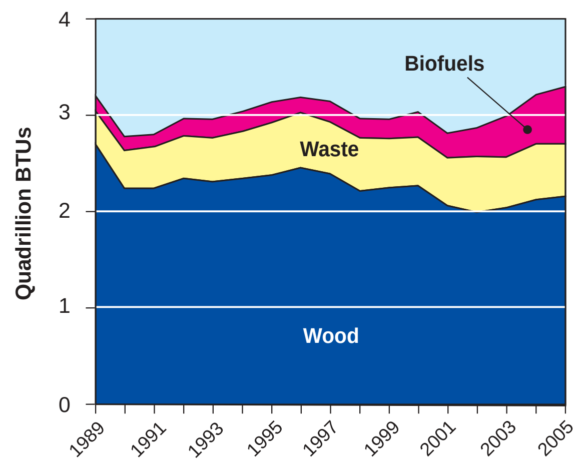
Detail on Biomass

Biomass-Based Energy in Massachusetts

Introduction

The purpose of this paper is to explore the issues surrounding the application of biomass-based energy in Massachusetts. Biomass-based energy will likely play an important role in our energy future both in the short- and long-term but it will not be the silver bullet, due in part to feedstock supply issues. The source of the biomass, the way in which the material is processed prior to its combustion, and the design of the energy facility all have important implications to consider. As part of a comprehensive mixture of renewable energy, biofuels could provide viable alternatives to energy derived from coal, oil, natural gas, and nuclear sources.

Figure 1: **U.S. Historical Consumption of Biomass by Type (1989 - 2005)**



Biomass Defined

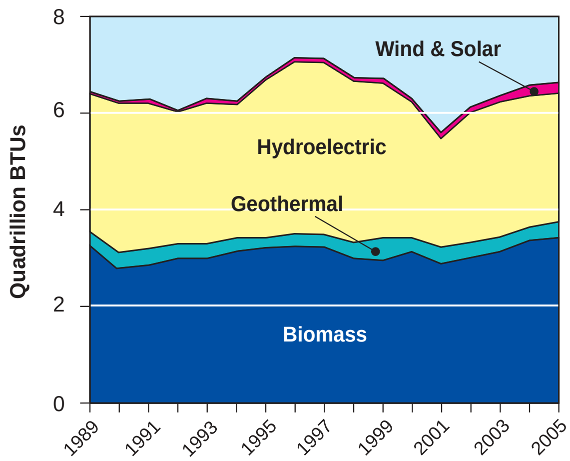
Biomass commonly refers to plant matter grown or harvested for use as fuel but it can also be used to describe animal and plant matter used for production of fibers, chemicals or heat. In other words, biomass is energy captured by photosynthesis. In the context of renewable energy, biomass can include wood, plant crops like soybeans and corn, liquid biofuels, and process wastes used in the production of electricity, power, and heat. Sources of biomass can be processed to create solid fuels like wood chips, liquid fuels like biodiesel and ethanol, and gases like methane from landfills. The term biofuels is also sometimes used to define a solid, gaseous, or liquid fuel produced from biomass. As a stored form of solar energy, biomass can be used to generate power and heat continuously, without the intermittency limitations of wind and solar energy systems.

National Trends in Biomass-Based Energy Consumption

According to the U.S. Energy Information Agency (EIA), biomass energy consumption increased to 3.3 quadrillion Btu in 2005, which is half of total renewable energy consumption and the largest domestic source of renewable energy. Biomass currently supplies over 3 percent of the U.S. total energy consumption — mostly through industrial heat and steam production by the pulp and paper industry and electrical generation with forest industry residues and municipal solid waste (MSW). Nearly 65 percent of biomass energy consumption was wood consumption and another 17 percent was energy generated from waste. Despite being a relatively small component of biomass, biofuels experienced the most rapid growth within that fuel category. Ethanol consumption in the transportation sector was four billion gallons in 2005, well on the way to allowing the ethanol industry to meet the Renewable Fuel Standard of 7.5 billion gallons in 2012. Biodiesel consumption in the transportation sector represented a much smaller volume of biofuels than ethanol, but it increased almost fourfold to 11 trillion Btu between 2004 and 2005, up from just 1 trillion Btu in 2001. Total biofuel consumption was 594 quadrillion Btu in 2005.

While some industries co-generate electricity and steam, most biomass energy consumption in the industrial sector was used for useful thermal output or process heat during 2005. The Paper and Allied Products industry consumed nearly two-thirds of all biomass for energy in 2005. Seventy percent of biomass energy consumed by the Paper and Allied Products industry was “black liquor”, a residue of the chemical wood-pulping process used in making paper.

Figure 2: **U.S. Historical Consumption of Renewable Energy by Energy Source (1989 - 2005)**



Overall, 109 electricity generating plants burned both biomass and coal in 2005. Plants for which biomass is only a small fraction of total energy consumption compared to coal are generally "co-fired" plants attempting to reduce emissions without making major retrofit investments. The remaining plants are dual- or multi-fired plants consuming fuels based on availability, demand and price. The average fuel mix for plants that use both coal and biomass was about 36 percent biomass and 55 percent coal in 2005, with the remainder being other fuels.

The National Capacity for Increased Biomass Energy Consumption

The U.S. Department of Energy (DOE) and the U.S. Department of Agriculture (USDA) put out a publication in 2005, Biomass as a Feedstock for a Bioenergy and Bioproducts Industry: The Technical Feasibility of a Billion-Ton Annual Supply. The two federal agencies are supporting biomass fuels and products as a way to reduce dependence on imported oil and gas; to support the growth of agriculture, forestry, and rural economies; and to foster major new domestic industries making a variety of fuels, chemicals, and other products.

The conclusion of the report was that there are adequate land resources in the United States capable of producing a sustainable supply of biomass sufficient to meet this goal. It would require approximately 1 billion dry tons of biomass feedstock per year. This could amount to a 30 percent replacement of the current U.S. petroleum consumption with biofuels by 2030.

