3. BIOPOWER

BIOMASS POWER OVERVIEW

Biomass power technologies convert renewable biomass fuels to heat and electricity using processes similar to that used with fossil fuels. Next to hydropower, more electricity is generated from biomass than any other renewable energy resource in the United States. A key attribute of biomass is its availability upon demand - the energy is stored within the biomass until it is needed. Other forms of renewable energy are dependent on variable environmental conditions such as wind speed or sunlight intensity.

Today in parts of the developing world (and until several decades ago in the United States), biomass is primarily used to provide heat for cooking and comfort. Technologies have now been developed which can generate electricity from the energy in biomass fuels. Biomass technologies are highly scaleable – small enough to be used on a farm or in remote villages, or large enough to provide power for a small city.

There are four primary classes of biopower systems: direct-fired, co-fired, gasification, and modular systems. Most of today's biopower plants are **direct-fired** systems that are similar to most fossil-fuel fired power plants. The biomass fuel is burned in a boiler to produce high-pressure steam. This steam is introduced into a steam turbine, where it flows over a series of aerodynamic turbine blades, causing the turbine to rotate. The turbine is connected to an electric generator, so as the steam flow causes the turbine to rotate, the electric generator turns and electricity is produced. Biomass power boilers are typically in the 20-50 MW range, compared to coal-fired plants in the 100-1500 MW range. The small capacity plants tend to be lower in efficiency because of economic trade-offs; efficiency-enhancing equipment cannot pay for itself in small plants. Although techniques exist to push biomass steam generation efficiency over 40%, actual plant efficiencies are often in the low 20% range.

Co-firing involves substituting biomass for a portion of coal in an existing power plant furnace. It is the most economic near-term option for introducing new biomass power generation. Because much of the existing power plant equipment can be used without major modifications, co-firing is far less expensive than building a new biopower plant. Compared to the coal it replaces, biomass reduces sulphur dioxide (SO2), nitrogen oxides (NOx), and other air emissions. After "tuning" the boiler for peak performance, there is little or no loss in efficiency from adding biomass. This allows the energy in biomass to be converted to electricity with the high efficiency (in the 33-37% range) of a modern coal-fired power plant.

Biomass gasifiers operate by heating biomass in an environment where the solid biomass breaks down to form a flammable gas. The biogas can be cleaned and filtered to remove problem chemical compounds. The gas can be used in more efficient power generation systems called combined-cycles, which combine gas turbines and steam turbines to produce electricity. The efficiency of these systems can reach 60%.

Modular systems employ some of the same technologies mentioned above, but on a smaller scale that is more applicable to villages, farms, and small industry. These systems are now under development and could be most useful in remote areas where biomass is abundant and electricity is scarce. There are many opportunities for these systems in developing countries.

Source:
U.S. Department of Energy, Energy Efficiency and Renewable Energy.

Table 3.1
Biomass Power Technology in Commercial/Demonstration Phase during 2000-2006

Technology Category	Biomass Conversion Technology	Primary Energy Form Produced	Primary Energy Conversion Technology	Final Energy Products
Direct combustion	Stove/Furnace	Heat	Heat exchanger	Hot air, hot water
Direct combustion	Pile burners	Heat, steam	Steam turbine	Electricity
Direct combustion	Stoker grate boilers	Heat, steam	Steam turbine	Electricity
Direct combustion	Suspension boilers: Air spreader stoker or cyclonic	Heat, steam	Steam turbine	Electricity
Direct combustion	Fluidized-bed combustor FB – bubbling CFB-circulating	Heat, steam	Steam turbine	Electricity
Direct combustion	Co-firing in coal-fired boilers (several types)	Heat, steam	Steam turbine	Electricity
Gasification (atmospheric)	updraft, counter current fixed bed	Low Btu producer gas	Combustion boiler + steam generator and turbine	Process heat or heat plus electricity
Gasification (atmospheric)	Downdraft, moving bed	Low Btu producer gas	Spark engine (internal combustion)	Power, electricity
Gasification (atmospheric)	Circulating Fluidized Bed (CFB) dual vessel	medium Btu producer gas	Burn gas in boiler w/ Steam Turbine	Electricity
Gasification (atmospheric)	Co-firing in CFB gasifiers	Low or medium Btu producer gas	Burn gas in boiler w/ Steam Turbine	Electricity
Pyrolysis	Kilns or retorts	Charcoal	Cook stoves and furnaces	Heat
Pyrolysis	Pryolysis units (for slow, fast or flash pyrolysis)	Synthetic fuel oil , gas and charcoal	Diesel engines, bioler/turbine, furnace	Power, electricity, heat
Anerobic digestion	Digesters, landfills	Low to medium Btu producer gas	Furnace, gas engine, gas turbine	Heat, electricity, power

Source:
Compiled by Lynn Wright, Oak Ridge, TN.

Note: See Glossary for definitions of terms found under the "Technology Category" column.
The following references are suggested for further reading:

Overend, Ralph. 2003. Heat, power and combined heat and power. Chapter 3 in: Sims, R. Bioenergy Options for a Cleaner Environment: In Developed and Developing Countries, Elsiver, ISBN: 0-08-044351-6. 193 pages

Broek, R. van den, Faaij, A., and van Wijk, J. 1995, Biomass Combustion Power Generation Technologies, Study performed within the framework of the extended JOULE-IIA programme of CECDGXII, project “Energy from biomass: an assessment of two promising systems for energy production”, Department of Science, Technology and Society, Utrech University, Utrecht (Report no. 95029). Available at website: http://www.chem.uu.nl/nws/www/publica/95029.htm

Table 3.2
Biomass Power Technology Fuel Specifications and Capacity Range

Biomass Conversion Technology	Commonly used fuel types[a]	Particle Size Requirements	Moisture Content Requirements (wet basis)[b]	Average capacity range / link to examples
Stove/Furnace	solid wood, pressed logs, wood chips and pellets	Limited by stove size and opening	10 – 30%	15 kWt to ?
Pile burners	Virtually any kind of wood residues[c] or agricultural residues[d] except wood flour	Limited by grate size and feed opening	< 65%	4 to 110 MWe
Pile burner fed with underfire stoker (biomass fed by auger below bed)	Sawdust, non-stringy bark, shavings, chips, hog fuel	0.25-2 in (6-38 mm)	10-30%	4 to 110 MWe
Stoker grate boilers	Sawdust, non-stringy bark, shavings, end cuts, chips, chip rejects, hog fuel	0.25 – 2 in (6 -50 mm)	10-50% (keep within 10% of design rate)	20 to 300 Mwe many in 20 to 50 MWe range
Suspension boilers Cyclonic	Sawdust. Non-stringy bark, shavings, flour, sander dust	0.25 in (6 mm) max	< 15%	many < 30 MWe
Suspension boilers, Air spreader-stoker	Wood flour, sander dust, and processed sawdust, shavings	0.04 in -0.06 in (1-1.6 mm)	< 20%	1.5 MWe to 30 Mwe
Fluidized-bed combustor (FB- bubbling or CFB-circulating)	Low alkali content fuels, mostly wood residues or peat no flour or stringy materials	< 2 in (<50 mm)	< 60%	Many at 20 to 25 MWe, up to 300 Example 1 Example 2
Co-firing: pulverized coal boiler	Sawdust, non-stringy bark, shavings, flour, sander dust	<0.25 in (<6 mm)	< 25%	Up to 1500 MWe[e] Example
Co-firing: cyclones	Sawdust, non-stringy bark, shavings, flour, sander dust	<0.5 in (<12 mm)	10 – 50%	40 to 1150 MWe[e] Example
Co-firing: stokers, fluidized bed	Sawdust, non-stringy bark, shavings, flour, hog fuel	< 3 in (<72 mm)	10 – 50%	MWe[e] Example
Counter current, fixed bed (updraft) atmospheric	Chipped wood or hog fuel, rice hulls, dried sewage sludge	0.25 – 4 in (6 – 100 mm)	< 20%	5 to 90 MWt, + up to 12 MWe Example
Downdraft, moving bed atmospheric gasifier	Wood chips, pellets, wood scrapes, nut shells	< 2 in (<50 mm)	<15%	~ 25-100 kWe Example
Circulating fluidized bed (CFB), dual vessel, gasifier	Most wood and chipped agricultural residues but no flour or stringy materials	0.25 – 2 in (6 -50 mm)	15-50%	~ 5 to 10 Mwe Example
Fast pryolysis	Variety of wood and agricultural resources	0.04-0.25 in (1-6 mm)	< 10%	~ 2.5 Mwe Example 1 Example 2
Anerobic digesters	Animal manures & bedding, food processing residues, brewery by-products, other industry organic residues	NA	65 to 99.9% liquid depending on type, i.e., 0.1 to 35% solids	145 to 1700 x 103 kwhr/yr Example 1 Example 2

Source:
Compiled by Lynn Wright, Oak Ridge, TN.

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[a] Primary source for fuel types is: Badger, Phillip C. 2002. *Processing Cost Analysis for Biomass Feedstocks*. ORNL/TM-2002/199. Available at http://bioenergy.ornl.gov/main.aspx (search by title or author).

[b] Most primary biomass, as harvested, has a moisture content (MC) of 50 to 60% (by wet weight) while secondary or tertiary sources of biomass may be delivered at between 10 and 30%. A lower MC always improves efficiency and some technologies require low MC biomass to operate properly while others can handle a range of MC.

[c] Wood residues may include forest logging residues and storm damaged trees (hog fuel), primary mill residues (e.g. chipped bark and chip rejects), secondary mill residues (e.g. dry sawdust), urban wood residues such as construction and demolition debris, pallets and packaging materials, tree trimmings, urban land clearing debris, and other wood residue components of municipal solid waste (as wood chips).

[d] Agricultural residues may include straws and dried grasses, nut hulls, orchard trimmings, fruit pits, etc. Slagging may be more of a problem in some types of combustion units with high alkali straws and grasses, unless the boilers have been specially designed to handle these type fuels.

[e] The biomass component of a co-firing facility will usually be less than the equivalent of 50MWe.

There are three distinct markets for green power in the United States. In regulated markets, a single utility may provide a green power option to its customers through "green pricing," which is an optional service or tariff offered to customers. These utilities include investor-owned utilities, rural electric cooperatives, and other publicly-owned utilities. More than 500 utilities in 34 states offer green pricing or are in the process of preparing programs.

In restructured (or competitive) electricity markets, retail electricity customers can choose from among multiple electricity suppliers, some of which may offer green power. Electricity markets are now open to full competition in a number of states, while others are phasing in competition.

Finally, consumers can purchase green power through "renewable energy certificates." These certificates represent the environmental attributes of renewable energy generation and can be sold to customers in either type of market, whether or not they already have access to a green power product from their existing retail power provider.

Utility market research shows that majorities of customer respondents are likely to state that they would pay at least $5 more per month for renewable energy. And business and other nonresidential customers, including colleges and universities, and government entities, are increasingly interested in green power.

Table 3.3
New Renewable Capacity Supplying Green Power Markets, 2004

Source	MW in Place	%	MW Planned	%
Wind	2045.6	91.6	364.5	80.1
Biomass	**135.6**	**6.1**	**58.8**	**12.9**
Solar	8.1	0.4	0.4	0.1
Geothermal	35.5	1.6	0	0
Small Hydro	8.5	0.4	31.3	6.9
Total	**2233.3**	**100**	**455**	**100**

Source:
National Renewable Energy Laboratory, *Power Technologies Energy Data Book*, Chapter 3, Table 3.6.5.
http://www.nrel.gov/analysis/power_databook/chapter3.html

Note: MW = megawatt.

Green pricing is an optional utility service that allows customers an opportunity to support a greater level of utility company investment in renewable energy technologies. Participating customers pay a premium on their electric bill to cover the extra cost of the renewable energy. Many utilities are offering green pricing to build customer loyalty and expand business lines and expertise prior to electric market competition. As of 2003, 36 utilities in 19 states had implemented green pricing options that used or included biomass feedstocks.

