Chapter 15
Wood

Introduction

Wood is an excellent source of energy. It can be used to create biofuels, burned directly, turned into a synthetic gas or pyrolyzed — turned into a liquid to create electricity.

Wood-fired power plants can have a positive impact on the economy of some rural areas. At present, Texas has no operating wood-to-electricity facilities, but two are being developed. Nacogdoches Power is building a large wood-burning facility in Sacul, Texas expected to be operational in late 2009. And Mesquite Fuels & Agriculture in Hamlin, Texas plans to establish a smaller-scale wood-gasification facility expected to be operational in spring or summer 2008.[1] These facilities are projected to add about 500 jobs to all sectors of the economy once completed.[2]

Potential fuel sources for wood-fired power plants include mill residues, sawdust, wood trimmings and construction debris. East Texas, home to much of the state's lumber industry, has a particularly large resource base. In 2005, East Texas wood products companies produced 9.5 million tons of logging and mill residues.[3]

History

Biomass is the oldest human energy source. Mankind has burned wood to create heat for tens of thousands of years. By 1890, commercial, residential and transportation sectors counted on wood as the primary fuel supply. The first power plant to generate electricity from wood was the Joseph McNeil generating station in Burlington, Vermont in 1984.[4]

Uses

Biomass (including organic waste, fuels derived from plants and wood) recently surpassed hydroelectric power to become the largest source of renewable energy in the U.S.

Industrial consumers use the majority of the energy generated from biomass. Most of this energy is generated at mills or paper plants that burn their own wood waste for power and heat (**Exhibit 15-1**).

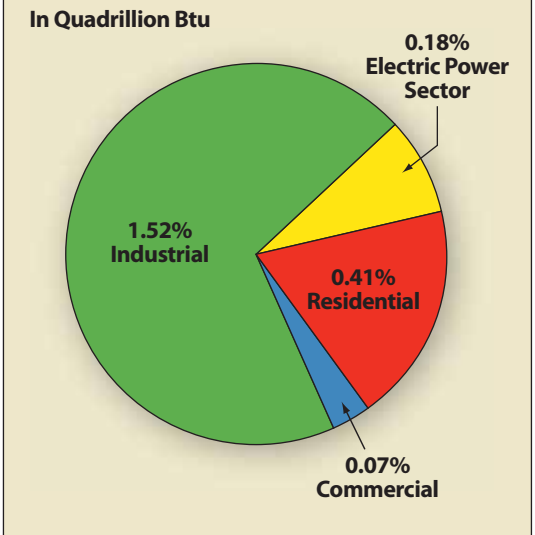
Biomass can be used to create electricity through a variety of methods, including direct firing, gasification and pyrolysis (the liquefaction of biomass to form an oil), among others. Direct firing is the most common of these methods.[5] Although other chapters in this report focus on municipal solid waste and landfill gas; this chapter is devoted to wood biomass only. Electricity generated from wood-fired biomass can be placed on the power grid for residential and commercial use, or used at the source of generation.

Wood Biomass in Texas

Texas produces an estimated 20 million tons per year of biomass that can be used as fuel. This

Exhibit 15-1

U.S. Wood Biomass Energy Consumption by Sector, 2006



Source: U.S. Energy Information Administration.

Potential fuel sources for wood-fired power plants include mill residues, sawdust, wood trimmings and construction debris.

includes forest residues, mill residues, urban wood waste, agricultural residues and dedicated energy crops.[6] According to Mark Kapner, a senior strategy engineer at Austin Energy, this is the equivalent of about 4,600 megawatts (MW) of potential capacity, enough to power more than 2.5 million homes in Texas, based on average electric use in 2006.[7] The U.S. had 6,372 MW of installed capacity (on the grid) of wood-fired biomass in 2006. This is up from 5,844 MW in 2002.[8]

Economic Impact

A 1999 study by the National Renewable Energy Laboratory (NREL) stated that 4.9 full-time jobs are created by every megawatt of generating capacity.[9] Applying this figure to the estimated 4,600 MW of total potential capacity in Texas indicates that the wood-fired energy industry could add more than 22,000 jobs to the state.