The two largest potential biomass sources in the United States are forestland and agricultural land, which according to the study would be enough to produce over 1.3 billion dry tons per year which would meet more than one-third of the current demand for transportation fuels. The full resource potential could be available within fifty years when large-scale bioenergy and biorefinery industries are likely to exist. This annual potential is based on a more than seven-fold increase in production from the amount of biomass currently consumed for bioenergy and biobased products.

Specifically, this study estimated that forestlands in the contiguous United States can produce 368 million dry tons annually: 14 percent from fuelwood; 39 percent as residues from wood processing mills and pulp and paper mills; 13 percent from urban wood residues including construction and demolition debris; 17 percent from site clearing operations; and, 17 percent from fuel treatment operations to reduce fire hazards. For estimating the residual tonnage from logging and site clearing operations and fuel treatment thinnings, a number of important assumptions were made:

- All forestland areas not currently accessible by roads were excluded;
- All environmentally sensitive areas were excluded;
- Equipment recovery limitations were considered; and
- Recoverable biomass was separated into two utilization groups – conventional forest products and biomass for bioenergy and biobased products.

The study estimated that from agricultural lands, the United States could produce nearly 1 billion dry tons of biomass annually and still continue to meet food, feed, and export demands. This projection includes 43 percent from annual crop residues, 38 percent as perennial crops, 9 percent in grains used for biofuels, and 11 percent as animal manures, process residues, and other miscellaneous feedstocks. Important assumptions, which appear to assume no limitation on petroleum inputs to agriculture, include the following:

- Yields of corn, wheat, and other small grains were increased by 50 percent
- The residue-to-grain ratio for soybeans was increased to 2:1

- Harvest technology was capable of recovering 75 percent of annual crop residues (when removal is sustainable)
- All cropland was managed with no-till methods
- Overall, 55 million acres of cropland, idle cropland, and cropland pasture were dedicated to the production of perennial bioenergy crops
- All manure in excess of that which can be applied on-farm for soil improvement under anticipated EPA restrictions was used for biofuel
- All other available residues were utilized

According to the federal agencies, the biomass resource potential identified in the report could be produced with relatively modest changes in land use, and agricultural and forestry practices.

It is important to note that a 2007 review of the Billion-ton study, found important flaws only one of which is that it relies on significant increased energy inputs especially in the case of agricultural-based biomass, which call for a 50 percent increase in harvests. Shifts in the supply or price of liquid fuels over the next 50 years would likely challenge the realization of these yield targets. Specifically, the Hirsch Report (see pages 18-20) describes consensus among researchers that a significant decrease in the availability of liquid fuels will come to pass over the next twenty years. Rising costs for transportation, fertilizer, electricity, etc. would likely result in lower yields than estimated by the supply study.

Biomass: A Renewable Source of Energy

All energy other than nuclear is ultimately derived from the sun. Biomass fuels are considered renewable because the trees and plants that store solar energy were recently growing and new biomass will be regenerated in their place in the immediate future. Fossil fuels on the other hand take millions of years to form and when burned, quickly release "new" greenhouse gases into the atmosphere disrupting the contemporaneous balance of the earth's atmosphere. Some other types of biofuels generated from municipal waste and construction and demolition debris streams for example, are also considered renewable (though not necessarily eligible under the State's RPS program) by Massachusetts state agencies because they are produced on a continual basis (like landfill gas).

Biomass-derived fuels, power, chemicals, materials, or other products essentially generate no net increase in greenhouse gas outside of any fossil-fuel use to grow, collect, and convert the biomass in a full life-cycle analysis. The carbon dioxide released when biomass is burned is balanced by the carbon dioxide captured when the biomass is grown. Its production and use will also generally be local and not entail global transport, so it has other important environmental, economic, and security benefits.

Woody Biomass Fuel in Massachusetts

In Massachusetts, the most prevalent form of biomass fuel is wood and woody debris. Although Massachusetts is one of the most densely populated states in the union, three-fifths of the land base is covered in forest and this forest cover has expanded significantly since the agricultural economy of the 1800's. According to a 2002 study produced by Breger and Fallon for the Division of Energy Resources, The Woody Biomass Supply in Massachusetts: A Literature-Based Estimate, there are seven main categories of woody biomass supply in the state (see the table below for estimated volumes):

1. Woody residue from the Municipal Solid Waste Stream (12%)
2. Woody residue from the Construction and Demolition (C &D) waste stream (9%)
3. Woody residue from primary wood manufacturers (6%)
4. Woody residue from secondary wood manufacturers (5%)
5. Urban wood residue (*branches, tree tops, etc.*) (24%)
6. Unutilized annual net growth in Massachusetts forests—Growing-Stock Trees (34%)
7. Unutilized annual net growth in Massachusetts forests—Branches, Top Wood (10%)

Municipal solid waste-based woody residues are defined as pallets and shipping containers. According to the study, nearly half of these pallets were disposed of in landfills in 1995, which as of July 2006, was no longer an option due to the Massachusetts wood ban (for disposal in in-state landfills). The study suggests that although woody debris from this waste stream could be recovered, contaminants associated with pallets and the complexity of stream-separation make this a less desirable fuel choice for

Table 1:
Estimated Annual Volumes of Woody Biomass in Massachusetts

Woody Biomass Source	Amount (tons/year)
Residue Sources	
Municipal Solid Waste	523,500
Construction and Demolition Debris	404,000
Primary Wood Manufacturers - Residues	279,608
Secondary Wood Manufacturers - Residues	225,000
Urban Wood Residues	1,049,200
Subtotal	2,481,308
Unutilized Annual Net Growth in Massachusetts Forests	
Growing-Stock Trees	1,484,000
Branches, Top Wood	446,000
Subtotal	1,930,000
TOTAL	4,411,308

New England's current and future biomass plants.