Table 3.4
New Renewable Capacity Supported through Utility Green Pricing Programs, 2004

Source	MW in Place	%	MW Planned	%
Wind	584.0	82.8	139.7	61.1
Biomass	76.3	10.8	57.5	25.1
Solar	6.1	0.9	0.2	0.1
Geothermal	30.5	4.3	0.0	0.0
Small Hydro	8.5	1.2	31.3	13.7
Total	**705.5**	**100.0**	**228.7**	**100.0**

Source:
National Renewable Energy Laboratory, *Power Technology Energy Data Book*, Table 3.7.1, http://www.nrel.gov/analysis/power_databook/chapter3.html

Note: MW = megawatt.

There are a growing number of utilities offering green pricing programs that utilize biomass resources.

Table 3.5
Utility Green Pricing Programs Using Biomass and Biomass Based Resources

State	Utility Name	Program Name	Resource Type	Start Date	Premium
Alabama	Alabama Power	Renewable Energy Rate	biomass co-firing	2003 / 2000	6.0¢/ kWh
	TVA	Green Power Switch	wind, landfill gas, solar	2000	2.67¢/ kWh
Arizona	Salt River Project	EarthWise Energy	central PV,landfill gas, small hydro	1998 / 2001	3.0¢/kWh
	Tucson Electric	GreenWatts	landfill gas, PV, wind	2000	7.5-10¢/ kWh
California	Los Angeles Dept. of Water and Power	Green Power for a Green LA	wind, landfill gas	1999	3.0¢/kWh
	Sacramento Municipal Utility District	Greenergy	wind, landfill gas, hydro	1997	1.0¢/kWh
Colorado	Tri-State Generation & Transmission	Renewable Resource Power Service	wind, landfill gas	1999	2.5¢/kWh
Florida	City of Tallahassee / Sterling Planet	Green for You	biomass, solar	2002	1.6¢/kWh
	Florida Power & Light / Green Mountain Energy	Sunshine Energy	biomass, wind, solar	2004	0.975¢/kWh
	Gainesville Regional Utilities	GRUgreen Energy	landfill gas, wind, solar	2003	2.0¢/kWh
	Tampa Electric Company (TECO)	Tampa Electric's Renewable Energy	PV, landfill gas	2000	10.0¢/kWh
Georgia	Georgia Electric Membership Corporation	Green Power EMC	landfill gas	2001	TBD
	Georgia Power	Green Energy	landfill gas, wind, solar	TBD	5.5¢/kWh
	Savannah Electric	Green Energy	landfill gas, wind, solar	TBD	6.0¢/kWh
	TVA	Green Power Switch	wind, landfill gas, solar	2000	2.67¢/ kWh
Iowa	Alliant Energy	Second Nature	wind, landfill gas	2001	2.0¢/kWh
	Farmers Electric Cooperative	Green Power Project	biodiesel, wind	2004	Contribution
	Iowa Association of Municipal Utilities	Green City Energy	wind, biomass, solar	2003	Varies by utility

Continued on next page

Table 3.5 (Continued)
Utility Green Pricing Programs Using Biomass and Biomass Based Resources

State	Utility Name	Program Name	Resource Type	Start Date	Premium
Illinois	City of St. Charles / ComEd and Community Energy, Inc.	TBD	wind, landfill gas	2003	Contribution
Indiana	Hoosier Energy	EnviroWatts	landfill gas	2001	2.0¢/kWh-4.0¢/kWh
	PSI Energy/Cinergy	Green Power Rider	wind, solar, landfill gas, digester gas	2001	Contribution
	Wabash Valley Power Association	EnviroWatts	landfill gas	2000	0.9-1.0¢/kWh
Kentucky	East Kentucky Power Cooperative	EnviroWatts	landfill gas	2002	2.75¢/kWh
	TVA	Green Power Switch	landfill gas, solar, wind	2000	2.67¢/kWh
Michigan	Lansing Board of Water and Light	GreenWise Electric Power	landfill gas, small hydro	2001	3.0¢/kWh
	We Energies	Energy for Tomorrow	wind, landfill gas, hydro	2000	2.04¢/kWh
Minnesota	Alliant Energy	Second Nature	wind, landfill gas	2002	2.0¢/kWh
Mississippi	TVA	Green Power Switch	wind, landfill gas, solar	2000	2.67¢/kWh
North Carolina	Dominion North Carolina Power, Power, Progress Energy/CP&L *Plus* 7 cities and 14 cooperatives	NC GreenPower	biomass, wind, solar	2003	4.0¢/kWh
	TVA	Green Power Switch	landfill gas, solar, wind	2000	2.67¢/kWh
Nebraska	Omaha Public Power District	Green Power Program	landfill gas, wind	2002	3.0¢/kWh
	Tri-State: Chimney Rock Public Power District,	Renewable Resource Power Service	wind, landfill gas	2001	2.5¢/kWh
New Mexico	Tri-State: Kit Carson Electric Cooperative	Renewable Resource Power Service	wind, landfill gas	2001	2.5¢/kWh
Ohio	City of Bowling Green	Bowling Green Power	small hydro, wind, landfill gas	1999	1.35¢/kWh
Oregon	Pacific Northwest Generating Cooperative	Green Power	landfill gas	1998	1.8-2.0¢/kWh
South Carolina	Eight different cooperatives	Green Power Program	landfill gas	2001	3.0¢/kWh

Source:
National Renewable Energy Laboratory, *Power Technologies Energy Data Book*, Table 3.8.2, http://www.nrel.gov/analysis/power_databook/chapter3.html

A growing number of states have companies that offer a range of green power products that allow consumers to purchase electricity generated in part or entirely from biomass resources.

Table 3.6
Competitive Electricity Markets Retail Green Power Product Offerings, October 2005

State	Company	Product Name	Residential Price Premium[a]	Fee	Resource Mix[b]	Certification
Connecticut	Community Energy (CT Clean Energy Options Program)	CT Clean Energy Options 50% or 100% of usage	1.1¢/kWh	—	50% new wind, 50% landfill gas	—
	Levco	100% Renewable Electricity Program	0.0¢/kWh	—	98% waste-to-energy and hydro (Class II), 2% new solar, wind, fuel cells, and landfill gas	—
	Sterling Planet (CT Clean Energy Options Program)	Sterling Select 50% or 100% of usage	1.15¢/kWh	—	33% new wind, 33% existing small low impact hydro, 34% new landfill gas	—
District of Columbia	PEPCO Energy Services[c]	Green Electricity 10%, 51% or 100% of usage	1.35¢/kWh (for 100% usage)	—	landfill gas	—
Maryland	PEPCO Energy Services[d]	Green Electricity 10%, 51% or 100% of usage	2.75¢/kWh (for 100% usage)	—	landfill gas	—
	PEPCO Energy Services[d]	Non-residential product	NA	—	50% to 100% eligible renewables	Green-e
Massachusetts	Cape Light Compact[e]	Cape Light Compact Green 50% or 100%	1.768¢/kWh (for 100% usage)	—	75% small hydro, 24% new wind or landfill gas, 1% new solar	—
	Massachusetts Electric/Nantucket Electric/Mass Energy Consumers Alliance	New England GreenStart 50% or 100% of usage	2.4¢/kWh (for 100% usage)	—	75% small hydro, 19% biomass, 5% wind, 1% solar (≥25% of total is new)	—
	Massachusetts Electric/Nantucket Electric/Sterling Planet	Sterling Premium 50% or 100% of usage	1.35¢/kWh	—	50% small hydro, 30% bioenergy, 15% wind, 5% new solar	Environmental Resources Trust
New Jersey	Green Mountain Energy Company[f]	Enviro Blend	1.0¢/kWh	$3.95/mo.	5% new wind, 0.4% solar, 44.6% captured methane, 50% large hydro	—
	PSE&G/JCP&L/ Sterling Planet	Clean Power Choice Program	1.2¢/kWh	—	33% wind, 33% small hydro, 34% bioenergy	Environmental Resources Trust
New York	Energy Cooperative of New York[g]	Renewable Electricity	0.5¢/kWh to 0.75¢/kWh	—	25% new wind, 75% existing landfill gas	—
	Long Island Power Authority / EnviroGen	Green Power Program	1.0¢/kWh	—	75% landfill gas, 25% small hydro	—
	Long Island Power Authority / Sterling Planet	New York Clean	1.0¢/kWh	—	55% small hydro, 35% bioenergy, 10% wind	—
	Long Island Power Authority / Sterling Planet	Sterling Green	1.5¢/kWh	—	40% wind, 30% small hydro, 30% bioenergy	—
	Niagara Mohawk / EnviroGen	Think Green!	1.0¢/kWh	—	75% landfill gas, 25% hydro	—
	Niagara Mohawk / Sterling Planet	Sterling Green	1.5¢/kWh	—	40% wind, 30% small hydro, 30% bioenergy	Environmental Resources Trust
	Suburban Energy Services /Sterling Planet	Sterling Green Renewable Electricity	1.5¢/kWh	—	40% new wind, 30% small hydro, 30% bioenergy	—
Pennsylvania	Energy Cooperative of Pennsylvania[h]	EcoChoice 100	2.78¢/kWh	—	89% landfill gas, 10% wind, 1% solar	Green-e
	PEPCO Energy Services[h]	Green Electricity 10%, 51% or 100% of usage	3.7¢/kWh (for 100% usage)	—	100% renewable	—
Rhode Island	Narragansett Electric / Sterling Planet	Sterling Supreme 100%	1.98¢/kWh	—	40% small hydro, 25% biomass, 25% new solar, 10% wind	Environmental Resources Trust
TX	Gexa Energy[i]	Gexa Green	-1.1¢/kWh	—	100% renewable	—
VA	PEPCO Energy Services[j]	Green Electricity 10%, 51% or 100% of usage	4.53¢/kWh (for 100% usage)	—	landfill gas	—

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Table 3.6 (Continued)
Competitive Electricity Markets Retail Green Power Product Offerings, October 2005

Source:
National Renewable Energy Laboratory, *Power Technologies Energy Data Book*, Table 3.8.8, http://www.nrel.gov/analysis/power_databook/chapter3.html.

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[a] Prices updated as of July 2005 and may also apply to small commercial customers. Prices may differ for large commercial/industrial customers and may vary by service territory.

[b] New is defined as operating or repowered after January 1, 1999 based on the Green-e TRC certification standards.

[c] Offered in PEPCO service territory. Product prices are for renewal customers based on annual average costs for customers in PEPCO's service territory (6.8¢/kWh).

[d] Product offered in Baltimore Gas and Electric and PEPCO service territories. Price is for PEPCO service territory based on price to compare of 6.55¢/kWh.

[e] Price premium is based on a comparison to the Cape Light Compact's standard electricity product.

[f] Green Mountain Energy offers products in Conectiv, JCPL, and PSE&G service territories. Product prices are for PSE&G (price to compare of 6.503¢/kWh).

[g] Price premium is for Niagara Mohawk service territory. Program only available in Niagara Mohawk service territory. Premium varies depending on energy taxes and usage.

[h] Product prices are for PECO service territory (price to compare of 6.21¢/kWh).

[i] Product prices are based on price to beat of 12.1¢/kWh for TXU service territory (specifically Dallas, Texas) (Except where noted). Except for Gexa Green, which is listed in price per kWh, prices based on 1000 kWh of usage monthly, and include monthly fees.

[j] Products are available in Dominion Virginia Power service territory.

Renewable energy certificates (RECs)—also known as green tags, renewable energy credits, or tradable renewable certificates—represent the environmental attributes of power generated from renewable electric plants. A number of organizations offer green energy certificates separate from electricity service (i.e., customers do not need to switch from their current electricity supplier to purchase these certificates). Organizations that offer green certificate products using biomass resources are listed below.