A 100 MW wood-fired biomass power plant being developed by Nacogdoches Power in Sacul (discussed below) is expected to create about 490 new jobs.[10] The 8 MW wood gasification power plant being developed by Mesquite Fuels & Agriculture in Hamlin will employ eight to nine people, with additional employees needed to harvest wood. Mesquite Fuels & Agriculture anticipates that employees will be paid between $10 and $14 per hour.[11]

In the most common method of electricity generation from biomass, wood waste is burned in a manner similar to coal or gas firing in a power plant.

Consumption

Again, Texas currently has no operational wood-fired biomass power plants, although two Texas plants are planned.

In 2006, energy from wood-fired biomass accounted for 2.1 quadrillion Btu, in the U.S., about 31 percent of all renewable energy consumed.[12]

Production

Most direct-fired biomass plants burn wood waste derived from sources such as mill residues, sawdust, wood trimmings and construction debris. This biomass can be burned alone or co-fired with fossil fuels. In the latter case, biomass generally replaces only a small portion of the fossil fuel (about 20 percent).[13]

In addition to trimmings collected off the forest floor after logs are harvested, forests can be "pre-trimmed" prior to logging. This "pre-commercial" trimming can produce biomass for electricity while decreasing the risk of forest fires and insect and disease attack.[14]

Transportation

Wood-fired biomass power plants usually are located near areas with large amounts of wood waste, to reduce or avoid the cost of transportation. (Transportation costs often account for the majority of the cost of any fuel.) To be economically feasible, wood-fired power plants generally are located within about 50 miles of the wood source.[15]

Power Generation

In the most common method of electricity generation from biomass, wood waste is burned in a manner similar to coal or gas firing in a power plant. The waste is sent through a chipper and then to a boiler where it is burned to heat water,

Producing Electricity from Wood using Gasification and Pyrolysis

Gasification and pyrolysis are similar processes. Both require high temperatures and a oxygen-limited environment.

Gasification

Gasification converts biomass to combustible gases by heating it at high temperatures in an oxygen-limited environment. The resulting "synthesis" gases contain hydrogen and carbon monoxide.[16] Synthesis gases are mixed with oxygen and burned to heat water and produce steam to turn a turbine and create electricity. Synthesis gases can also be used in gas turbines or converted into other fuels.[17] Gasification of biomass removes pollutants such as ash and other particulates.[18]

Pyrolysis

Pyrolysis is used to convert biomass to a liquid. Heating biomass at extremely high temperatures (more than 1,000°F) in an environment with no oxygen produces vapors that can be condensed into a liquid called pyrolysis oil. This oil, a renewable liquid fuel, can be stored and transported easily.[19] It can be burned to create electricity or used to produce chemicals, plastics and other products.[20]

producing steam. The resulting steam spins turbines, which in turn drive generators to produce electricity (**Exhibit 15-2**). In co-firing, fossil fuels and wood waste are burned together to create steam. The wood waste may need to be dried prior to burning to reduce its moisture content.

The wood-fired biomass power plant proposed for Sacul, a small town near Nacogdoches, will employ a fluidized bed combustion boiler (FBC).[21] In an FBC, a layer of sand is heated and agitated using upflowing jets of air. The heated sand is used to distribute air evenly throughout the chamber. Wood waste then is injected into the boiler. The jets of air suspend the wood in midair, allowing it to burn on all sides, yielding a more efficient combustion process.[22]