Construction and demolition (C&D) woody debris estimates showed that 30 percent of the C&D materials entering state processing facilities were wood (21% clean wood, 9% dirty wood). The report estimated that 30 percent of the C&D materials currently unrecovered (exported and disposed of) could be recovered and used as biomass fuels. The study also noted that including these "dirty" woody debris would require different "conversion technologies or emission controls."

Primary and secondary wood manufacturers in Massachusetts include the fifty remaining sawmills that generate sawdust, wood chips and bark. Secondary manufacturers work with wood to create consumer goods including furniture and casket makers.

Urban sources of woody debris include chips, logs, tops, brush, mixed wood and whole stumps generated by commercial firms, municipal tree care, nurseries and other types of companies.

Woody biomass derived from forest harvests includes the net growth of larger trees within the forest as well as the tops of trees harvested already. Harvesting net growth is similar to taking the interest and leaving the principal. Much debris would continue to fall naturally and replenish the soil. And roots and below-ground biomass are not considered as a source of fuel in the United States.

Why depend on a combustible?

Each renewable energy technology requires consideration of technical research and development issues, cradle to grave environmental impacts, scenic impacts, expense, relative efficiency, and availability of the resource to the demand. Increasing energy efficiency and conservation are very attractive strategies for reducing use of fossil fuels as compared to siting any single type of renewable energy facility. Still, while wind, solar power, and tidal energy are relatively emission-free technologies in their operation, biomass fuels emit pollutants when combusted.

When biomass and biofuels are burned (either directly or after gasification), the resulting emissions often contain carbon monoxide, nitrous oxides, sulfur dioxide, and small particulates. Emissions vary depending on the type of fuel, the method, size, and efficiency of the combustion system. Other environmental impacts can include increased traffic, noise, dust, water withdrawals, and others. Although these emissions and impacts are regulated by environmental protection agencies like the Massachusetts Department of Environmental Protection one must ask the question, with all the choices why consider anything but a *very* clean energy source?

The answer is efficiency and availability. Efficiency is the relative ability of an energy facility whether powered by biomass, the sun, or wind to generate electricity or heat or both over a set period of time based on a known capacity. For example, wind turbines have a particular blade and generator size and solar arrays have their associated square footage of panel space. How much electricity they produce is dependent not only on the size of the blade or panel but also on how much wind passes over the turbine's blades or how much of the sun's rays reach the panels' surface over time. Availability relates to the degree to which energy is produced in proximity, in both space and time, to the demand. Wind and solar energy facilities are generally unable to contribute to peak capacity. A biomass facility can generate electricity and steam heat twenty-four hours a day.

In this way, biomass is one of the few fuel sources that can replace the generation capacity currently held by coal, oil, and nuclear fuels.

When considering renewable energy choices, one must also consider costs. Compared to biomass, solar PV is substantially more expensive in terms of the lifecycle $/kwh of electricity generated, and only the best of the Massachusetts wind sites would provide electricity as inexpensive as biomass.

A Look at Our Energy Choices: Mt. Tom Coal Plant and a Biomass Plant

The Pioneer Valley Clean Energy Plan demonstrates that if people are intent on reducing carbon dioxide, then finding ways to reduce our use of carbon-intensive fuels has to be a major part of the picture. Reducing our use, and being much more efficient with our energy is critical. Our Plan states that a 30 percent reduction in carbon dioxide by 2020 is possible if half of that amount comes from better efficiency and reducing our use. The other half would need to come from replacing fossil fuel power plants like the Mt. Tom coal plant with renewable energy facilities.

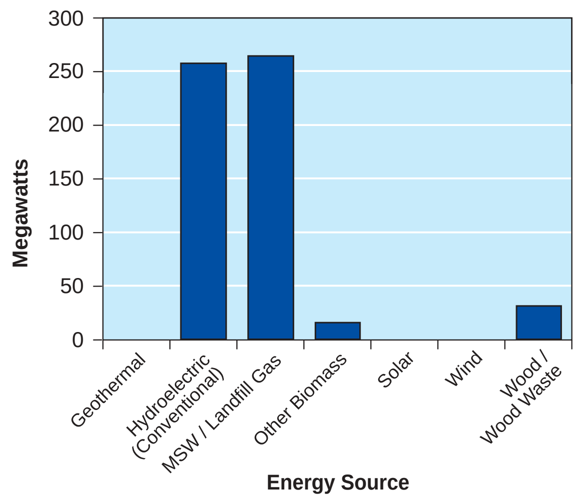
Research by the Clean Air Task Force (CATF), the U.S. Public Interest Research Group Education Fund and the National Environmental Trust, shows that no other single industry comes close to matching the negative impacts generated by electric fossil fuel power plants. They are the single largest industrial source of sulfur dioxide, nitrogen dioxides, carbon dioxide, and mercury.

According to First Light and Power's website, the Mt. Tom coal-burning power plant in Holyoke, Massachusetts has a generating capacity of 146 MW, which is enough to meet the electrical demand of a city more than twice the size of Holyoke. In 2002, the Mt. Tom plant emitted 5,282 tons of sulfur dioxide, 1,991 tons of nitrous oxides, over one million tons of carbon dioxide, and 32 lbs. of mercury per year (CATF).

There are nine fossil fuel-based generating power plants in Massachusetts. Outside of Mt. Tom the plants include: MassPower 1&2 (natural gas), Salem Harbor (coal), New Boston (natural gas), Mystic (oil), Bellingham B1 & 2 (natural gas), Somerset (coal), Brayton Point (coal), and Canal (oil). Together they generate over 90,000 tons of sulfur dioxide, 28,000 tons of nitrous oxides, 21 million tons of carbon dioxide and 324 lbs of mercury.

What can Western Massachusetts use to replace the need for a Mt. Tom-sized coal-burning plant? Under our plan's premise, we would need to come up with half of the plant's capacity or, 73 MW. That is a lot of power capacity, which we would be challenged to satisfy using just wind turbines and photo-voltaic arrays.