Table 3.7
Renewable Energy Certificate Product Offerings, October 2005

Certificate Marketer	Product Name	Renewable Resources	Location of Renewable Resources	Residential Price Premium	Certification
Blue Sky Energy Corp	Greener Choice™ Green Tags	Landfill Gas	Utah	1.95¢/kWh	—
Bonneville Environmental Foundation	Green Tags	≥98% new wind, ≤ 1% new solar, ≤ 1% new biomass	Washington, Oregon, Wyoming, Montana, Alberta	2.0¢/kWh	Green-e
Clean Energy Partnership/Sterling Planet	National New Clean Energy MIx	24% wind, 25% biomass, 50% landfill gas, 1% solar	National	0.6¢/kWh	Environmental Resources Trust
Maine Interfaith Power & Light/BEF	Green Tags (supplied by BEF)	≥98% new wind, ≤ 1% new solar, ≤ 1% new biomass	Washington, Oregon, Wyoming, Montana, Alberta	2.0¢/kWh	—
NativeEnergy	CoolHome	New biogas and new wind	Vermont and Pennsylvania (biomass), South Dakota (wind)	0.8¢/kWh - 1.0¢/kWh	[a]
Sterling Planet	Green America	45% new wind 50% new biomass 5% new solar	Nationwide	1.6¢/kWh	Green-e
TerraPass Inc.	TerraPass	Various (including efficiency and CO2 offsets)	Nationwide	~$11/ton CO2	—

Source:
National Renewable Energy Laboratory, Power Technologies Energy Data Book, Table 3.8.9, http://www.nrel.gov/analysis/power_databook/chapter3.html

Note: — = Information not available.
New is defined as operating or repowered after January 1, 1999, based on the Green-e TRC certification standards. Most product prices are as of July 2005.

[a] The Climate Neutral Network certifies the methodology used to calculate the CO2 emissions offset.

Table 3.8
Current Biomass Power Plants

Plant Name	Boiler/Generator/ Committed Unit	State Name	County	Capacity MW	Heat Rate	Cogeneration	On-line Year
Florida Coast Paper Co LLC	G	Florida	GULF	0.128873283	8538.991465	Yes	1937
Florida Coast Paper Co LLC	G	Florida	GULF	0.128873283	8538.991465	Yes	1937
Florida Coast Paper Co LLC	G	Florida	GULF	0.128873283	8538.991465	Yes	1947
Florida Coast Paper Co LLC	G	Florida	GULF	0.180422596	8538.991465	Yes	1952
Florida Coast Paper Co LLC	G	Florida	GULF	0.214788805	8538.991465	Yes	1952
Great Northern Paper	G	Maine	PENOBSCOT	0.044617579	8538.991465	Yes	1954
Great Northern Paper	G	Maine	PENOBSCOT	0.044617579	8538.991465	Yes	1956
Fort Bragg Western Wood Products	G	California	MENDOCINO	1.448629561	8538.991465	Yes	1961
Stone Container Corporation Florence	G	South Carolina	FLORENCE	3.280605752	8538.991465	Yes	1963
Fort Bragg Western Wood Products	G	California	MENDOCINO	1.448629561	8538.991465	Yes	1969
Florida Coast Paper Co LLC	G	Florida	GULF	0.365140968	8538.991465	Yes	1974
Stone Container Corporation Florence	G	South Carolina	FLORENCE	4.199175363	8538.991465	Yes	1974
Somerset Plant	G	Maine	SOMERSET	0.673694411	8538.991465	Yes	1976
Fort Bragg Western Wood Products	G	California	MENDOCINO	1.448629561	8538.991465	Yes	1977
Vaagen Brothers Lumber Incorporated	G	Washington	STEVENS	4.00	8538.991465	Yes	1979
Forster Inc Strong Plant	G	Maine	FRANKLIN	0.12519927	8538.991465	Yes	1980
Stone Container Corporation Hopewell	G	Virginia	PRINCE	4.760897033	8538.991465	Yes	1980
Diamond Walnut	G	California	SAN JOAQUIN	3.901181102	15339	Yes	1981
Wheelabrator Hudson Energy Co	G	California	SHASTA	5.841304881	12368.66667	No	1982
Rayonier Inland Wood Products	G	Idaho	BENEWAH	6.25	8538.991465	Yes	1982
Tamarack Energy Partnership	G	Idaho	ADAMS	5.201707828	25416.43077	Yes	1983
Snider Industries Incorporated	G	Texas	HARRISON	1.542490288	12368.66667	Yes	1983
Agrilectric Power Partners Limited	G	Louisiana	CALCASIEU	9.213845328	9224	No	1984
Bio Energy Corporation	G	New Hampshire	MERRIMACK	11.42246966	8538.991465	Yes	1984
Susanville Facility	G	California	LASSEN	1.002430238	9224	No	1985
Collins Pine Company Project	G	California	PLUMAS	4.169269438	8538.991465	Yes	1985
Wheelabrator Martell Inc	G	California	AMADOR	6.487078891	8538.991465	Yes	1985
Susanville Facility	G	California	LASSEN	7.503397937	9224	No	1985
Pacific Oroville Power Inc	G	California	BUTTE	8.53833579	9224	No	1985
Pacific Oroville Power Inc	G	California	BUTTE	8.53833579	9224	No	1985
Mt Lassen Power	G	California	SHASTA	10.33804027	9224	No	1985
Burney Mountain Power	G	California	SHASTA	10.57367613	9224	No	1985
Ultrapower Chinese Station	G	California	TUOLUMNE	21.38108255	9224	No	1985
Biomass One L P	G	Oregon	JACKSON	0.882171777	8538.991465	Yes	1985
Biomass One L P	G	Oregon	JACKSON	13.23257666	8538.991465	Yes	1985
Crestwood Corporation Dothan	G	Alabama	HOUSTON	3.733695627	8538.991465	Yes	1986
Lincoln Facility	G	California	PLACER	2.13531303	9224	No	1986
Quincy Facility	G	California	PLUMAS	10.50316385	9224	No	1986
Burney Facility	G	California	SHASTA	11.96450375	9224	No	1986
Fairhaven Power Co	G	California	HUMBOLDT	15.19195204	9224	No	1986
Timber Energy Resources Incorporated	G	Florida	LIBERTY	13.56859989	9224	No	1986
Sherman Energy Facility	G	Maine	PENOBSCOT	18.45844126	8538.991465	Yes	1986
Pinetree Power Incoporated	G	New Hampshire	GRAFTON	16.35655942	9224	No	1986
Co Gen LLC	G	Oregon	GRANT	6.84375	25416.43077	Yes	1986
Wheelabrator Shasta	G	California	SHASTA	16.35622526	9224	No	1987
Wheelabrator Shasta	G	California	SHASTA	16.35622526	9224	No	1987
Wheelabrator Shasta	G	California	SHASTA	16.35622526	9224	No	1987
Gorbell Thermo Electron Power	G	Maine	SOMERSET	14.0130841	9224	No	1987
Hillman Power Company L L C	G	Michigan	MONTMORENCY	18.10515075	9224	No	1987
Hemphill Power and Light Company	G	New Hampshire	SULLIVAN	14.27220787	9224	No	1987
Bridgewater Power Company LP	G	New Hampshire	GRAFTON	18.05291407	9224	No	1987
Pinetree Power Tamworth Inc	G	New Hampshire	CARROLL	22.69876766	9224	No	1987
Co-Gen II, LLC	G	Oregon	DOUGLAS	6.852791878	25416.43077	Yes	1987
Stone Container Corporation Florence	G	South Carolina	FLORENCE	20.7596732	8538.991465	Yes	1987
The Pacific Lumber Company	G	California	HUMBOLDT	6.001523055	8538.991465	Yes	1988
Greenville Steam Company	G	Maine	PISCATAQUIS	14.59498243	25416.43077	No	1988
Viking Energy of McBain	G	Michigan	MISSAUKEE	16.51695997	9224	No	1988
Whitefield Power and Light Co	G	New Hampshire	COOS	14.51030066	9224	No	1988
Susquehanna Plant	G	Pennsylvania	LYCOMING	10.91578166	7995.373263	Yes	1988
Viking Energy of Northumberland	G	Pennsylvania	NORTHUMBERL	16.94882449	9224	No	1988
The Pacific Lumber Company	G	California	HUMBOLDT	6.001523055	8538.991465	Yes	1989
Loyalton Facility	G	California	SIERRA	15.50036449	8538.991465	Yes	1989
Woodland Biomass Power Limited	G	California	YOLO	24.57285808	9224	No	1989
Mendota Biomass Power Limited	G	California	FRESNO	24.70598521	9224	No	1989
Wadham Energy Limited Partnership	G	California	COLUSA	25.4990433	9224	No	1989
Burney Forest Products	G	California	SHASTA	27.61054735	9082.609668	Yes	1989
HL Power Plant	G	California	LASSEN	31.50214419	9224	No	1989
A R Lavallee Incorporated	G	Maine	YORK	0.447784134	8538.991465	Yes	1989
S D Warren Company 2	G	Maine	CUMBERLAND	4.066280247	8538.991465	Yes	1989
Winslow, Maine	G	Maine	KENNEBEC	10.36716597	8538.991465	Yes	1989
S D Warren Company 2	G	Maine	CUMBERLAND	12.87655412	8538.991465	Yes	1989
Boralex Stratton Energy Inc	G	Maine	FRANKLIN	41.89923255	9224	No	1989
Viking Energy of Lincoln	G	Michigan	ALCONA	16.44424521	9224	No	1989

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Table 3.8 (Continued)
Current Biomass Power Plants

Plant Name	Boiler/Generator/ Committed Unit	State Name	County	Capacity MW	Heat Rate	Cogeneration	On-line Year
Tracy Biomass Plant	G	California	SAN JOAQUIN	20.50248146	9224	No	1990
Delano Energy Company Incorporated	G	California	KERN	27.07152119	9224	No	1990
Great Northern Paper	G	Maine	PENOBSCOT	0.086375057	8538.991465	Yes	1990
Somerset Plant	G	Maine	SOMERSET	0.842118014	8538.991465	Yes	1990
Craven County Wood Energy L P	G	North Carolina	CRAVEN	46.69179392	9224	No	1990
Potlatch Corp Southern Wood Products	G	Arkansas	BRADLEY	7.683280889	8538.991465	Yes	1991
Mecca Plant	G	California	RIVERSIDE	48.30915139	9224	No	1991
Beaver Livermore Falls	G	Maine	ANDROSCOGGI	36.25127717	9224	No	1992
Pinetree Power Fitchburg Inc	G	Massachusetts	WORCESTER	16.07467078	9224	No	1992
Lyonsdale Power Company LLC	G	Michigan	GRATIOT	19.36820024	8538.991465	Yes	1992
Grayling Generating Station	G	Michigan	CRAWFORD	37.99570523	9224	No	1992
Ryegate Power Station	G	Vermont	CALEDONIA	19.50652465	9224	No	1992
Delano Energy Company Incorporated	G	California	KERN	21.48884374	9224	No	1993
Beaver Ashland	G	Maine	AROOSTOOK	36.2184593	9224	No	1993
Cadillac Renewable Energy	G	Michigan	WEXFORD	35.86121164	10013.6	No	1993
KES Chateaugay Power Station	G	New York	FRANKLIN	17.62961823	9224	No	1993
Sauder Power Plant	G	Ohio	FULTON	3.085144462	10891.8	Yes	1993
Sauder Power Plant	G	Ohio	FULTON	3.085144462	10891.8	Yes	1993
Ridge Generating Station	G	Florida	POLK	40.06031261	9224	No	1994
Aroostook Valley	G	Maine	AROOSTOOK	29.50	9224	No	1994
Multitrade of Pittsylvania County L P Pl	G	Virginia	PITTSYLVANIA	41.347412	9224	No	1994
Multitrade of Pittsylvania County L P Pl	G	Virginia	PITTSYLVANIA	41.347412	9224	No	1994
Okeelanta Power Limited Partnership	G	Florida	PALM BEACH	61.33887206	8538.991465	Yes	1995
Cox Waste to Energy	G	Kentucky	TAYLOR	1.075439298	9224	No	1995
Agrilectric Power Partners Limited	G	Louisiana	CALCASIEU	1.139857154	9224	No	1995
Genesee Power Station Limited	G	Michigan	GENESEE	36.03528491	9224	No	1996
Everett Cogen	G	Washington	SNOHOMISH	36.00	8538.991465	Yes	1996
Bioten Operations Inc	G	Tennessee	MACON	0.731874145	10013.6	No	1997
Anderson Facility	G	California	SHASTA	0.679977523	10891.8	No	1998
Washington Veneer	G	Washington	OKANOGAN	0.962570193	8538.991465	Yes	1998
Washington Veneer	G	Washington	OKANOGAN	1.443855289	8538.991465	Yes	1998
Lincoln Facility	G	California	PLACER	0.060566964	8011	Yes	1999
Quincy Facility	G	California	PLUMAS	5.799762734	8011	No	1999
Trigen-Colorado Metro Facility Site	G	Colorado	ADAMS	3.52	29657	Yes	2000
Trigen-Colorado Metro Facility Site	G	Colorado	ADAMS	3.52	29657	Yes	2000
Horry LFG Site	G	South Carolina	HORRY	1.00	29657	No	2001
Horry LFG Site	G	South Carolina	HORRY	1.00	29657	No	2001
Jacobs Energy Corporation	C	Illinois	[a]	4.68	8911	No	2002
St. Paul Cogen, NonMandated	C	Minnesota	[a]	7.60	8911	No	2002
St. Paul Cogen, Mandated	C	Minnesota	[a]	23.75	8911	No	2002
Scott Wood	C	Virginia	[a]	0.90	8911	No	2002
Scott Wood	C	Virginia	[a]	2.80	8911	No	2002
Gorge Energy Div SDS	C	Washington	[a]	5.00	8911	No	2002
Environmental Forest Solutions	C	Arizona	[a]	2.85	8911	No	2003
Jacobs Energy Corporation	C	Illinois	[a]	0.62	8911	No	2003
Ware Biomass Cogen	C	Massachusetts	[a]	7.79	8911	No	2003
Massachusetts RPS 2003 - Biomass	C	Massachusetts	[a]	9.22	8911	No	2003
Aberdeen	C	Washington	[a]	16.00	8911	No	2003