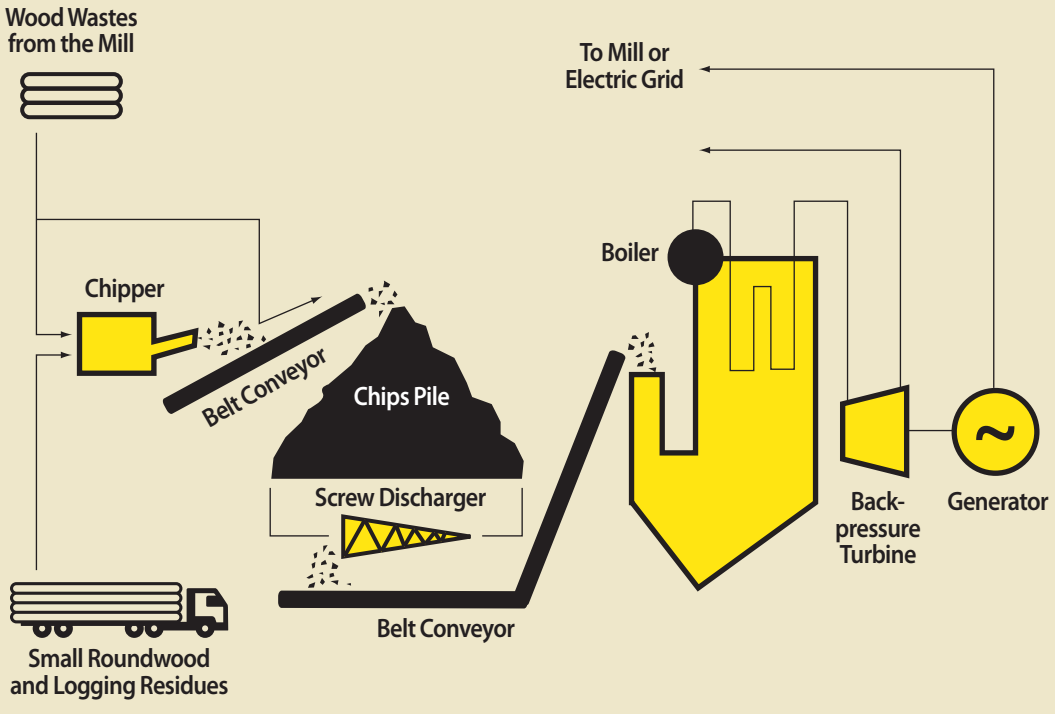
Selective non-catalytic reduction (SNCR) systems can be used to control wood-fired emissions of NO_X, a known greenhouse gas with adverse health and environmental effects.[23] SNCR involves a chemical reaction that employs NO_X rather than oxygen as its primary reactant. SNCR works by injecting either ammonia (NH_3) or urea into the gas produced during combustion. NO_X then undergoes a reaction in the presence of oxygen; the oxygen is removed from the NO_X and bonds to the hydrogen from ammonia or urea, forming nitrogen gas (the most common gas in the atmosphere) and water vapor. SNCR can reduce NO_X emissions levels by 30 to 75 percent.[24]

Storage and Disposal

Burning wood biomass for electricity can help to reduce the amount of wood waste sent to landfills. Wood waste can be stored in a variety of ways, depending on the scale of the plant and the fuel's moisture content: in open uncovered wood piles, partially covered wood piles (open sheds), or enclosed wood piles (storage bins, hoppers, or silos).[25] Foreign debris in the wood waste, such as stones, nails and other metal, must be removed prior to use.[26]

EXHIBIT 15-2

Electricity Production from Wood Firing



Source: Food and Agriculture Organization of the United Nations.

Burning wood biomass for electricity can help to reduce the amount of wood waste sent to landfills.

Availability

Although only a portion could be used for energy generation, Texas has a very large biomass resource base, with more than 12 million acres of forests, mostly of pine, in 43 counties in East Texas alone.

More than 90,000 Texans work in the state's $2.3 billion forest products industry. Texas has more than 1,200 lumber and wood-product mills.[27]

Many sites in the state, such as mills, use wood waste to heat and power their own facilities.

Although only a portion could be used for energy generation, Texas has a very large biomass resource base.

The 100 MW wood-fired biomass power plant being developed in Sacul, located in Nacogdoches County, will use logging residue as its main fuel source, but also could use urban wood waste. Nacogdoches Power estimates that the plant will require 1 million tons of biomass per year.[28] It will be the largest wood-fired power plant in the nation, according to Nacogdoches Power.[29]

In 2005, 3.1 million green tons of logging residues were available for use in East Texas, as well as 6.3 million dry tons of mill residues (**Exhibit 15-3**). Mill residue is already being used; it can be burned to power and heat mills or sold for landscaping materials, sawdust or pulping material. On the other hand, most logging residue is simply left at the logging site and this, too, could be sold for energy production. [30]

The energy content of this material will vary depending on its moisture content. The moisture content of raw wood that has just been cut is typically between 30 and 40 percent.[31]

Exhibit 15-3

Logging and Mill Residue in East Texas, 2005

Type of Wood	Logging Residue (green tons)	Mill Residue (dry tons)	Total (tons)
Hardwood	1,035,334	978,342	2,013,676
Softwood	2,102,947	5,333,589	7,436,536
Total	3,138,281	6,311,932	9,450,213

Note: Numbers may not total due to rounding.
Sources: Texas Comptroller of Public Accounts and Texas Forest Service.