Figure 3: **Total Renewable Net Summer Capacity by Energy Source in Massachusetts (2005)**



Note: No data to report for geothermal, solar, and wind energy sources.

Source: Energy Information Administration, Form EIA-860, "Annual Electric Generator Report."

Figure 3 displays data on the amount of summer peak power capacity of different renewable energy technologies in Massachusetts in 2005. According to the U.S. Energy Information Agency the state did not have any data describing the contribution of solar, wind, and geothermal sources. The contribution of hydroelectric, municipal solid waste, landfill gas, and biomass to peak summer capacity was known and likely contributed the lion share of the available power. Society needs to reduce summer peak demand through demand response, conservation and efficiency combined with renewables. The question is, what are the best sources able to take the place of fossil fuels?

If Cape Wind is constructed with 130, 3.6 MW wind turbines, it will be an example of the siting of a renewable energy technology close to both the demand (it will satisfy 75% of electricity needs of the Cape and Islands) and the source. At an average capacity of 170 MW, it represents a significant source of electric capacity for that region.

The environmental advocacy organization Healthlink posted a letter to Governor Patrick dated July 11, 2007 with signatories including representatives across the state including Clean Water Action, Environmental League of Mass., Conservation Law Foundation, American Lung Association, Clean Air Cool Planet, Toxics Action Center, etc. The letter urges the Governor to invest in renewable energy and not in clean-coal technology unless it results in zero-net gain in carbon dioxide emissions. The letter asks Governor Patrick to consider that, "there is substantial untapped energy efficiency available at a cost far cheaper than buying electricity. Further, low- and zero-carbon renewable energy technologies are poised for major growth in the coming decade." While wind power must be seen as a one of the low or zero-carbon technologies, could biomass be considered one as well?

The proposed Russell Biomass Plant is included here to illustrate the emissions of a clean wood-based biomass plant in comparison to a coal plant. The potential maximum emissions of the major ("criteria") pollutants are the following, assuming 365 days per year of operation (Russell Biomass Expanded Environmental Notification Form):

nitrogen oxides (NOx)	245 tons/year;
carbon monoxide (CO)	425 tons/year;
volatile organic compds. (VOC)	32 tons/year,
sulfur dioxide (SO2)	117 tons/year
particulate matter (PM)	40 tons/year
carbon dioxide (C02)	632,180 tons/year

In the following table, the estimated emission figures per MW of power capacity for the Russell biomass plant are described. The proposed biomass plant would emit 36 percent of the nitrogen oxide emitted by Mt. Tom and 6 percent of its sulfur dioxide. Finally, while the carbon dioxide released by the biomass plant would be nearly double that of the coal plant on a per MW basis, biomass energy is net zero in carbon emissions as discussed earlier. The coal plant's carbon dioxide emissions on the other hand represent the addition of substantial new carbon to the atmosphere.

Table 2:
A Comparison of Pollutants per MW of Capacity for Russell Biomass and Mt. Tom Power Plant

Pollutant	**Russell Biomass (50 MW)** (est. tons/year/MW)	**Mt. Tom Coal (146 MW)** (tons/year/MW)
nitrogen oxides	4.9	13.6
carbon dioxide*	0 (net)*	6,850
sulfur dioxide	2.3	36

Note*: CO2 released from trees is roughly equal to C02 sequestered in trees; gross emissions are 12,644 tons/yr/MW.

This added "new" carbon is what is causing climate change. Carbon that is released by combusting wood is not the problem for as long as we protect forests from development and encourage sustainable forest management

Three Key Factors Affecting Impacts from Biomass Plants: Design, Size, and Fuel Type

Any manufacturing facility allowed through a special permit process in a Massachusetts municipality must show how the activities and processes at the site will impact the community. Special permit language in local zoning bylaws describe impacts that the city or town will investigate to determine if the project complies with zoning and is appropriate to the city. These can include traffic, fiscal and environmental impacts.

Impacts to air and water quality also need to be determined and often the city or town will defer to the regulatory powers of the Massachusetts Department of Environmental Protection and other permitting agencies.

Let's assume that these and other impacts (e.g. noise, dust, and scenic impacts) would be typical of many other types of manufacturing uses whether they were a cement factory or a paper company. What are the attributes of a biomass facility that are wholly unique to an energy facility and in this case, a combustion-based facility?

Design of the Biomass Plant

The first question relates to whether the biomass plant generates electricity only or does it also utilize the extra heat generated by the process? A Co-Gen biomass plant typically generates electricity for a host industry or the grid and heat for an on-site industrial use or a local use including a village district. In addition, biomass plants might also utilize the ashes left over from combustion to fertilize the forests or fields from which the biomass material was harvested. In essence, biomass plants would seek to utilize as much of the energy and by-products of electric generation as possible.

The more efficient a biomass plant is the more the biomass facility can use the heat and waste products generated by the combustion process, the more efficient the plant is. Greater efficiency could also mean fewer negative impacts on the environment. Increasing the use of heat produced through combustion of the biomass could increase overall efficiency and result in less impact on the environment. For example, a plant could use that extra energy to heat homes and businesses within a village during the heating months and to another industrial property nearby in the summer months. Using process heat for winter season space heating could result in a reduction in the need for burning firewood, oil, or coal in a dense village area benefiting residents with cleaner relatively particulate-free air.

Size of Biomass Plants

There are three main reasons why size matters with regards to siting biomass facilities.

Pollution Control: The cost of a bag house to catch fine particulates is enough to ensure that below a certain size, the best pollution controls can be cost prohibitive. On the other hand, the larger the plant is, the more pollution per unit time will be expelled from the plant.