Source:
(National Electric Energy System (NEEDS) Database for IPM 2004, http://www.epa.gov/airmarkets/epa-ipm/#needs.

[a] Data are not available.

Table 3.9
Current Landfill Gas Power Plants

Plant Name	Boiler/Generator/Committed Unit	State Name	County	Capacity MW	Heat Rate	Cogeneration	On-line Year
Puente Hills Energy Recovery	G	California	LOS ANGELES	44.76434101	11000	No	1986
Palos Verdes Gas to Energy Facility	G	California	ORANGE	11.60288061	11000	No	1988
Coyote Canyon Steam Plant	G	California	ORANGE	17.5218204	11000	No	1989
BKK Landfill	G	California	LOS ANGELES	5.984199375	11805	No	1993
O Brien Biogas IV LLC	G	New Jersey	MIDDLESEX	9.986892485	11805	No	1997
North City Cogeneration Facility	G	California	SAN DIEGO	0.933474164	11805	No	1999
North City Cogeneration Facility	G	California	SAN DIEGO	0.933474164	11805	No	1999
North City Cogeneration Facility	G	California	SAN DIEGO	0.933474164	11805	No	1999
North City Cogeneration Facility	G	California	SAN DIEGO	0.933474164	11805	No	1999
Prima Desheha Landfill	G	California	ORANGE	2.65094446	11805	No	1999
Prima Desheha Landfill	G	California	ORANGE	2.65094446	11805	No	1999
Kiefer LF	G	California	SACRAMENTO	2.769899605	11805	No	1999
Kiefer LF	G	California	SACRAMENTO	2.769899605	11805	No	1999
Kiefer LF	G	California	SACRAMENTO	2.769899605	11805	No	1999
BKK Landfill	G	California	LOS ANGELES	4.245327517	11805	No	1999
Tazewell Gas Recovery	G	Illinois	TAZEWELL	0.566133167	11805	No	1999
KMS Joliet Power Partners LP	G	Illinois	WILL	0.754613209	13648	No	1999
Roxana LF	G	Illinois	MADISON	1.000000002	13648	No	1999
Roxana LF	G	Illinois	MADISON	1.000000002	13648	No	1999
Roxana LF	G	Illinois	MADISON	1.000000002	13648	No	1999
Brickyard	G	Illinois	VERMILION	1.000000037	13648	No	1999
Brickyard	G	Illinois	VERMILION	1.000000037	13648	No	1999
Brickyard	G	Illinois	VERMILION	1.000000037	13648	No	1999
Dixon	G	Illinois	LEE	1.000000047	13648	No	1999
Dixon	G	Illinois	LEE	1.000000047	13648	No	1999
Dixon	G	Illinois	LEE	1.000000047	13648	No	1999
Streator	G	Illinois	LA SALLE	1.000000058	13648	No	1999
Streator	G	Illinois	LA SALLE	1.000000058	13648	No	1999
Biodyne Pontiac	G	Illinois	LIVINGSTON	1.54425	11805	No	1999
Deercroft Gas Recovery	G	Indiana	LA PORTE	0.783213037	11805	No	1999
Metro Methane Recovery Facility	G	Iowa	POLK	0.786481001	11805	No	1999
HMDC Kingsland Landfill	G	New Jersey	BERGEN	0.881475967	11805	No	1999
HMDC Kingsland Landfill	G	New Jersey	BERGEN	0.881475967	11805	No	1999
LFG Energy Inc	G	New York	ERIE	0.765217333	11805	No	1999
LFG Energy Inc	G	New York	ERIE	0.765217333	11805	No	1999
LFG Energy Inc	G	New York	ERIE	0.765217333	11805	No	1999
LFG Energy Inc	G	New York	ERIE	0.765217333	11805	No	1999
LFG Energy Inc	G	New York	ERIE	0.765217333	13648	No	1999
High Acres Gas Recovery	G	New York	MONROE	0.778894571	11805	No	1999
Blackburn Co-Generation	G	North Carolina	CATAWBA	0.857569492	11805	No	1999
Blackburn Co-Generation	G	North Carolina	CATAWBA	0.857569492	11805	No	1999
Blackburn Co-Generation	G	North Carolina	CATAWBA	0.857569492	13648	No	1999
Blackburn Co-Generation	G	North Carolina	CATAWBA	0.857569492	13648	No	1999
Charlotte Motor Speedway	G	North Carolina	CABARRUS	4.499151173	11805	No	1999
Cuyahoga Regional Landfill	G	Ohio	CUYAHOGA	1.777833611	11805	No	1999
Cuyahoga Regional Landfill	G	Ohio	CUYAHOGA	1.777833611	11805	No	1999
Roosevelt Biogas 1	G	Washington	KLICKITAT	2.10	11805	No	1999
Roosevelt Biogas 1	G	Washington	KLICKITAT	2.10	11805	No	1999
Roosevelt Biogas 1	G	Washington	KLICKITAT	2.10	11805	No	1999
Roosevelt Biogas 1	G	Washington	KLICKITAT	2.10	11805	No	1999
Tajiguas Landfill	G	California	SANTA BARBARA	2.752165154	11805	No	2000
KMS Joliet Power Partners LP	G	Illinois	WILL	0.759300247	13648	No	2000
Biodyne Pontiac	G	Illinois	LIVINGSTON	0.778130417	11805	No	2000
Upper Rock	G	Illinois	ROCK ISLAND	1.00	13648	No	2000
Upper Rock	G	Illinois	ROCK ISLAND	1.00	13648	No	2000
Upper Rock	G	Illinois	ROCK ISLAND	1.00	13648	No	2000
Roxana LF	G	Illinois	MADISON	1.000000002	13648	No	2000
Fall River Electric	G	Massachusetts	BRISTOL	0.879903479	11805	No	2000
Fall River Electric	G	Massachusetts	BRISTOL	0.879903479	11805	No	2000
Randolph Electric	G	Massachusetts	NORFOLK	0.943396199	11805	No	2000
Randolph Electric	G	Massachusetts	NORFOLK	0.943396199	11805	No	2000
Randolph Electric	G	Massachusetts	NORFOLK	0.943396199	11805	No	2000
Fall River Electric	G	Massachusetts	BRISTOL	4.399517393	11805	No	2000
Grand Blanc Generating Station	G	Michigan	GENESEE	0.767358272	11805	No	2000
M M Nashville	G	Tennessee	DAVIDSON	0.95	11805	No	2000
M M Nashville	G	Tennessee	DAVIDSON	0.95	11805	No	2000
Roosevelt Biogas 1	G	Washington	KLICKITAT	2.10	11805	No	2000
Metro Gas Recovery	G	Wisconsin	MILWAUKEE	0.698586128	13648	No	2000
Metro Gas Recovery	G	Wisconsin	MILWAUKEE	0.698586128	13648	No	2000
Metro Gas Recovery	G	Wisconsin	MILWAUKEE	0.698586128	13648	No	2000
Metro Gas Recovery	G	Wisconsin	MILWAUKEE	0.698586128	13648	No	2000

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Table 3.9 (Continued)
Current Landfill Gas Power Plants