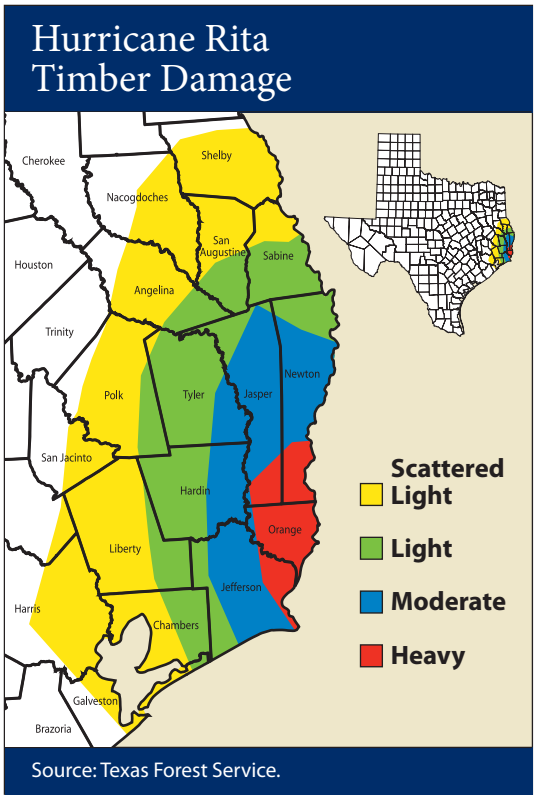
Trees damaged in the wake of Hurricane Rita could have been used in a wood-burning power plant. Hurricane Rita caused more damage to East Texas timber than any disaster in recent history, destroying or damaging about 6 percent or 771,000 acres of East Texas timber (**Exhibit 15-4**).[32]

The 2007 Texas Legislature directed the State Energy Conservation Office (SECO) to update a 1995 assessment of Texas renewable energy resources. This report, which will be released before the start of the 2009 Texas legislative session, will include up-to-date data on the availability of various renewable energy resources, including biomass.

Costs and Benefits

Prices for electricity generated from wood-fired power plants tend to range from 5 cents to 7 cents per kilowatt hour (kWh), with a national average cost of about 6 cents.[33] This price includes incentives that are available for this type of electricity generation, including a 1 cent to 2 cent per kilowatt-hour (kWh) federal renewable energy production credit on corporate income tax.

Exhibit 15-4



Wood Gasification Plant in Texas

Mesquite Fuels & Agriculture is in the process of constructing a wood gasification facility in Hamlin, Texas, that is expected to open in spring or summer 2008. Hamlin is located about 40 miles northwest of Abilene. The facility will cost $2.5 to 3 million per MW; at 8 MW the facility is expected to cost more than $20 million. This facility will employ 8 to 9 people on a permanent basis, as well as other employees needed to harvest and transport wood.[34] The facility will employ gasification technology to produce electricity from mesquite. Its generation capacity is expected to be 8 MW.[35]

The plant also will be able to generate steam that could be sold to other industrial consumers in the immediate area.[36] In addition to the first plant in Hamlin, Mesquite Fuels & Agriculture is examining other sites in West Texas, and believes there is enough mesquite in these areas for five or six more facilities.[37]