Efficiency: Generally, larger facilities can afford the most advanced technologies to most efficiently convert biomass fuel to electricity. Small powerplants, however, may be more conducive to siting closer to loads that can utilize the units thermal output creating significant overall efficiency benefits,

Supply Considerations: The larger the plant, the more materials it would need to keep on hand to ensure a continued supply. These materials would need to be transported by truck or rail to the site where both transport and storage of materials could involve dust, fumes, and smoke. However, given higher efficiency of larger plants, less fuel overall would be required compared to the same energy generated by a large number of smaller plants.

Type of Fuel

There are a number of issues which could affect local acceptance of a biomass power plant. The guiding principles listed in the Pioneer Valley Clean Energy Plan provide a glimpse as to how a project might be designed so that it would receive public support by communities. Like the design and size of the project, the type of fuel can affect the impacts, both positive and negative, people associate with the technology and with a proposed plant.

For example, consider the ramifications to the host community and the region if the fuel source is mostly wood from sustainably managed forests. The plant would be buying wood chips sourced from forest landowners all over the region and beyond. By expanding markets for low-grade forest products, new jobs would be created and foresters would have a wider choice of management options.

Now imagine that the fuel mix was to include “clean” wood sorted from construction and demolition materials at facilities designed for that purpose (two C&D sorting facilities are currently located in Ware and Taunton). Woody debris could be coming in from around Massachusetts or from other nearby states. As of July 2006, Massachusetts banned wood from in-state landfills. This created the market for sorting, recycling, and reuse operations. One benefit of using C&D wood for generating electricity is that it would reduce fossil fuels used to transport the materials to out-of-state landfills. A serious concern however is that DEP cannot guarantee facilities permitted to burn C&D woody debris would not also combust contaminated wood. DEP would regulate the emissions based on the air permit held by the power plant. How these emissions would be regulated over time is another concern.

Outstanding Issues for Biomass Fuels

There are several issues that have been at the center of discussion concerning biomass energy in Massachusetts. These areas of concern are described by the following questions:

- Which bio-fuels should be considered clean burning?

- What do Massachusetts communities need to understand about construction and demolition (C&D) woody debris with regards to the Renewable Portfolio Standard and the State's Solid Waste Master Plan?
- What is the role of the Massachusetts Department of Public Utilities in our biomass-based energy future in Massachusetts?
- Can woody debris biomass be harvested from forests in a sustainable manner?
- What is the connection between biomass and biofuels and the global supply of oil?

Which bio-fuels should be considered clean burning?

The American Lung Association in their State of the Air (2007) report gives Hampden and Hampshire Counties an "F" air quality rating for particle pollution and an "F" for Hampden County for high ozone days. As a point of comparison, Worcester County received a "C" rating for ozone and a "D" for particulates. Biomass energy production is seen by many as a less desirable source of renewable energy because in many of its applications the resulting emissions, though regulated by the DEP, add to an atmosphere already plagued with low air quality.

Typically, solids produce more particulates and more pollution when combusted than a bio-gas or a bio-liquid. In gasification systems, biomass is heated to high temperatures in a gasifier. The solid biomass is converted to a gas primarily composed of hydrogen, carbon monoxide, carbon dioxide, water vapor, and methane. The gas is then used in a variety of applications, including gas electricity-generating turbines and boilers.

Gasifiers have several advantages over systems that burn biomass solids. Most notably, they emit less air pollution. They are significantly more efficient than biomass combustion facilities, so they require fewer raw materials and can potentially generate electricity more cheaply. The technology is still being perfected and refined for use in large power plants.

Liquid pyrolysis technology is similar in concept. Solid biomass is heated rapidly in a high-temperature, oxygen-free environment, converting it into a liquid fuel (bio-oil) as well as other products. The bio-oil can then be converted into useful energy in conventional combustion systems.

Since gasifier and liquefier technologies are still in the research and design phases we are likely to see improvements in the application of biomass fuels in the coming decades. Until these exciting technologies are available, it would seem the cleanest biofuels will be solids generated from forest harvests and from other woody debris sources, but not include "dirty" (painted or treated wood) construction and demolition woody debris.

What do Massachusetts communities need to understand about construction and demolition (C&D) woody debris with regards to the Renewable Portfolio Standard and the State's Solid Waste Master Plan?

This question perhaps needs to be answered by looking at how the state through its agencies plans for C&D materials. Overall, state agencies see C&D woody debris as both a potential source of energy and as a waste management issue.

In the regulations of the Massachusetts Renewable Energy Portfolio Standard, the term *organic refuse-derived fuel* is included in a list of eligible biomass fuels, and has been interpreted by the Division of Energy Resources (DOER) as being inclusive of wood derived from construction and demolition (C&D) debris. In several Advisory Rulings and two Statements of Qualification for proposed biomass projects, DOER provided contingent approval of the use of C&D wood along with clear direction as to the stringent emission limits and monitoring of toxics that would need to be met.

In 2005, and continuing through 2007, DOER opened a Notice of Inquiry to consider revisions to the RPS regulations pertaining primarily to biomass and including the inclusion of C&D wood as an eligible biomass fuel. During this process, much information and public comment was heard with regard to current and advanced sorting practices for C&D, emissions from C&D combustion, gasification and other technologies that might reduce toxics in the exhaust air stream, and public concerns and perceptions of C&D burning.

While C&D is a fuel which can be burned in Massachusetts, subject to MassDEP permit regulations, the issue of whether such material is an eligible biomass fuel for the purpose of generating renewable energy credits under the RPS program remains under discussion by the DOER and the EOEEA. DOER anticipates that a decision on this issue will be made in the middle of 2008.

A change in policy excluding C&D from consideration as a RPS fuel would support the efforts of the Massachusetts Department of Conservation and Recreation, which supports the development of markets for forest-derived biomass. Biomass harvested as part of timber and fuelwood sales on private and public forests will likely be the tops and small-diameter wood. Yet the estimated volume of waste-based to forest-based wood would be 2:1 based on findings reported in Woody Biomass Supply in Massachusetts: A Literature-Based Estimate. Unlike forest-based biomass, the expense of C&D to the plant would be low, nil, or might generate additional revenue as the wood ban on Massachusetts landfills could result in a demand for other disposal options. C&D woody debris as a biomass feedstock may be an attractive option for those seeking to dispose of these materials.