Plant Name	Boiler/Generator/Committed Unit	State Name	County	Capacity MW	Heat Rate	Cogeneration	On-line Year
Pheasant Run Landfill Gas Recovery	G	Wisconsin	KENOSHA	0.75417871	11805	No	2000
Pheasant Run Landfill Gas Recovery	G	Wisconsin	KENOSHA	0.75417871	11805	No	2000
Pheasant Run Landfill Gas Recovery	G	Wisconsin	KENOSHA	0.75417871	13648	No	2000
Pheasant Run Landfill Gas Recovery	G	Wisconsin	KENOSHA	0.75417871	13648	No	2000
Winnebago County Landfill Gas	G	Wisconsin	WINNEBAGO	0.930046772	11805	No	2000
Winnebago County Landfill Gas	G	Wisconsin	WINNEBAGO	0.930046772	11805	No	2000
Winnebago County Landfill Gas	G	Wisconsin	WINNEBAGO	0.930046772	11805	No	2000
Tri - Cities	G	Arizona	MARICOPA	0.80	11805	No	2001
Tri - Cities	G	Arizona	MARICOPA	0.80	11805	No	2001
Tri - Cities	G	Arizona	MARICOPA	0.80	11805	No	2001
Tri - Cities	G	Arizona	MARICOPA	0.80	11805	No	2001
Tri - Cities	G	Arizona	MARICOPA	0.80	11805	No	2001
Badlands	G	California	RIVERSIDE	1.10	11805	No	2001
Biodyne Congress	G	Illinois	COOK	1.794993515	11805	No	2001
Biodyne Congress	G	Illinois	COOK	1.794993515	11805	No	2001
Biodyne Congress	G	Illinois	COOK	1.794993515	11805	No	2001
Biodyne Pontiac	G	Illinois	LIVINGSTON	3.60325	11805	No	2001
Model City Energy	G	New York	NIAGARA	0.686324989	11805	No	2001
Model City Energy	G	New York	NIAGARA	0.686324989	11805	No	2001
Model City Energy	G	New York	NIAGARA	0.686324989	11805	No	2001
Model City Energy	G	New York	NIAGARA	0.686324989	11805	No	2001
Model City Energy	G	New York	NIAGARA	0.686324989	11805	No	2001
Model City Energy	G	New York	NIAGARA	0.686324989	11805	No	2001
Model City Energy	G	New York	NIAGARA	0.686324989	11805	No	2001
Green Knight	G	Pennsylvania	NORTHAMPTON	2.494937456	11805	No	2001
Green Knight	G	Pennsylvania	NORTHAMPTON	2.494937456	11805	No	2001
Green Knight	G	Pennsylvania	NORTHAMPTON	2.494937456	11805	No	2001
Superior Glacier Ridge Landfil	G	Wisconsin	DODGE	0.90	11805	No	2001
Superior Glacier Ridge Landfil	G	Wisconsin	DODGE	0.90	11805	No	2001
Omega Hills Gas Recovery	G	Wisconsin	WASHINGTON	2.50	11805	No	2001
Jamacha LFG	C	California	[a]	0.27	13648	No	2002
Operating Industries LFG	C	California	[a]	0.40	13648	No	2002
Lopez Canyon LFG	C	California	[a]	1.43	13648	No	2002
Central Disposal Sonoma Phase	C	California	[a]	1.52	13648	No	2002
AB1890City/Cty San F	C	California	[a]	1.95	13648	No	2002
Quad Cities	C	Illinois	[a]	0.90	13648	No	2002
Morris	C	Illinois	[a]	1.30	13648	No	2002
Morris	C	Illinois	[a]	1.30	13648	No	2002
Morris	C	Illinois	[a]	1.30	13648	No	2002
Biodyne Pontiac	C	Illinois	[a]	4.20	13648	No	2002
Onyx Zion LFG	C	Illinois	[a]	5.04	13648	No	2002
BioEnergy Com-Ed Biogas	C	Illinois	[a]	5.16	13648	No	2002
South Side LFG	C	Indiana	[a]	4.75	13648	No	2002
Brent Run	C	Michigan	[a]	0.80	13648	No	2002
Elk River	C	Minnesota	[a]	2.28	13648	No	2002
Douglas County LFG	C	Nebraska	[a]	3.04	13648	No	2002
Brookhaven Facility	C	New York	[a]	1.20	13648	No	2002
Brookhaven Facility	C	New York	[a]	1.20	13648	No	2002
Blackburn Co-Generat	C	North Carolina	[a]	0.99	13648	No	2002
Bradford	C	Pennsylvania	[a]	0.76	13648	No	2002
Rolling Hills	C	Pennsylvania	[a]	2.50	13648	No	2002
Rolling Hills	C	Pennsylvania	[a]	2.50	13648	No	2002
Reliant Energy Renew	C	Texas	[a]	1.02	13648	No	2002
Reliant Energy Renew	C	Texas	[a]	1.02	13648	No	2002
Reliant Energy Renew	C	Texas	[a]	1.02	13648	No	2002
Reliant Energy Renew	C	Texas	[a]	1.02	13648	No	2002
Reliant Energy Renew	C	Texas	[a]	1.02	13648	No	2002
Reliant Energy Renew	C	Texas	[a]	1.30	13648	No	2002
Reliant Energy Renew	C	Texas	[a]	1.36	13648	No	2002
Reliant Energy Renew	C	Texas	[a]	1.36	13648	No	2002
Reliant Energy Renew	C	Texas	[a]	1.36	13648	No	2002
Reliant Energy Renew	C	Texas	[a]	1.36	13648	No	2002
Reliant Energy Renew	C	Texas	[a]	1.36	13648	No	2002
Reliant Energy Renew	C	Texas	[a]	1.36	13648	No	2002
Reliant Energy Renew	C	Texas	[a]	1.36	13648	No	2002
Reliant Energy Renew	C	Texas	[a]	1.36	13648	No	2002
Reliant Energy Renew	C	Texas	[a]	1.36	13648	No	2002
Reliant Energy Renew	C	Texas	[a]	1.36	13648	No	2002
Reliant Energy Renew	C	Texas	[a]	1.36	13648	No	2002
Reliant Energy Renew	C	Texas	[a]	1.36	13648	No	2002
Reliant Energy Renew	C	Texas	[a]	1.36	13648	No	2002
Reliant Energy Renew	C	Texas	[a]	1.36	13648	No	2002
Reliant Energy Renew	C	Texas	[a]	1.36	13648	No	2002

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Table 3.9 (Continued)
Current Landfill Gas Power Plants

Plant Name	Boiler/Generator/Committed Unit	State Name	County	Capacity MW	Heat Rate	Cogeneration	On-line Year
Tessman Road Project LFG, Phas	C	Texas	[a]	4.94	13648	No	2002
Covel Gardens	C	Texas	[a]	6.65	13648	No	2002
Arlington LF	C	Texas	[a]	8.55	13648	No	2002
Chesterfield County LFG	C	Virginia	[a]	0.52	13648	No	2002
Amelia Landfill LFG	C	Virginia	[a]	3.99	13648	No	2002
Va Beach Mt Trashmore II LFG	C	Virginia	[a]	11.97	13648	No	2002
Pheasant Run Landfil	C	Wisconsin	[a]	0.80	13648	No	2002
Pheasant Run Landfil	C	Wisconsin	[a]	0.80	13648	No	2002
Ridgeview	C	Wisconsin	[a]	0.80	13648	No	2002
Ridgeview	C	Wisconsin	[a]	0.80	13648	No	2002
Ridgeview	C	Wisconsin	[a]	0.80	13648	No	2002
Acme Landfill	C	California	[a]	0.27	13648	No	2003
AB1890RiversideCty,C	C	California	[a]	0.90	13648	No	2003
California Street	C	California	[a]	0.95	13648	No	2003
AB1890Colton (NEO Co	C	California	[a]	1.14	13648	No	2003
AB1890Milliken(NEO C	C	California	[a]	2.38	13648	No	2003
AB1890Mid-Valley(NEO	C	California	[a]	2.38	13648	No	2003
Keller Canyon LFG	C	California	[a]	2.66	13648	No	2003
AB1890EgyDevelopment	C	California	[a]	3.71	13648	No	2003
AB1890BFI, Newby Isl	C	California	[a]	5.23	13648	No	2003
Bradley	C	California	[a]	6.18	13648	No	2003
SW Alachua	C	Florida	[a]	2.38	13648	No	2003
Beecher LFG	C	Illinois	[a]	4.94	13648	No	2003
Bavarian Waste	C	Kentucky	[a]	4.75	13648	No	2003
Massachusetts RPS 2003 - LFG	C	Massachusetts	[a]	3.90	13648	No	2003
Plainville LFG	C	Massachusetts	[a]	5.32	13648	No	2003
Chicopee II LFG	C	Massachusetts	[a]	5.42	13648	No	2003
Grand Blanc	C	Michigan	[a]	0.78	13648	No	2003
3 Landfill Gas Projects	C	New York	[a]	4.94	13648	No	2003
Palmetto	C	South Carolina	[a]	4.75	13648	No	2003
Reliant Energy Renew	C	Texas	[a]	0.99	13648	No	2003
Reliant Energy Renew	C	Texas	[a]	0.99	13648	No	2003
Blue Bonnet LFG	C	Texas	[a]	2.00	13648	No	2003
Tessman Road LFG - Added Capac	C	Texas	[a]	2.47	13648	No	2003
Hutchins LFG	C	Texas	[a]	2.47	13648	No	2003
City of Conroe LFG	C	Texas	[a]	2.76	13648	No	2003
Sanifill - Baytown	C	Texas	[a]	3.80	13648	No	2003
Security Recycling LFG	C	Texas	[a]	5.99	13648	No	2003
Coastal Plains	C	Texas	[a]	6.37	13648	No	2003
Coastal Plains	C	Texas	[a]	9.50	13648	No	2003
WMI Atascocit LFG	C	Texas	[a]	9.98	13648	No	2003
Essex Junction Wastewater Trea	C	VERMONT	[a]	0.06	13648	No	2003
Janesville Landfill (WI)	C	Wisconsin	“	2.91	13648	No	2003

Source:

National Electric Energy System (NEEDS) Database for IPM 2004, http://www.epa.gov/airmarkets/epa-ipm/#needs.

Table 3.10
Total Net Generation of Electricity by State from Wood and Wood Waste, 2002
(Thousand Kilowatt Hours)

State	Wood/Wood Waste	Percent of all Renewables	Total from all Renewables
Alabama	3,727,493	29.6%	12,575,137
Alaska	1,031	0.1%	1,451,506
Arkansas	1,580,608	31.5%	5,021,095
California	3,957,589	7.2%	54,821,196
Florida	1,552,891	29.1%	5,327,515
Georgia	6,218,978	68.1%	9,130,809
Idaho	508,303	5.5%	9,277,624
Iowa	91	0.0%	1,963,785
Kentucky	365,465	8.3%	4,390,214
Louisiana	2,748,900	73.2%	3,754,232
Maine	3,723,759	51.7%	7,197,599
Maryland	182,904	7.5%	2,437,654
Massachusetts	106,687	3.7%	2,913,724
Michigan	1,474,552	35.4%	4,170,656
Minnesota	377,392	13.1%	2,886,179
Mississippi	936,593	98.7%	948,724
Missouri	143	0.0%	1,423,273
Montana	63,470	0.7%	9,630,379
New Hampshire	699,767	33.9%	2,065,997
New York	412,218	1.5%	27,671,006
North Carolina	1,682,804	31.7%	5,310,327
Ohio	126,067	19.7%	639,640
Oklahoma	239,045	10.7%	2,226,889
Oregon	624,086	1.8%	35,500,087
Pennsylvania	766,289	15.4%	4,968,055
South Carolina	1,228,895	46.7%	2,634,168
Tennessee	750,892	8.6%	8,776,126
Texas	1,073,462	21.0%	5,116,927
Vermont	355,599	24.0%	1,480,893
Virginia	1,407,922	41.6%	3,386,411
Washington	1,126,145	1.4%	79,955,049
West Virginia	51	0.0%	1,097,110
Wisconsin	644,947	17.5%	3,676,150
Total	**38,665,038**	**11.9%**	**323,826,136**

Source:
Energy Information Administration, Renewable *Energy Annual 2004*, Table C6.
http://www.eia.doe.gov/cneaf/solar.renewables/page/rea_data/rea_sum.html.

Note: States not listed contained no data for wood/wood waste.

Table 3.11
Net Generation and Fuel Consumption at Power Plants Consuming Coal and Biomass by State and Plant Name, 2003