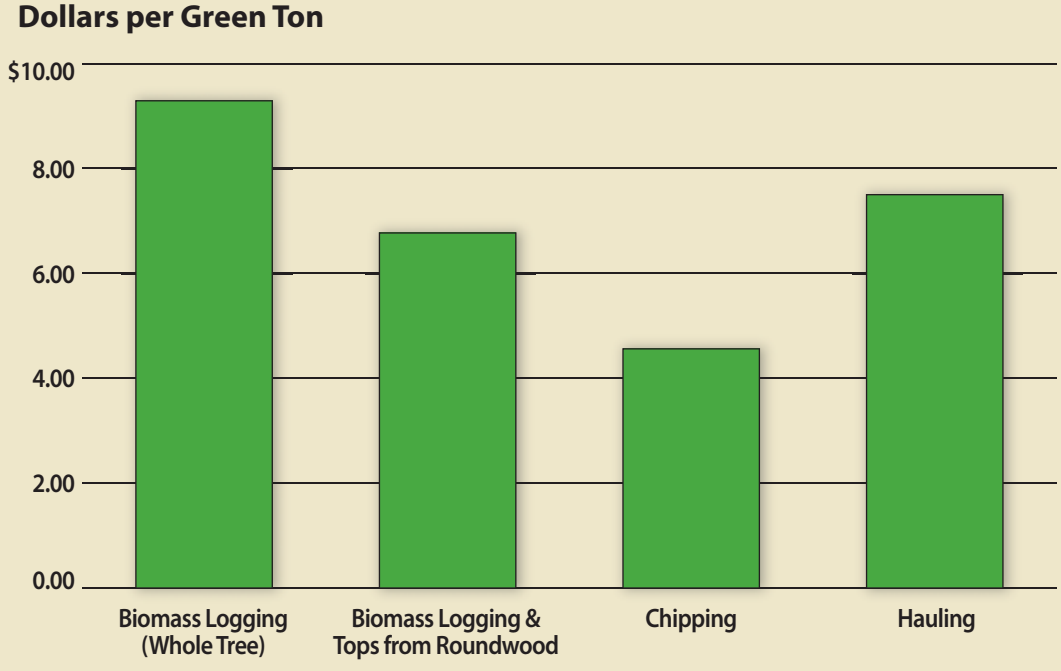
More information on this incentive is found in the Incentives, Subsidies, Taxes and Tariffs section of this chapter.

The Sacul plant will cost about $400 million to build, or about $4,000 per installed kilowatt. In addition to construction costs, the costs of fuel and chipping and transporting it must be considered (**Exhibit 15-5**). For example, a ton of chips produced from whole trees would cost an average of $21.35. This figure includes an average cost of $9.29 per ton for the wood, $4.56 per ton for chipping and $7.50 per ton for transporting the wood. In addition, drying costs may be significant depending on the wood's moisture content.

While Nacogdoches Power officials did not provide their expected costs, in Oregon and other areas of the Pacific Northwest, wood-fired electricity costs from 5.2 cents to 6.7 cents per kWh to produce.[38]

EXHIBIT 15-5

Cost of Biomass Production in East Texas, 2007



Sources: Texas Forest Service and Texas Comptroller of Public Accounts.

Sugarcane Bagasse to Energy Project

The Rio Grande Valley Sugar Growers, Inc. is turning sugar cane waste into electricity. The facility, located in Santa Rosa, uses waste to produce electricity via steam turbines. Currently, the facility is undergoing a renovation to replace the boilers and turbines with newer, more energy efficient equipment. At an estimated cost of $26.5 million, the project will allow the facility to create enough electricity to run the sugar processing plant (about 9 MW) and to sell the remaining electricity on the grid (about 4.5 MW).[39] In addition, the project will save an estimated 80 percent of natural gas purchases and 90 percent of electricity purchases. This, together with the revenue from selling electricity to the grid, will save an estimated $3.5 to $4 million annually. The use of sugarcane waste to create energy will also save on disposal costs and landfill space.[40]

Environmental Impact

Wood-fired biomass power plants produce some air and water pollution. The grinding or chipping of wood creates dust, although wetting the wood before chipping can reduce dust levels. Furthermore, burning wood releases volatile organic compounds, or VOCs, which pose a health risk.[41] The amount of air pollutants, including NO_X and SO_2, emitted by wood burning power plants is significantly lower than those emitted by plants using coal.[42]

The amount of ash produced by burning wood varies depending on the type of wood wastes used. Clean chips containing no bark have a low ash content, typically less than 0.5 percent. Wood chips containing bark have a higher ash content of around 1 percent. Sawdust has a low ash content of around 0.5 percent.[43] Ash resulting from burning wood can be sold as a fertilizer or disposed of in landfills. Typically, softwoods such as pine have higher ash contents than hardwoods.[44]

Co-firing biomass with coal can reduce coal's harmful emissions.