In 2006, the Northeast States for Coordinated Air Use Management (NESCAUM), whose members represent states' environmental protection departments, including MassDEP, prepared a report, Emissions from Burning Wood Fuels Derived from Construction and Demolition Debris to "gain a better understanding of emissions and related environmental issues from the use of construction and demolition (C&D) wood for power generation." NESCAUM estimated that economic and regulatory shifts were increasing interest in using C&D as a biomass feedstock. As costs to dispose of C&D materials increased, companies were investigating ways of reducing disposal costs and generating power at the same time. C&D woody debris were estimated to cost ten to twenty dollars less per ton to process as fuel than to send to a landfill. Two other factors supporting the use of C&D wood were increasing costs of oil and natural gas and increased regulatory incentives to use renewable energy sources. Coal emission control costs were rising while renewable energy credits (RECs) for biomass generated electricity using virgin biomass and C&D wood were becoming available.

As of May 2006, three states in the NESCAUM region received permit applications proposing new wood-fired power plants that could be fired with wood derived from C&D waste. The proposed facilities are in Athens, Maine, Russell, Massachusetts, and Hinsdale, New Hampshire. In addition, some existing plants are assessing the addition of C&D wood to their fuel mix.

While public opposition to the use of C&D woody debris for power generation has been strong, NESCAUM's review of the data suggested that if C&D wood could be appropriately processed, its emissions would be similar to that of virgin wood. However, they determined that control requirements for C&D-derived wood would be similar to or more stringent than that required for plants burning clean wood. For example, air pollution controls proposed for the plant in Athens, Maine would include control equipment similar to that found on municipal waste combustors.

Only New Hampshire, via a temporary moratorium likely to continue until December 31, 2007, has restricted the use of C&D wood for fuel. Other states do not have official restrictions, but do place operational limitations on these sources through their regulatory process. The report finds that a critical element for use of C&D wood as a fuel source is the development of "strict" fuel standards.

According to NESCAUM, adequate fuel standards would include the following:

- The limitation of treated wood such as chromated copper arsenate (CCA) wood and penta-treated wood to reduce arsenic emissions;
- Minimizing contamination from other C&D materials and removal of C&D fine material (known as "fines") from the fuel chips to increase fuel quality substantially, and result in lower metal and other air toxic emissions; and,
- Requiring comprehensive testing and sampling of the fuel at both the processing facility and at the power plant to assure that the fuel quality is maintained.

According to the Massachusetts Department of Environmental Protection's (DEP) solid waste master plan, the *Beyond 2000 Plan,* wood and asphalt shingles represent the largest un-diverted portion of C&D waste, as asphalt, brick, and concrete (ABC) are recycled at a very high rate. Excluding ABC, remaining C&D materials are only recycled at a 10 percent rate. Therefore, DEP plans on focusing on these other materials, particularly wood, gypsum wallboard, and asphalt shingles.

Over the past five years, seven new construction and demolition (C&D) processing facilities have been built, equal to approximately 800,000 tons of annual processing capacity in Massachusetts. Most of the material produced by these facilities is used at active and inactive landfills as daily cover and shaping and grading material.

In the long term, DEP plans to stimulate additional markets and uses for C&D materials that are not dependent on landfills. Because most C&D is generated by a relatively small group of companies, the report states that DEP should be able to target waste reduction initiatives. DEP's strategy for increasing the diversion of wood from disposal is centered on the disposal ban on wood, combined with technical assistance. The ban has, according to DEP, already stimulated C&D processing investments in Massachusetts. DEP's efforts will be to work with solid waste facilities to implement the ban and with the construction and demolition industry and other stakeholders to develop additional markets for C&D wood, particularly clean wood that can be separated at construction sites.

A concern expressed in clean energy planning forums between 2005 and 2007 as part of the development of the Pioneer Valley Clean Energy Plan, is that by permitting C&D woody debris as a biomass feedstock, a back door is created for the incineration industry to be able to increase the burning of municipal solid waste (MSW) and other wastes in the generation of electricity. The concern is that a plant owner, years after the operation has commenced, could successfully argue before the Massachusetts Department of Public Utilities' Siting Board to revise their fuel from forest-based biomass to C&D woody debris, or perhaps to municipal solid waste, despite these fuels being explicitly prohibited by the local special permit. Such a change would also require the power plant owner to apply for a change in its DEP Air Permit, which would be difficult but not impossible.

On the other hand, DEP has maintained a moratorium on new municipal waste combustion capacity due to concerns about mercury emissions. Despite significant reductions in mercury emissions over the past several years, municipal waste combustion facilities continue to represent the largest in-state source of mercury emissions. DEP believes that further expanding municipal waste combustion capacity, which already represents nearly 50 percent of Massachusetts total disposal capacity and 65 percent of in-state disposal capacity, is inconsistent with EOEEA's Zero Mercury Strategy and the New England Governors/Eastern Canadian Premiers Mercury Strategy.

The biomass field is clearly in a state of flux and uncertainty. Other states in New England may include C&D wood and MSW as an RPS eligible fuel. It also remains to be seen how DEP will regulate C&D sorting. If DEP cannot demonstrate that they can effectively regulate the sorting of C&D, should there not be a DEP regulation prohibiting the burning of C&D woody debris in any new biomass facility?

Can society afford to ban all C&D wood from use as biomass feedstock? To answer that question may require consideration of a larger context to energy use based on the relative capacities of alternates to coal, oil, natural gas, and nuclear energy. Based on the Independent System Operator (ISO) New England 2005 peak summer capacity figures, Massachusetts' demand share of the total New England load was approximately 13,690 MW. Less than 10 percent of that capacity was provided via hydro and other renewable energy sources. Therefore, to replace fossil and nuclear fuels with renewables would require alternatives with considerable capacity in terms of the technology, plant design and fuel supply.