State	County	Plant Name	Net Electricity Generation (Thousand Kilowatthours)	Total Energy Consumed (MMBtu)	Energy Consumed from Biomass (MMBtu)	Percent of Energy Consumed from		
						Biomass	Coal	Other
Alabama	Talladega	U S Alliance Coosa Pines	173,254	13,134,273	5,911,501	45.01	54.99	
	Choctaw	Georgia Pacific Naheola Mill	428,406	17,123,967	12,892,753	75.29	14.18	10.53
	Marengo	Gulf States Paper	144,742	10,488,058	8,689,654	82.85	7.30	9.85
	Autauga	International Paper Prattville	496,108	20,716,033	16,225,436	78.32	8.78	12.89
	Mobile	Mobile Energy Services LLC	416,485	6,961,111	3,033,258	43.57	52.68	3.75
	Wilcox	Weyerhaeuser Pine Hill Operati	477,473	6,352,999	3,621,355	57.00	10.01	32.99
Alaska	Fairbanks North Star	Eielson AFB Central Heat & Pow	82,455	2,919,023	26,599	0.91	97.77	1.32
Arizona	Pima	Irvington	1,048,187	11,086,805	154,014	1.39	56.56	42.05
Arkansas	Little River	Ashdown	849,495	41,001,419	36,029,685	87.87	8.03	4.10
California	San Joaquin	Stockton Cogen	452,689	5,741,432	528,273	9.20	54.29	36.50
	Kern	Mt Poso Cogeneration	450,228	5,125,472	12,237	0.24	69.44	30.32
Connecticut	Hartford	Covanta Mid-Connecticut Energy	450,215	8,664,367	8,512,216	98.24	1.76	
Florida	Escambia	Crist	6,413,151	66,408,961	2,080	0.00	99.79	0.21
	Escambia	International Paper Pensacola	463,167	19,758,653	14,615,865	73.97	13.54	12.48
	Duval	Northside Generating Station	4,724,993	48,641,433	76,943	0.16	15.18	84.67
	Nassau	Jefferson Smurfit Fernandina B	593,529	18,167,538	11,360,666	62.53	30.73	6.74
	Polk	C D McIntosh Jr	4,271,266	39,831,464	62,406	0.16	59.17	40.67
	Orange	Stanton Energy Center	6,054,342	59,081,269	1,007,967	1.71	98.14	0.16
	Bay	Stone Container Panama City Mi	236,641	20,068,826	17,409,869	86.75	7.52	5.73
	Duval	Cedar Bay Generating LP	1,833,539	23,812,502	60,039	0.25	99.54	0.21
Georgia	Early	Georgia Pacific Cedar Springs	701,709	37,200,341	28,956,649	77.84	18.10	4.06
	Effingham	Savannah River Mill	616,517	9,999,695	55,381	0.55	9.12	90.33
	Floyd	Inland Paperboard Packaging Ro	437,595	21,075,416	12,717,543	60.34	27.61	12.05
	Chatham	International Paper Savanna Mi	819,569	22,625,484	13,597,613	60.10	30.75	9.15
	Richmond	International Paper Augusta Mi	499,834	23,164,308	15,929,560	68.77	22.49	8.74
	Bibb	Riverwood International Macon	272,388	12,444,817	9,829,168	78.98	9.98	11.04
	Laurens	SP Newsprint	257,674	8,242,895	5,876,174	71.29	19.73	8.98
Hawaii	Oahu	AES Hawaii	1,558,310	15,768,698	197,811	1.25	98.03	0.72
	Maui	Hawaiian Comm and Sugar Puunen	196,437	6,327,592	5,073,883	80.19	18.02	1.80
Illinois	Macon	Archer Daniels Midland Decatur	1,285,911	35,123,776	379,235	1.08	98.92	
	Randolph	Baldwin Energy Complex	13,090,406	133,957,397	1,082,779	0.81	99.10	0.09
Iowa	Story	Ames Electric Services Power P	417,670	5,042,727	351,818	6.98	92.46	0.56
	Linn	Prairie Creek	988,852	10,404,803	126,754	1.22	97.23	1.55
	Linn	Sixth Street	147,644	3,280,837	20,616	0.63	77.34	22.03
	Johnson	University of Iowa Main Power	96,154	3,493,728	303,494	8.69	80.71	10.60
Kentucky	Daviess	Elmer Smith	2,576,356	26,232,220	315,669	1.20	97.60	1.20
Louisiana	De Soto	Mansfield Mill	823,390	25,267,624	20,284,572	80.28	5.28	14.44
	Morehouse	International Paper Louisiana	573,028	20,240,021	17,793,018	87.91	1.44	10.65
Maine	Oxford	Rumford Cogeneration	761,994	14,988,922	10,674,204	71.21	28.79	
	Cumberland	S D Warren Somerset	405,698	6,776,035	3,981,923	58.76	37.70	3.54
Maryland	Allegany	Luke Mill	479,094	17,525,830	7,452,148	42.52	57.48	
Michigan	Dickinson	International Paper Quinnesec	220,975	10,079,834	9,772,982	96.96	0.18	2.86
	Alpena	Louisiana Pacific	44,646	739,198	57,597	7.79	60.85	31.36
	Delta	Mead Paper	684,599	18,935,467	12,154,663	64.19	22.06	13.75
	Muskegon	S D Warren Muskegon	250,591	7,668,122	2,867,940	37.40	58.72	3.87
	Manistee	TES Filer City Station	458,857	6,101,760	501,018	8.21	91.79	
	Wayne	Wyandotte	270,603	3,951,663	305,851	7.74	91.39	0.87
Minnesota	St Louis	Hibbing	45,670	1,531,495	78	0.01	99.99	0.00
	Itasca	Rapids Energy Center	130,699	3,608,215	2,769,301	76.75	16.16	7.09
Mississippi	Lowndes	Weyerhaeuser Columbus MS	613,650	20,090,225	18,705,609	93.11	3.83	3.06
Missouri	St Louis City	Anheuser Busch St Louis	120,498	4,094,333	278,326	6.80	88.85	4.35
	Jackson	Sibley	3,170,801	32,841,421	314,186	0.96	99.01	0.04
	Jasper	Asbury	1,301,578	14,793,004	298,172	2.02	97.72	0.27
	Pike	Hercules Missouri Chemical Wor	84,970	2,864,296	3,573	0.12	98.92	0.95
	Saline	Marshall	35,538	571,009	4,734	0.83	94.14	5.03
	St Charles	Sioux	6,332,833	60,585,566	631,649	1.04	98.15	0.81
	Boone	University of Missouri Columbi	127,509	3,444,927	76,558	2.22	91.00	6.78

Continued on next page.

Table 3.11 (Continued)
Net Generation and Fuel Consumption at Power Plants Consuming Coal and Biomass by State and Plant Name, 2003

State	County	Plant Name	Net Electricity Generation (Thousand Kilowatthours)	Total Energy Consumed (MMBtu)	Energy Consumed from Biomass (MMBtu)	Percent of Energy Consumed from		
						Biomass	Coal	Other
New York	Yates	AES Greenidge LLC	1,040,354	11,705,155	99,328	0.85	98.90	0.25
	Jefferson	Black River Power LLC	355,861	4,539,007	9,635	0.21	74.06	25.73
	Niagara	WPS Power Niagara	251,890	3,353,781	28,760	0.86	98.21	0.94
North Carolina	Haywood	Canton North Carolina	344,245	20,265,972	9,641,230	47.57	52.12	0.30
	Forsyth	Corn Products Winston Salem	56,591	3,948,209	3,441,379	87.16	11.73	1.11
	Halifax	International Paper Roanoke Ra	174,563	12,732,892	8,624,055	67.73	23.23	9.04
	Columbus	International Paper Riegelwood	503,301	25,783,234	18,114,256	70.26	5.22	24.52
	Bladen	Elizabethtown Power LLC	117,590	1,659,872	383,987	23.13	76.87	
	Robeson	Lumberton	83,280	1,075,248	201,011	18.69	81.31	
	Martin	Weyerhaeuser Plymouth NC	806,280	39,957,341	32,330,211	80.91	17.27	1.81
	Pickaway	Picway	402,519	4,674,846	29,550	0.63	98.86	0.51
Ohio	Ross	Mead Custom Paper	532,453	15,151,763	8,077,827	53.31	45.29	1.40
Pennsylvania	Delaware	Chester Operations	389,779	6,591,803	23,657	0.36	54.54	45.10
	Northampton	Northhampton Generating LP	820,274	8,762,273	205,553	2.35	56.42	41.24
	Schuylkill	Kline Township Cogen Facility	393,564	5,978,255	423,384	7.08	92.01	0.91
	York	P H Glatfelter	680,328	17,422,344	8,766,181	50.32	48.75	0.94
	Elk	Johnsonburg Mill	279,550	8,572,138	4,801,100	56.01	38.92	5.07
South Carolina	Richland	International Paper Eastover F	529,454	21,208,564	16,189,319	76.33	16.94	6.72
	Georgetown	International Paper Georgetown	527,894	21,735,489	17,702,311	81.44	10.33	8.23
	Florence	Stone Container Florence Mill	710,340	20,402,914	12,541,662	61.47	27.28	11.25
Tennessee	McMinn	Bowater Newsprint Calhoun Oper	525,280	21,325,300	15,574,553	73.03	25.16	1.81
	Sullivan	Tennessee Eastman Operations	1,239,569	40,812,321	300,054	0.74	98.39	0.88
	Hardin	Packaging Corp of America	373,340	22,112,700	18,034,060	81.56	9.63	8.82
	Sullivan	Weyerhaeuser Kingsport Mill	101,154	6,722,666	5,825,213	86.65	13.35	
Virginia	Bedford	Georgia Pacific Big Island	52,032	3,357,369	1,720,872	51.26	46.83	1.91
	Isle of Wight	International Paper Franklin M	776,727	25,587,752	14,481,554	56.60	22.09	21.32
	King William	St Laurent Paper West Point	525,859	17,126,189	12,851,000	75.04	17.05	7.92
	Portsmouth City	SPSA Waste To Energy Power Pla	173,116	5,415,699	5,388,534	99.50	0.00	0.50
	Hopewell City	Stone Container Hopewell Mill	319,104	8,636,244	6,255,293	72.43	25.30	2.27
	Covington	Covington Facility	671,771	29,004,636	13,064,973	45.04	42.23	12.72
Washington	Cowlitz	Weyerhaeuser Longview WA	327,661	18,235,976	14,422,210	79.09	7.72	13.19
West Virginia	Preston	Albright	1,669,380	18,709,260	1,806	0.01	99.79	0.20
	Pleasants	Willow Island	1,095,678	12,279,409	196,900	1.60	98.02	0.37
	Kanawha	Union Carbide South Charleston	21,488	3,309,914	73,163	2.21	64.49	33.30
Wisconsin	Wood	Georgia Pacific Nekoosa Mill	203,635	5,584,402	3,224,101	57.73	36.09	6.17
	Price	Fraser Paper	36,422	334,360	113,361	33.90	66.10	
	Outagamie	International Paper Kaukauna M	211,943	7,634,467	3,344,608	43.81	39.06	17.13
	Dane	Blount Street	451,308	6,299,195	180,864	2.87	80.63	16.50
	Manitowoc	Manitowoc	315,087	4,761,246	23,264	0.49	66.17	33.34
	Ashland	Bay Front	296,711	4,529,448	1,795,854	39.65	58.60	1.75
	Lincoln	Packaging of America Tomahawk	133,041	10,575,641	7,959,582	75.26	23.01	1.72
	Dane	Univ of Wisc Madison Charter S	42,282	3,947,769	323,026	8.18	82.18	9.64
	Dodge	Waupun Correctional Central He	4,130	288,951	20,665	7.15	88.90	3.95
	Wood	Biron Mill	246,244	4,614,572	326,216	7.07	91.64	1.29
	Marinette	Niagara Mill	114,749	3,000,275	196,181	6.54	71.80	21.66
	Portage	Whiting Mill	25,362	1,572,137	208,755	13.28	78.43	8.29
	Wood	Wisconsin Rapids Pulp Mill	374,930	12,125,962	8,338,658	68.77	26.14	5.10
	Marathon	Wausau Mosinee Paper Pulp	122,059	12,335,121	10,406,885	84.37	13.37	2.26
	Sheboygan	Edgewater	4,893,820	47,746,013	665,280	1.39	98.48	0.12
Total			**95,304,634**	**1,709,675,399**	**630,926,946**	**36.90**	**53.78**	**9.32**

Source:
Energy Information Administration. Derived from Table 9: Net Generation and Fuel Consumption at Power Plants Consuming Coal and Biomass by State and Plant name, 2003, http://www.eia.doe.gov/cneaf/solar.renewables/page/trends/table1.html

Note: MMBtu = One million British thermal units. Blank cell indicates the plant had no consumption or other energy to report.

Table 3.12
Coal Displacement Calculation, 2006

Conversion Formula: Step 1 Capacity (A) x Capacity Factor (B) x Annual Hours (C) = Annual Electricity Generation (D)
Step 2 Annual Electricity Generation (D) x Conversion Efficiency (E) = Total Output (F)
Step 3 Total Output (F) / Fuel Heat Rate (G) = Quantity Fuel (H)

Technology	Wind	Geothermal	Biomass
(A) Capacity (kW)	11,558,205	2,232,495	6,594,096
(B) Capacity Factor (%)	36.0%	90.0%	80.0%
(C) Annual Hours	8,760	8,760	8,760
(D) Annual Electricity Generation (kWh)	36,449,954,187	17,600,991,128	46,211,427,727
(E) Conversion Efficiency (Btu/kWh)	10,107	10,107	10,107
(F) Total Output (Million Btu)	368,399,686	177,893,217	467,058,900
(G) Coal Heat Rate (Btu per short ton)	20,411,000	20,411,000	20,411,000
(H) Coal (short tons)	18,049,076	8,715,556	22,882,705

Technology	Hydropower	PV	Solar Thermal
(A) Capacity (kW)	78,312,583	280,355	388,893
(B) Capacity Factor (%)	44.2%	22.5%	24.4%
(C) Annual Hours	8,760	8,760	8,760
(D) Annual Electricity Generation (kWh)	303,176,455,525	552,579,314	831,235,472
(E) Conversion Efficiency (Btu/kWh)	10,107	10,107	10,107
(F) Total Output (Million Btu)	3,064,204,435	5,584,919	8,401,296
(G) Coal Heat Rate (Btu per short ton)	20,411,000	20,411,000	20,411,000
(H) Coal (short tons)	150,125,150	273,623	411,606

Source:
National Renewable Energy Laboratory, *Power Technologies Energy Data Book*, Table 12.3, http://www.nrel.gov/analysis/power_databook/chapter12.html.
Original Sources: Capacity: EIA, Annual Energy Outlook 2006, DOE/EIA-0383 (2006) (Washington, D.C., February 2006), Table A16.
Capacity Factors: Hydropower calculated from EIA, Annual Energy Outlook 2006, DOE/EIA-0383 (2006) (Washington, D.C., February 2006), Table A16. All others based on DOE, Renewable Energy Technology Characterizations, EPRI TR-109496, 1997 and Program data.
Conversion Efficiency: EIA, Annual Energy Review 2004, DOE/EIA-0384(2004) (Washington, D.C., August 2005), Table A6.
Heat Rate: Annual Energy Outlook 2006, DOE/EIA-0383 (2006) (Washington, D.C., February 2006), Table F1.