On the other hand, co-firing biomass with coal can reduce coal's harmful emissions. In particular, co-firing can reduce sulfur oxides (SO_X), which produce acid rain, on a one-to-one basis; in other words, replacing 10 percent of coal with biomass reduces its SO_X emissions by 10 percent.[45]

Depending upon the plant type, electricity generation from wood biomass requires withdrawals of between 9 gallons and 14,655 gallons per million Btu of heat produced.[46] This is the amount of water extracted from a water source; most of the water withdrawn is returned to that source. Water consumption refers to the portion of those withdrawals that is actually used and no longer available. Water consumption ranges from zero to 150 gallons per million Btu produced.[47]

Other Risks

During the Texas Forestry and Bioenergy Conference held in Nacogdoches in May 2007, participants discussed concerns about fertilizer use in the forestry industry. Logging residue provides natural fertilization for remaining trees as well as for new trees that may be planted at the same site. Foresters are concerned that removing these trimmings and other residues will require them to use more fertilizer, adding to their costs.

Finally, wood fuel typically is transported to the power plants by truck, leading to increased traffic in local areas, high transportation fuel costs and increased emissions. Increased truck traffic in areas without a robust transportation infrastructure leads to heavy wear and tear on existing rural roadways.

State and Federal Oversight

The federal Clean Air Act and Clean Water Act both affect wood-burning power plants. Wood-fired power plants are particularly affected by the National Ambient Air Quality Standards, which quantify the amount of particulate matter that a facility may generate, both in a 24-hour period and annually. Wood combustion produces fine particulate matter (2.5 micrometers in diameter or smaller). The standards also regulate course particulate matter (between 2.5 and 10 micrometers in diameter), such as the dust generated by truck traffic.[48]

The Texas Commission on Environmental Quality grants permits for air and wastewater quality. As with other electricity generation facilities, wood biomass plants require other permits including wetland impact permits, a threatened and endangered species permit and an acid rain permit. Permits required vary by geographical location.

Subsidies and Taxes

The federal Renewable Electricity Production Tax Credit, established in 1992 and extended and renewed several times, is a corporate income tax credit that provides an annually adjusted incentive to utilities that produce power from renewable sources. In 2008, the incentive is 2.0 cents per kWh for many renewable sources such as wind, geothermal and

closed-loop biomass (see sidebar). A smaller incentive of one cent per kWh was available for energy produced using open-loop biomass, small irrigation hydroelectric power (generated without a dam and with a capacity of between 150 kW and 5 MW), landfill gas and municipal solid waste.[49]

The 2007 Texas Legislature's House Bill 1090 creates incentives of up to $30 million annually to support electricity produced from biomass and made available to the state's electric grid. H.B. 1090 will provide subsidies of $20 per bone-dry ton of wood, up to $6 million per year, for each qualifying entity.[50] This incentive will be given to wood suppliers (loggers, mills and landfills), who could in turn pass along lower fuel costs to electricity generators. Funding for this program will require an appropriation and will not begin until 2009 at the earliest.

Another 2007 bill, H.B. 1214, would have strengthened the current law stating that 500 MW of renewable power in Texas should come from a source other than wind, making it a requirement rather than a suggestion, but the bill did not pass.

More information on subsidies and incentives for wood biomass can be found in Chapter 28.

Other States and Countries

Many states operate wood-fired biomass power plants. California and Michigan have several smaller-scale sites in the range of 10 to 35 MW.[51]

One of the most successful wood biomass operations is the Joseph C. McNeil Generating Station in Burlington, Vermont, a 50 MW electricity plant mostly powered by wood. The facility consumes 180,000 tons of wood per year. Seventy percent of this comes from "low-quality" trees; 25 percent from chip and bark residues; and 5 percent is clean recycled wood. McNeil estimates that the wood it uses costs about $12 to $20 per ton. The facility also has a waste yard where individuals can dispose of wood and yard waste. It sells wood ash to a contractor who mixes it with limestone as a soil conditioner.[52]

Outlook for Texas

Wood-fired biomass has some potential for Texas, particularly East Texas, which has enough potential capacity to produce the majority of the state's suggested goal of 500 MW of non-wind renewable energy capacity. The main obstacle to wood-fired biomass power plants is economic. Without incentives and subsidies, the cost of the fuel is too high to make such plants profitable.