What is one of the roles of the Massachusetts Department of Public Utilities in our collective biomass-based energy future in Massachusetts?

According to Governor Patrick's Reorganization Plan, House Bill 2034, the Department of Telecommunications & Energy ceased to exist as of April 11, 2007. In its place, the Plan established two new agencies: The Department of Telecommunications & Cable (DTC) that would handle telecommunications and cable issues and The Department of Public Utilities (DPU), which would handle electric and gas siting of new facilities, and pipeline, water and transportation issues.

The DTC is overseen by the Office of Consumer Affairs and Business Regulation and is within the Executive Office of Housing & Economic Development. The DPU is overseen by the Undersecretary of Energy and is within the Executive Office of Energy and Environmental Affairs.

The DPU's Siting Board is responsible for providing the most reliable supply of electricity, with the least environmental impact for the lowest price to the Massachusetts consumer. As part of carrying out its responsibilities, the Siting Board provides a process within which a power plant developer can appeal the conditions set by an existing local permit. This appeal process can result in negating local control of a plant's permit conditions. This is obviously a concern of residents and town officials who have a desire to control the siting of projects and the fuels under which an electric generating plant would be permitted. As long as C&D and MSW materials are, or could be in the future, permitted sources of biomass feedstock, communities considering hosting cleaner fuel biomass facilities may be at risk of surreptitious fuel replacement.

Can woody debris biomass be harvested from forests in a sustainable manner?

As increasing investment in the production of energy and from biomass occurs, there is concern that withdrawals of woody debris from forests will negatively impact wildlife habitat, forest health, and soil nutrients.

In response to these concerns, the Minnesota State Legislature, as part of legislation on energy production from woody biomass, required the Minnesota Forest Resources Council (MFRC) and the Minnesota Department of Natural Resources (DNR) to develop guidelines or best management practices for "sustainably managed woody biomass" (MN Statute 216B.2424). Draft Biomass Harvesting on Forest Management Sites in Minnesota, was prepared by the Minnesota Forest Resources Council Biomass Harvesting Guideline Development Committee.

Typically biomass harvesting is usually conducted in conjunction with timber and firewood (roundwood) harvesting. Biomass harvests might include the utilization of tops and limbs, small diameter trees, or stems which have historically been "non-merchantable" dead trees, down and dead woody material, and brush. Biomass harvests typically remove more woody material from a site than would be removed under traditional harvest.

Woody debris retention in forests is essential for sustaining biodiversity and wildlife populations. Natural disturbances create and retain considerably more woody debris than commercial timber harvests and that this difference is increased by a woody biomass harvest. This study determined that the development of a market for woody biomass would remove much of the coarse woody debris and slash (or fine woody debris) that normally would remain on site.

However, in the development of their guidelines, the MFRC determined that in most cases biomass harvesting would not adversely impact soil productivity if certain guidelines are followed. Where biomass harvesting may create an increased impact compared to conventional forest harvesting, is with respect to nutrient removals. . However, new long term research on nutrient budgets indicate that for most mineral soils (in Minnesota) the nutrient capital on-site in soil and plant matter is sufficient to tolerate a large number of such harvest rotations without deleterious effects. On the other hand, deep organic soils would require fertilization and steep shallow soils would be most at risk for nutrient loss.

The MFRC has developed a set of guidelines for sustainably removing woody debris for biomass feedstock. Their findings included that on mineral soils, as long as the leaves and small stems are left to develop a rich leaf litter, the removal of other biomass in conjunction with a conventional harvest would not have significant negative impacts on soil nutrients or forest floor biodiversity, within a forest with a 50-year rotation (from seedling to final harvest).

The results of an older study in 1986 indicate that forest biomass should not be harvested using the whole-tree method. This study of average potential whole-tree (above-ground) harvest removals of biomass in conifer and hardwood stands in central Nova Scotia, described average increases over sawlog (main stem of the tree)-only harvesting of 50 percent for biomass, 170 percent for nitrogen, 200 percent for phosphorus, 160 percent for potassium, 100 percent for calcium, and 120 percent for magnesium. In other words, much larger increases in removals of major nutrients occurred with whole-tree harvests as compared to harvests of the main stem only.

What is the connection between biomass, biofuels and the global supply of oil?

The main connection between biomass, biofuels and global oil supplies is the future promise of cellulosic ethanol, which based on existing research, could provide a much greater return on energy investment than what is currently possible with corn-based ethanol. Wood-based ethanol could become an important liquid fuel product for use in existing transportation support infrastructure. This potential alternative to oil may become commercialized at a critical point in the history of the world: the peaking of global oil production.

Some energy experts estimate that sometime between 2007 and 2025, the earth's total supply of oil will peak in production (*see table on the following page*). This is not to say that we will run out of oil during this time, only that supplies of oil will neither be cheap nor plentiful. The peak-oil theorists continue that from that point forward there will never be more oil in production. New discoveries and changes in technology will only help to accelerate the withdrawal of oil to keep up with an ever growing demand. Beyond this, different views of what a post-peak production world will be like are widely offered. A common theme among many is a widespread and growing shortage of liquid fuels for space heating, transportation, food production, etc. following a period of dynamic fuel prices.

