schools and Beyond, a regional website for six Western state community-scale biomass programs, www.fuelsforschools.info

Massachusetts Sustainable Forest Bioenergy Initiative, a state-based effort to evaluate the availability, silviculture, applications and harvesting methodologies for woody biomass. http://www.mass.gov/doer/programs/renew/bio-initiative.htm

Northeast Regional Biomass Program, a regional biomass promotion organization operated in collaboration with the Council of Northeast Governors (CONEG). www.nrbp.org

U.S. Environmental Protection Agency Combined Heat and Power Partnership, a voluntary program that seeks to reduce the environmental impact of power generation by promoting the use of combined heat and power applications. www.epa.gov/chp

U.S. Department of Energy Biomass Program, http://www1.eere.energy.gov/biomass

Western Regional Biomass Energy Program, a project of the Western Governors' Association to promote the use of woody biomass and biomass from agriculture as feedstocks to help meet regional energy needs. http://www.westgov.org/wga/initiatives/biomass

Wisconsin Biorefining Development Initiative, a project that evaluates processes, feedstocks and products to show the possibilities presented by biomass energy. www.wisbiorefine.org

Endnotes

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[i] National Renewable Energy Laboratory, "Biomass Energy Basics". http://www.nrel.gov/learning/re_biomass.html
[ii] U.S. Department of Energy – Energy Information Agency. "Energy in Brief: How Much Renewable Energy Do We Use?" http://tonto.eia.doe.gov/energy_in_brief/renewable_energy.cfm
[iii] www.pelletheat.com
[iv] International Energy Annual 2002 (US Department of Energy, Energy Information Agency), Tables 1.2 and 8.1.
[v] Innovative Natural Resource Solutions LLC and Draper Lennon, Inc. *Identifying and Implementing Alternatives to Sustain the Wood-Fired Electricity Generating Industry in New Hampshire.* Prepared for the NH Department of Resources & Economic Development. January 2002.
[vi] Public Service Company of New Hampshire, Northern Wood Power Project at Schiller Station. http://www.psnh.com/Energy/EnergyProject/NWPP/NWPPdefault.asp
[vii] "Sustainable management" as used here includes sustained yields of timber, where regrowth meets or exceeds harvest levels over the management rotation.
[viii] This is not strictly true, as some fossil fuels are needed to harvest, process and transport biomass. These amounts are modest when compared to the energy contained in biomass fuel.
[ix] The Arizona Renewable Portfolio Standard does contain a provision to support renewable thermal energy, including biomass thermal. The Arizona RPS allows the issue of one REC for each 3,415 BTUs of renewable thermal energy. Arizona Corporations Commission, Docket Number RE-OOOOOC-05-0030, Decision Number 69127.
[x] No federal Renewable Portfolio Standard exists at this time, though a number of congressional proposals exist to establish one.
[xi] A voluntary market for Renewable Energy Certificates exists as well. Values in the voluntary markets are generally significantly less than values in the robust regulatory markets.
[xii] From the Database of State Incentives for Renewable Energy, www.dsireusa.org
[xiii] "Closed loop biomass" is biomass grown specifically as an energy crop. No facility in the country has qualified for this tax credit since its inception in 1992.
[xiv] For example, a number of biomass energy conversion technologies require that chips be less than ¼" x 2½" x 2½" in order to have uniform and complete combustion.
[xv] It is important to note that this map treats all counties as an equal unit of measurement, distorting biomass availability on a "per acre" basis. As such, this map from NREL should be viewed only as a starting point for understanding geographic availability of forest residues.
[xvi] Milbrandt, A. "A Geographic Perspective on the Current Biomass Resource Availability in the United States." National Renewable Energy Laboratory Technical Report NREL/TP-560-39181. December 2005.
[xvii] Oak Ridge National Laboratory estimated this volume to be 67 million dry tons per year (~127 green tons) in its April 2005 report, "Biomass as Feedstock for a Bioenergy and Bioproduct Industry: The Technical Feasibility of a Billion Ton Annual Supply."
[xviii] U.S. Department of Energy, Energy Information Agency. *Sales to Bundled and Unbundled Consumers by Sector, Census Division, and State 2006.* http://tonto.eia.doe.gov/state/SEP_MorePrices.cfm
[xix] U.S. Department of Energy, Energy Information Agency. *Refiner Motor Gasoline Sales Volumes 2007.* http://tonto.eia.doe.gov/dnav/pet/pet_cons_refmg_a_EPM0_VTR_mgalpd_a.htm
[xx] Wakefield, Emily. "PyNe Workshop Report." *ThermalNet.* Issue 04. June 2007.
[xxi] It is important to note that this map treats all counties as an equal unit of measurement, distorting biomass availability on a "per acre" basis. As such, this map from NREL should be viewed only as a starting point for understanding geographic availability of sawmill residues.
[xxii] Milbrandt, A. "A Geographic Perspective on the Current Biomass Resource Availability in the United States." National Renewable Energy Laboratory Technical Report NREL/TP-560-39181. December 2005.
[xxiii] This figure combined both used and unused sawmill residue, and may significantly overstate total wood available for biomass production.
[xxiv] U.S. Department of Energy, Energy Information Agency. *Sales to Bundled and Unbundled Consumers by Sector, Census Division, and State 2006.* http://tonto.eia.doe.gov/state/SEP_MorePrices.cfm
[xxv] U.S. Department of Energy, Energy Information Agency. *Refiner Motor Gasoline Sales Volumes 2007.* http://tonto.eia.doe.gov/dnav/pet/pet_cons_refmg_a_EPM0_VTR_mgalpd_a.htm
[xxvi] Zhu, J.Y.; Scott, C.T.; Gleisner, R.; Mann, D.; Vahey, D.W.; Dykstra, D.P.; Quinn, G.H.; Edwards, L.L. 2007. Forest thinnings : for integrated lumber and paper production Forest products journal. Vol. 57, no. 11 (Nov. 2007): Pages [8]-13.
[xxvii] Developed by Innovative Natural Resource Solutions from data developed by the USDA Forest Service – Resource Planning Act. *Data in:* Pugh, Scott A. *RPA Data Wiz 1.0.* USDA Forest Service – North Central Research Station. 2004.

[xxviii] Greenwood, Michael; Seymour, Robert S; and Blumenstock, Marvin W. *Productivity of Maine's Forest Underestimated – More Intensive Approaches are Needed.* Maine Agric Exp Stat Misc Report No. 328.
[xxix] This differs from gasification, which uses a reduced oxygen environment.
[xxx] The volumes listed for each facility are the anticipated initial production; a number of facilities have plans to expand production once operational and commercial milestones are achieved.
[xxxi] Harper, Carla. *National Sustainable Forestry Markets Initiative. A Strategic Plan Submitted by the National Association of State Foresters Forest Markets Committee.* In draft. July 2008.

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