Note: Capacity values exclude combined-heat-and-power (CHP) data but include end-use sector (industrial and commercial) non-CHP data.

Table 3.13
Renewable Energy Impacts Calculation, 2006

Conversion Formula: Step 1 Capacity (A) x Capacity Factor (B) x Annual Hours (C) = Annual Electricity Generation (D)
Step 2 Annual Electricity Generation (D) x Competing Heat Rate (E) = Annual Output (F)
Step 3 Annual Output (F) x Emissions Coefficient (G) = Annual Emissions Displaced (H)

Technology	Wind	Geothermal	Biomass
(A) Capacity (kW)	11,558,205	2,232,495	6,594,096
(B) Capacity Factor (%)	36.0%	90.0%	80.0%
(C) Annual Hours	8,760	8,760	8,760
(D) Annual Electricity Generation (kWh)	36,449,954,187	17,600,991,128	46,211,427,727
(E) Competing Heat Rate (Btu/kWh)	10,107	10,107	10,107
(F) Annual Output (Trillion Btu)	368.4	177.9	467.1
(G) Carbon Coefficient (MMTCB/Trillion Btu)	0.01783	0.01783	0.01783
(H) Annual Carbon Displaced (MMTC)	6.569	3.172	8.328

Technology	Hydropower	PV	Solar Thermal
(A) Capacity (kW)	78,312,583	280,355	388,893
(B) Capacity Factor (%)	44.2%	22.5%	24.4%
(C) Annual Hours	8,760	8,760	8,760
(D) Annual Electricity Generation (kWh)	303,176,455,525	552,579,314	831,235,472
(E) Competing Heat Rate (Btu/kWh)	10,107	10,107	10,107
(F) Annual Output (Trillion Btu)	3,064.2	5.6	8.4
(G) Carbon Coefficient (MMTCB/Trillion Btu)	0.01783	0.01783	0.01783
(H) Annual Carbon Displaced (MMTC)	54.635	0.100	0.128

Source:
National Renewable Energy Laboratory. *Power Technologies Energy Data Book*, Table 12.1, http://www.nrel.gov/analysis/power_databook/chapter12.html
Original sources: Capacity: EIA, *Annual Energy Outlook 2005*, DOE/EIA-0383 (2005) (Washington, DC, February 2005), Table A16, 2005.
Capacity Factors: Hydropower calculated from EIA, *Annual Energy Outlook 2005*, DOE/EIA-0383 (2005) (Washington, DC, February 2005), Table A16. All others based on DOE, Renewable Energy Technology Characterizations, EPRI TR-109496, 1997 and Program data.
Heat Rate: EIA, *Annual Energy Review 2003*, DOE/EIA-0384(2003) (Washington, DC, September 2004), Table A6.
Carbon Coefficient: DOE, GPRA2003 Data Call, Appendix B, page B-16, 2003.

Note: Capacity values exclude combined-heat-and-power (CHP) data but include end-use sector (industrial and commercial) non-CHP data. Competing heat rate from fossil-fueled steam-electric plants heat rate.

Table 3.14
Number of Home Electricity Needs Met Calculation, 2006

Conversion Formula: *Step 1* *Capacity (A) x Capacity Factor (B) x Annual Hours (C) = Annual Electricity Generation (D)*
Step 2 *Annual Electricity Generation (D) / Average Consumption (E) = Number of Households (F)*

Technology	Wind	Geothermal	Biomass	Hydropower	PV	Solar Thermal
(A) Capacity (kW)	11,558,205	2,232,495	6,594,096	78,312,583	280,355	388,893
(B) Capacity Factor (%)	36.0%	90.0%	80.0%	44.2%	22.5%	24.4%
(C) Annual Hours	8,760	8,760	8,760	8,760	8,760	8,760
(D) Annual Electricity Generation (kWh)	36,449,954,187	17,600,991,128	46,211,427,727	303,176,455,525	552,579,314	831,235,472
(E) Average Annual Household Electricity Consumption (kWh)	11,576	11,576	11,576	11,576	11,576	11,576
(F) Number of Households	3,148,804	1,520,497	3,992,068	26,190,515	47,736	71,808

Source:

National Renewable Energy Laboratory, *Power Technologies Data Book*, Table 12.2, http://www.nrel.gov/analysis/power_databook/chapter12.html.

Original sources: Capacity: EIA, Annual Energy Outlook 2006, DOE/EIA-0383 (2006) (Washington, D.C., February 2006), Table A16, 2006.

Capacity Factors: Hydropower calculated from EIA, Annual Energy Outlook 2005, DOE/EIA-0383 (2005) (Washington, D.C., February 2005), Table A16. All others based on DOE, Renewable Energy Technology Characterizations, EPRI TR-109496, 1997 and Program data.

Household electricity Consumption: Calculated from EIA, Annual Energy Outlook 2006, DOE/EIA-0383 (2006) (Washington, D.C., February), Tables A4 and A8, 2006.

Note: Capacity values exclude combined-heat-and-power (CHP) data but include end-use sector (industrial and commercial) non-CHP data.

A tax credit for biomass power production from closed-loop biomass was first enacted as part of the comprehensive Energy Policy Act of 1992. Subsequent acts extended the credit to various other types of renewable energy facilities. Because no biomass power facilities were able to meet the closed-loop biomass definition of the 1992 Act, the tax credit was expanded in 2005 to include open-loop biomass at ½ the tax credit available to a closed-loop facility. Closed and open-loop biomass are defined as follows:

Closed-loop biomass - Crops grown, in a sustainable manner, for the purpose of optimizing their value for bioenergy and bioproduct uses. This includes annual crops such as maize and wheat, and perennial crops such as trees, shrubs, and grasses such as switchgrass.

Open-loop biomass - Biomass that can be used to produce energy and bioproducts even though it was not grown specifically for this purpose. Examples of open-loop biomass include agricultural livestock waste and residues from forest harvesting operations and crop harvesting.

Table 3.15
Major Federal Biomass Power Incentives

Title	Code	Fuel Type	Incentive	Qualifying Period	Limits[c]
Production Tax Credit – extension[a]	IRC §45	Closed-loop biomass	$0.019/kWhr[b] -2005	In service between 2003 - 2007. 10 year max	phase out above 8¢/kWhr (inflation adjusted)
Production Tax Credit – extension[a]	IRC §45	Closed-loop biomass, co-fired with coal or other biomass	$0.019/kWhr[b] -2005	Anytime before 2008, 10 year max from 10/23/2004 or in-service date	Same as above
Production Tax Credit – extension[a]	IRC §45	Open-loop biomass - existing	$0.009/kWhr[b] (2005)	In service before 1/1/2005, 5 year limit	Credit to operator not owner; phase out above 8¢/kWhr; exclusion of biomass co-fired with fossil fuel
Production Tax Credit – extension[a]	IRC §45	Open-loop biomass - new	$0.009/kWhr[b] (2005)	In service between 8/8/2005-12/31/2007, 10 year limit	Same as above
Renewable Energy Production Incentive (REPI)[d]	42 USCS § 13317	Biomass except for MSW combustion	$0.015/kWhr (1993 $ indexed for inflation)	Renewed appropriations for 2006 - 2026	Available to non-profit electrical co-ops, public utilities, government facilities

More information on this can be found at the following websites:
http://www.msi-network.com/content/cmsdoc496.asp
Internal Revenue Code bulletins on §45 at http://www.irs.gov/irb/2004-17_IRB/ar09.html and at: http://www.irs.gov/irb/2005-20_IRB/ar08.html
A business can take the credit by completing Form 8835 (http://www.irs.gov/pub/irs-pdf/f8835.pdf)"Renewable Energy Production Credit."

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[a] The 2004 American Jobs Creation Act and the 2005 Energy Policy Act extended the Production Tax Credit §45 so that it now includes wind, open and closed loop biomass, geothermal energy, solar energy, small irrigation power, landfill gas, municipal solid waste, and qualified hydropower production, as well as refined coal production and Indian coal production facilities.

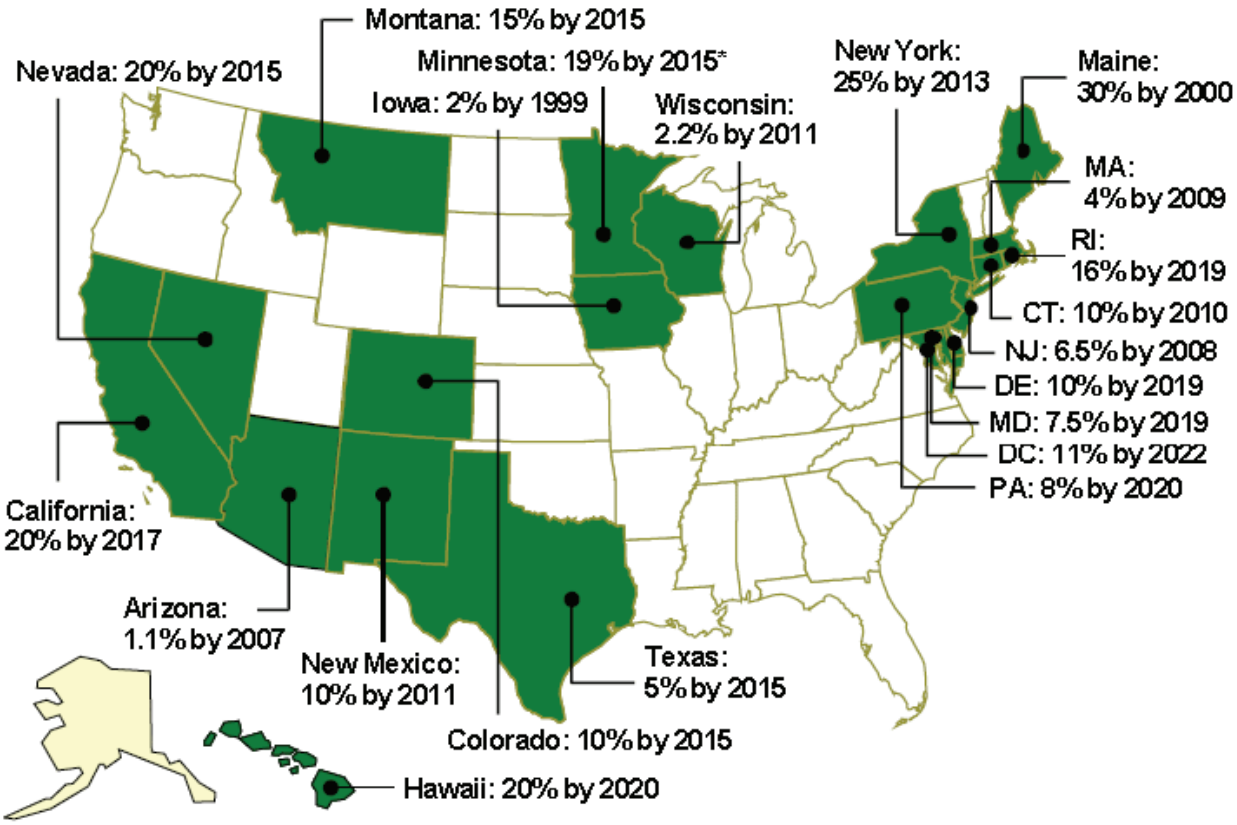
[b] Annual inflation adjusted rate above the base §45 tax credit rate of $0.015/kWhr or ½ the adjusted rate in the case of open-loop biomass, small irrigation power facilities, landfill gas facilities, hydropower facilities. Rates are adjusted annually.