In 2002, the U.S. Department of Energy commissioned a study on the future outlook of oil. The "Peaking of World Oil Production: Impacts, Mitigation, and Risk Management" authored by Robert L. Hirsch, Roger Bezdek, and Robert Wendling, frames our energy future within the context of how quickly we can switch to alternate liquid fuels. Hirsch used three scenarios to describe our options and estimated the impacts of each. Each scenario was based on how many years ahead of the peak do we aggressively implement mitigation efforts to wean ourselves from oil. The conclusions of the "Hirsch Report" include the following:

- When world oil peaking will occur is not known with certainty. A fundamental problem in predicting oil peaking is the poor quality of and possible political biases in world oil reserves data. Some experts believe peaking may occur soon. This study indicates that "soon" is within twenty years.
- The problems associated with world oil production peaking will not be temporary, and past "energy crisis" experience will provide relatively little guidance. The challenge of oil peaking deserves immediate, serious attention, if risks are to be fully understood and mitigation begun on a timely basis.
- Oil peaking will create a severe liquid fuels problem for the transportation sector, not an "energy crisis" in the usual sense that term has been used.
- Peaking will result in dramatically higher oil prices, which will cause protracted economic hardship in the United States and the world. However, the problems are not insoluble. Timely, aggressive mitigation initiatives addressing both the supply and the demand sides of the issue will be required.
- Mitigation will require a minimum of a decade of intense, expensive effort, because the scale of liquid fuels mitigation is extremely large.
- While greater end-use efficiency is essential, increased efficiency alone will be neither sufficient nor timely enough to solve the problem. Production of large amounts of substitute liquid fuels will be required. A number of commercial or near-commercial substitute fuel production technologies are currently available for deployment, so the production of vast amounts of substitute liquid fuels is feasible with existing technology.
- Intervention by governments will be required, because the economic and social implications of oil peaking would otherwise be chaotic. The experiences of the 1970s and 1980s offer important guides as to government actions that are desirable and those that are undesirable, but the process will not be easy.

What source of liquid fuels might be available in modest supplies over the next five to twenty years? The answer will likely include biofuels, especially cellulosic ethanol, which interestingly enough will likely require harvests of woody debris from many sources, just like biomass-fueled power plants require today. It will also require machines to harvest and chip these woody materials and transport them to bio-refineries. Developing the markets and support infrastructure for biomass today may give society a

Table 2:
Projections of the Peaking of World Oil Production

Projected Date	Source of Projection	Background & Reference
2006-2007	Bakhitan, A.M.S.	Oil Executive (Iran)[1]
2007-2009	Simmons, M.R.	Investment banker (U.S.)[2]
After 2007	Skrebowski, C.	Petroleum journal editor (U.K.)[3]
Before 2009	Deffeyes, K.S.	Oil company geologist (ret., U.S.)[4]
Before 2010	Goodstein, D.	Vice Provost, Cal Tech (U.S.)[5]
Around 2010	Campbell, C.J.	Oil geologist (ret,. Ireland)[6]
After 2010	World Energy Council	World Non-Government Org.[7]
2012	Pang Xiongqi	Petroleum Executive (China)[8]
2010-2020	Laherrere, J.	Oil geologist (ret., France)[9]
2016	EIA nominal case	DOE analysis / information (U.S.)[10]
After 2020	CERA	Energy consultants (U.S.)[11]
2025 or later	Shell	Major oil company (U.K.)[12]

1 Bakhtiari, A.M.S. *World Oil Production Capacity Model Suggests Output Peak by 2006-07*. *Oil and Gas Journal*. April 26, 2004.
2 Simmons, M.R. ASPO Workshop. May 26, 2003
3 Skrebowski, C. *Oil Field Mega Projects - 2004*. Petroleum Review. January 2004.
4 Deffeyes, K.S. *Hubbert's Peak-The Impending World Oil Shortage*. Princeton University Press. 2003.
5 Goodstein, D. *Out of Gas – The End of the Age of Oil*. W.W. Norton. 2004.
6 Campbell, C.J. *Industry Urged to Watch for Regular Oil Production Peaks, Depletion Signals*. *Oil and Gas Journal*. July 14, 2003.
7 *Drivers of the Energy Scene*. World Energy Council. 2003.
8 Pang Xiongqi. *The Challenges Brought by Shortages of Oil and Gas in China and Their Countermeasures*. ASPO Lisbon Conference. May 19-20, 2005.
9 Laherrere, J. Seminar Center of Energy Conversion. Zurich. May 7, 2003.
10 DOE EIA. *Long Term World Supply.* April 18, 2000. See Appendix I for discussion.
11 Jackson, P. et al. *Triple Witching Hour for Oil Arrives Early in 2004 – But As Yet, No Real Witches*. *CERA Alert*. April 7, 2004.
12 Davis, G. *Meeting Future Energy Needs*. The Bridge. National Academies Press. Summer 2003.

head start on establishing a sustainable supply of biofuels for tomorrow.

Conclusion

If Massachusetts communities and state government are serious about developing a sustainable energy future, then biomass energy and biofuels need to be seriously considered. Forest-based feedstocks are by far the better biomass fuel choice for today compared to C&D woody debris. Additionally, cellulosic ethanol and biogas will be much cleaner fuels for the future and are well deserving of intense research and development efforts.

In light of both global warming and the likely future shortages in liquid fuels, society needs to reduce its dependence on fossil fuels and come up with viable replacements that do not include nuclear energy, an unsafe and non-renewable fuel. Whatever the fuel choice, navigating to a clean, safe, and viable energy future will require communities, businesses, and government agencies at all levels working together to solve these challenges.

If state agencies cannot guarantee that C&D woody debris biomass feedstock will not contain contaminated wood and that the DPU Siting Board is authorized to override local control over the types of fuels used in locally-sited plants, should Massachusetts communities not support a change in DEP policies and regulations that in effect ban, in perpetuity, new C&D and MSW-fueled power plants? How will biomass energy change over the coming decades as markets develop for carbon sequestration and demand grows for the replacement of fossil derived energy? When will our society recognize the economic, social and ecological benefits of proper forest management and support businesses that utilize wood as a local, carbon-neutral energy source and commercial product? Given the potential supply issues with regards to woody biomass, how will we as a state develop renewable energy facilities to replace fossil and nuclear fuels more effectively? We all need to work together to find answers to our energy questions. Our answers will reflect what we as a society value, the limitations of resources and time, and our ability to strive and overcome these challenges.

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