Furthermore, some oppose the use of wood waste for electricity generation. As already noted, some Texas foresters believe that gathering logging residue off the forest floor may require them to use more fertilizer to grow trees, although further study of this issue is needed.

Some Texas mills and paper plants believe that Texas' incentives and subsidies for biomass-generated electricity are unfair.[53] Again, many mills and paper plants produce electricity for their own use from their own wood waste, yet this electricity is not eligible for state incentives and subsidies because it does not go to the power grid.[54]

Other critics oppose a state mandate requiring non-wind renewable sources such as wood-fired biomass because they believe that it will cost more than electricity generated from other sources.[55] Electricity generated from biomass that is placed on the grid becomes part of the mix of the state's energy portfolio; electricity consumers generally do not get to choose from which source their electricity is generated.

Wood-fired biomass may never comprise more than a small percentage of the state's energy portfolio, but it could create jobs in rural areas and stimulate the local economy in East Texas.

Wood-fired biomass has some potential for Texas, particularly East Texas.

The Energy Policy Act of 2005 defines Closed and Open Loop Biomass:

Closed-loop Biomass: any organic material from a plant that is planted exclusively for use at a qualified facility to produce electricity.

Open-loop Biomass: any agricultural livestock waste nutrients or any solid, nonhazardous, cellulosic waste material or nonhazardous lignin waste material that is segregated from other waste materials and derived from forest-related resources, including mill and harvesting residues, precommercial thinnings, slash and brush or solid wood waste materials. This does not include municipal solid waste, gas derived from the biodegradation of solid waste, paper that is commonly recycled or biomass used in co-firing.

Source: Energy Policy Act of 2005.

Endnotes

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13 U.S. Department of Energy, *Federal Technology Alert: Biomass Cofiring in Coal-Fired Boilers* (Washington, D.C., June, 2004), p. 1, http://www1.eere.energy.gov/femp/pdfs/fta_biomass_cofiring.pdf. (Last visited April 19, 2008.)

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30 Texas Forest Service, *Biomass from Logging Residue and Mill Residue in East Texas*, 2005, by Weihuan Xu and Burl Carraway (College Station, Texas, May 2007), pp. 3 and 5.

[31] A simple formula can be used to calculate Btu per pound of wood: Energy Content (Btu/pound) = (1-m)*8500, where 'm' is the fractional moisture content of the wood. For example, a wood sample with a moisture content of 30 percent would have an energy content equal to (1-0.3)*8500 = 5,950 Btu/pound.

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[34] Interview with Jack Lauterbach, chief operating officer, Mesquite Fuels and Agriculture, Austin, Texas, January 24, 2008.

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[38] The State of Oregon, "Biomass Energy: Cost of Production," http://www.oregon.gov/ENERGY/RENEW/Biomass/Cost.shtml. (Last visited April 20, 2008.)

[39] Conference call with Wayne Fleenor, consultant, ROSS Communications, Austin, Texas, Jeff Snowden, consultant, CAPEX Consulting Group, Frisco, Texas and Steve Bearden, President and CEO, Rio Grande Valley Sugar Growers, Inc., March 5, 2008.

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[46] U.S. Department of Energy, *Energy Demands on Water Resources*, pp. 65.

[47] U.S. Department of Energy, *Energy Demands on Water Resources*, pp. 65.

[48] U.S. Environmental Protection Agency, Air Quality Planning and Standards, *Fact Sheet: Final Revisions to the National Ambient Air Quality Standards for Particle Pollution* (Research Triangle Park, North Carolina, September 21, 2006), pp. 1 and 4, http://www.epa.gov/oar/particlepollution/pdfs/20060921_factsheet.pdf. (Last visited April 20, 2008.)

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