[c] More limits and explanations of limits can be found at http://www.msi-network.com/content/cmsdoc496.asp and in the August 2005 issue of Bioenergy Update.

[d] More information on REPI, including reauthorizing language in Section 202 of the Energy Policy Act of 2005 is available at http://www.dsireusa.org.

A Renewable Portfolio Standard (RPS) is a policy that obligates a retail electricity supplier to include renewable resources in its electricity generation portfolio. Retail suppliers can meet the obligation by constructing or owning eligible renewable resources or purchasing the power from eligible generators. To date, 16 states have adopted RPS policies or renewable purchase obligations. All these states include some type of biomass as a qualifying renewable energy technology. Initially, most states adopted RPS policies as part of electric industry restructuring; but, more recently, a number of states have implemented policies by legislation or proceedings that are separate from restructuring activities. In conjunction with system benefits funds, RPS policies are expected to lead to the development of more than 17,000 MW of new renewable energy capacity by 2017.

Figure 3.1
States with Renewable Portfolio Standards



Source:
National Renewable Energy Laboratory, *Power Technologies Energy Data Book*, Chapter 3, http://www.nrel.gov/analysis/power_databook/chapter3.html

Almost half of the states have renewable portfolio standards and purchase requirements; the standards and requirements vary widely among those states that do have renewable portfolio requirements.

Table 3.16
State Renewable Portfolio Standards and Purchase Requirements

State	Purchase Requirements	Eligible Resources	Credit Trading	Penalties
Arizona	15% by 2015 (of this 30% must be customer sited)	PV and solar thermal electric, R&D, solar hot water, and in-state **landfill gas**, wind, and **biomass**.	No central credit trading system	Under consideration
California	Investor-owned utilities must add minimum 1% annually to 20% by 2017.	**Biomass**, solar thermal, photovoltaic, wind, geothermal, existing hydro < 30MW, fuel cells using renewable fuels, **digester gas**, **landfill gas**, ocean energy.	WREGIS system under development	At discretion of CPUC
Colorado	10% by 2015	Photovoltaics, **Landfill Gas**, Wind, **Biomass**, Geothermal Electric, **Anaerobic Digestion**, Small Hydroelectric, Fuel Cells (Renewable Fuels)	WREGIS system under development	To be determined
Connecticut	3% Class I or II Technologies by Jan 1, 2004. Class I 1% Jan 1, 2004 increasing to 1.5% by 2005, 2% by 2006, 3.5% by 2007, 5% by 2008, 6% by 2009, and 7% by Jan 1, 2010	Class I: solar, wind, **new sustainable biomass**, **landfill gas**, fuel cells, ocean thermal, wave, tidal, advanced renewable energy conversion technologies, new run of river hydro (<5MW). Class II: licensed hydro, **MSW**, and **other biomass**.	Yes. Using NEPOOL Generation Information System.	Penalty of 5.5¢/kWh paid to the Renewable Energy Investment Fund for the development of Class I renewables
Delaware	10% by 2019	Solar Thermal Electric, Photovoltaics, **Landfill Gas**, Wind, **Biomass**, Hydroelectric, Geothermal Electric, **Anaerobic Digestion**, Tidal Energy, Wave Energy, Ocean Thermal, Fuel Cells (Renewable Fuels)	Yes. GATS	Penalty of 2.5¢/kWh (increases to 5¢/kWh for multi-year noncompliance)
District of Columbia	11% by 2022 (0.386% solar)	Solar Thermal Electric, Photovoltaics, **Landfill Gas**, Wind, **Biomass**, Hydroelectric, Geothermal Electric, Municipal Solid Waste, Cofiring, Tidal Energy, Wave Energy,	Yes. GATS. Electric delivery requirement to PJM	Penalty of 2.5¢/kWh for tier 1 resources, 1¢/kWh for tier II, and 30¢/kWh for PV
Hawaii	8% by end of 2005, 10% by 2010, 15% by 2015 and 20% by 2020	Wind, solar, hydropower, **biomass** including **landfill gas**, **waste to energy**, and **fuels derived from organic sources**, geothermal, ocean energy, fuel cells using hydrogen from renewables	Unspecified	Unspecified: standard to be revisited if utilities can not meet it in cost-effective manner
Iowa	Investor-owned utilities to purchase 105 MW (~2% of 1999 sales)	Solar, wind, **methane recovery,** and **biomass**	No	Unspecified

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Table 3.16 (Continued)
State Renewable Portfolio Standards and Purchase Requirements

State	Purchase Requirements	Eligible Resources	Credit Trading	Penalties
Maine	30% of retail sales in 2000 and thereafter. PUC will revisit within 5 years.	Fuel cells, tidal, solar, wind, geothermal, hydro, **biomass**, and **MSW** (<100MW); high efficiency cogeneration. Selfgeneration is not eligible. Resource supply under this definition exceeds RPS requirement.	Yes. NEPOOL Generation Information System.	Possible sanctions at discretion of PUC
Maryland	3.5% by 2006 with 1% from Tier 1 sources, Tier 1 increasing by 1% every other year from 2007 to 2018, Tier II remains at 2.5%, 7.5% total by 2019 and in subsequent years.	Tier 1: solar, wind, geothermal, **qualifying biomass**, small hydropower (<30MW), and **landfill methane** Tier II: existing large hydropower, **poultry litter incineration**, **existing waste to energy**	Yes	Alternative Compliance fee of 2¢/kWh for Tier 1 and 1.5¢/kWh for Tier 2 paid to Maryland Renewable Energy Fund
Massachusetts	1% of sales to enduse customers from new renewables in 2003, +0.5%/yr to 4% in 2009 1%/yr increase thereafter until determined by Division of Energy Resources	New renewables placed into commercial operation after 1997, including solar, wind, ocean thermal, wave, tidal, fuel cells using renewable fuels, **landfill gas**, and **low-emission advanced biomass**. Excess production from existing generators over historical baseline eligible.	Yes. Using NEPOOL Generation Information System.	Entities may comply by paying 5¢/kWh. Non-complying retailers must submit a compliance plan. Revocation or suspension of license is possible.
Minnesota	(Not true RPS) Applies to Xcel Energy only: 425 MW wind by 2002 and 110 MW biomass. Additional 400 MW wind by 2006 and 300 MW by 2010	**Wind, biomass**	No, other than standard regulatory oversight.	No
Montana	5% in 2008; 10% in 2010; 15% in 2015	Solar Thermal Electric, Photovoltaics, **Landfill Gas**, Wind, **Biomass**, Hydroelectric, Geothermal Electric, **Anaerobic Digestion**, Fuel Cells (Renewable Fuels)	Yes. Electricity must be delivered to MT.	Penalty of 1¢/kWh goes to universal low-income energy assistance fund.
Nevada	6% in 2005, rising to 20% by 2015.	Solar, wind, geothermal, & **biomass (includes agricultural waste, wood, MSW, animal waste and aquatic plants)**. Distributed resources receives extra credit (1.15).	Yes.	Financial penalties may be applied for noncompliance.
New Jersey	Class I or II: 2.5% by 2008 Class I: 4% by 2008, with solar requirement of 0.16% retail sales (90MW) Goal of 20% by 2020.	Class I.: Solar, PV, wind, fuel cells, geothermal, wave, tidal, **landfill methane**, and **sustainable biomass**. Class II: hydro <30 MW and MSW facilities that meet air pollution requirements.	Yes. GATS.	Alternative Compliance Payment of 5¢/kWh, 30¢/kWh for solar.

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Table 3.16 (Continued)
State Renewable Portfolio Standards and Purchase Requirements

State	Purchase Requirements	Eligible Resources	Credit Trading	Penalties
New Mexico	5% of retail sales by 2006. Increase by 1%/yr to 10% by January 1, 2011 and thereafter.	Solar, wind, hydro (<=5 MW), **biomass**, geothermal, and fuel cells. 1 kWh solar =3kWh; **1 kWh biomass**, geothermal, **landfill gas**, or fuel cells =2 kWh toward compliance.	Yes. RECs valid for 4 years from date of issuance.	At discretion of PUC
New York	25% by 2013; 1% voluntary standard; 2% of total incremental RPS requirement (7.71%) is set-aside for customer-sited	Photovoltaics, **Landfill Gas**, Wind, **Biomass**, Hydroelectric, Fuel Cells, CHP/Cogeneration, **Biogas**, **Liquid Biofuel**, **Anaerobic Digestion**, Tidal Energy, Wave Energy, Ocean Thermal	Possibly. Electricity must be delivered to NY.	Unspecified
Pennsylvania	18% by 2020; 8% Tier 1 and 10% Tier II Solar set-aside of 0.5% by 2020	Solar Water Heat, Solar Space Heat, Solar Thermal Electric, Solar Thermal Process Heat, Photovoltaics, **Landfill Gas**, Wind, **Biomass**, Hydroelectric, Geothermal Electric, Fuel Cells, Municipal Solid Waste, CHP/Cogeneration, Waste Coal, Coal Mine Methane, Coal Gasification, **Anaerobic Digestion**, Other Distributed Generation Technologies.	Yes. GATS	Penalty of 4.5¢/kWh, for solar penalty is 200% of PV REC value.
Rhode Island	16% by 2020; 3% by 2003, increasing 0.5% annually 2008-2010, increasing 1% annually 2011-2014, increasing 1.5% annually 2015-2019	Solar, wind, **eligible biomass, including cofiring**, geothermal, small hydropower, ocean, fuel cells using hydrogen derived from renewables.	Yes. Using NEPOOL Generation Information System.	Penalty of 5¢/kWh can be made to Renewable Energy Development Fund.
Texas	5,880 MW by 2015 (5000 MW new) Target of at least 500 MW from renewables other than wind	Solar, wind, geothermal, hydro, wave, tidal, **biomass**, **including landfill gas**. New (operational after Sept. 1, 1999) or small (<2MW) facilities eligible.	Yes. ERCOT REC Trading System.	Lesser of 5¢/kWh or 200% of average market value of renewable energy credits.
Wisconsin	0.5% by 2001 increasing to 2.2% by 2011 (0.6% can come from facilities installed prior to 1998).	Wind, solar, **biomass**, geothermal, tidal, fuel cells that use renewable fuel, & hydro under 60 MW. Eligibility may be xtended by PUC.	Yes. Utilities with excess RECs can trade or bank them.	Penalty of $5,000-$500,000 is allowed in legislation.

Source:
National Renewable Energy Laboratory, *Power Technologies Energy Data Book*, Chapter 3, Table 3.3.1, http://www.nrel.gov/analysis/power_databook/chapter3.html

In addition to State Renewable Portfolio Standards and Purchase Requirements, there are also some nonbinding goals that three states have adopted.

Table 3.17
State Renewable Energy Goals (Nonbinding)

State	Purchase Requirements	Eligible Resources
Illinois	8% by 2013 (75% wind)	Solar Water Heat, Solar Thermal Electric, Photovoltaics, **Landfill Gas**, Wind, **Biomass**, Hydroelectric, CHP/Cogeneration, "Other Such Alternative Sources of Environmentally Preferable Energy"
Minnesota	1% by 2005 increasing by at least 1%/year to 10% by 2015	Wind, solar, hydro (<60 MW), and **biomass**
Vermont	Meet growth in electricity demand from 2005-2013 with renewable energy sources (becomes mandatory in 2013 if not met).	Solar Thermal Electric, Photovoltaics, **Landfill Gas**, Wind, **Biomass**, Hydroelectric, **Anaerobic Digestion**, Fuel Cells (Renewable Fuels)

Source:
National Renewable Energy Laboratory, Power Technologies Energy Data Book, Chapter 3, Table 3.3.2, http://www.nrel.gov/analysis/power_databook/chapter3.html