

Biomass Energy Data Book

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Analysis Platform Review

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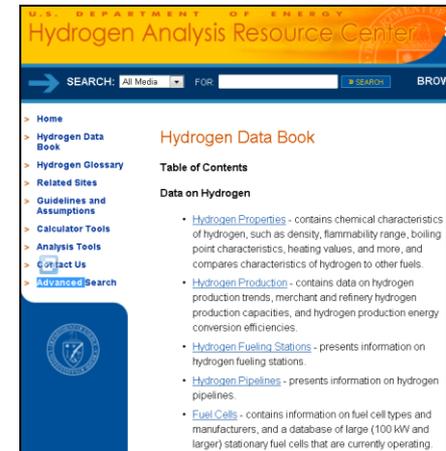
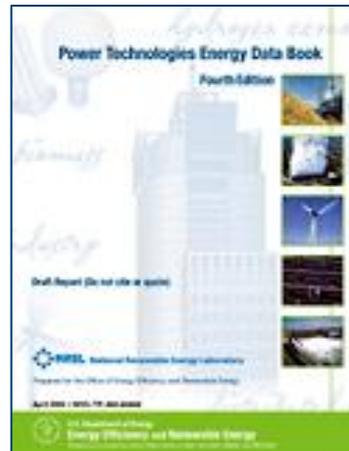
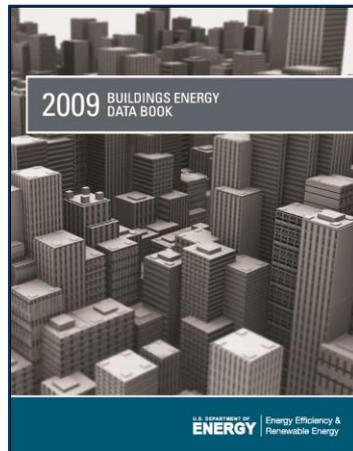
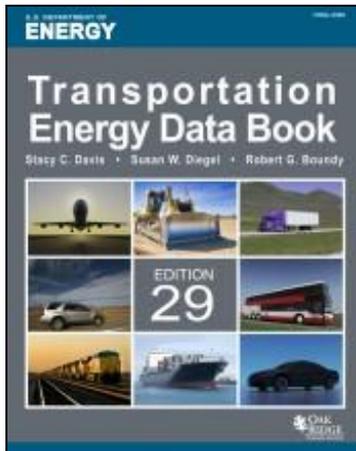
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Goal Statement

The objective is to create tabulations and graphics from existing biomass data sources to produce a comprehensive compilation of data and information that supports anyone with an interest or stake in the biomass industry.

Project Overview

- Biomass area was growing quickly
- Need for data and information on the industry
- No centralized location for biomass data
- EERE had four other Data Books:



Project Overview - 2

- Researched, compiled, and posted the first Biomass Energy Data Book website in 2006.

The screenshot shows the homepage of the Biomass Energy Data Book website. At the top, the title "Biomass Energy Data Book" is displayed in green, alongside the U.S. Department of Energy logo and the text "U.S. Department of Energy Energy Efficiency and Renewable Energy". Below the title is a search bar with the word "Search" and a magnifying glass icon. A navigation menu on the left lists the "List of Contents" with items: Acronyms, Preface, Abstract, 1. INTRODUCTION TO BIOMASS, 2. BIOFUELS, 3. BIOPOWER, 4. BIOREFINERIES, 5. FEEDSTOCKS, Appendix A - Conversions, Appendix B - Biomass Characteristics, Appendix C - Assumptions, and Glossary. The main content area features a link to "Download and print the Biomass Energy Data Book in PDF format" and a section titled "Other EERE Data Books:" listing "Buildings Energy Data Book", "Hydrogen Data Book", "Power Technologies Data Book", and "Transportation Energy Data Book". A photograph of a yellow tractor in a field is visible on the right. At the bottom, there are logos for "GTA Center for Transportation Analysis" and "ornl OAK RIDGE NATIONAL LABORATORY". A footer bar contains links for "Contact us", "Webmaster", "U.S. Department of Energy", "EERE Home", and "Disclaimer".

Project Overview - 3

- Replaced the first edition content on the website in 2009.

The screenshot shows the homepage of the Biomass Energy Data Book. At the top, the title "Biomass Energy Data Book" is displayed next to the U.S. Department of Energy logo and the text "U.S. Department of Energy Energy Efficiency and Renewable Energy". Below the title is a navigation bar with a search box and a "GO" button. The main content area is divided into several sections:

- List of Contents:** A vertical menu on the left side listing various sections such as "Acronyms", "Preface", "Abstract", "1. INTRODUCTION TO BIOMASS", "2. BIOFUELS", "3. BIOWATER", "4. BIOPROCESSING", "5. FEEDSTOCKS", and several appendices.
- Download the Biomass Energy Data Book in PDF format:** A prominent link with a red "Feedback" button.
- Other EERE Data Books:** A list of related publications including "Buildings Energy Data Book", "Hydrogen Data Book", "Power Technologies Data Book", and "Transportation Energy Data Book".
- Center for Transportation Analysis (CTA):** A logo and name for the CTA, which is part of the Oak Ridge National Laboratory.
- oml (Oak Ridge National Laboratory):** The logo for the Oak Ridge National Laboratory.
- Biomass Energy Data Book Edition 2:** A thumbnail image of the book cover, showing a forest scene.

At the bottom of the page, there is a footer with links for "Contact us", "Webmaster", "U.S. Department of Energy", "EERE Home", and "Disclaimer".

Project Overview - 4

- Replaced the second edition content on the website in 2010.

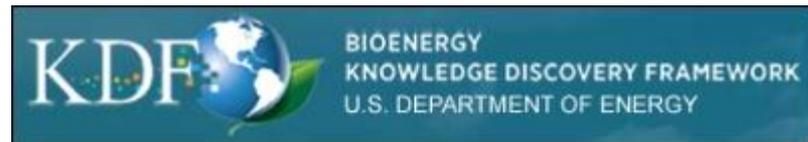
The screenshot shows the homepage of the Biomass Energy Data Book. At the top, the title "Biomass Energy Data Book" is displayed in green, alongside the U.S. Department of Energy logo and the text "Energy Efficiency & Renewable Energy". Below the title is a horizontal strip of nine small images related to biomass energy. The main content area is divided into several sections:

- List of Contents:** A vertical menu on the left with links for "Acronyms", "Preface", "Abstract", "1. INTRODUCTION TO BIOMASS", "2. BIOFUELS", "3. BIOWATER", "4. BIOREFINERIES", "5. FEEDSTOCKS", "Appendix A - Conversions", "Appendix B - Biomass Characteristics", "Appendix C - Sustainability", "Glossary", and "Useful Web Sites". A note above the links states: "* Links below offer tables in spreadsheet format." Below the menu is a small image of a biomass pile.
- Download:** A link to "Download the Biomass Energy Data Book: Edition 3 in PDF format".
- Feedback:** A red button labeled "Feedback".
- Other EERE Data Books:** A list of links for "Buildings Energy Data Book", "Hydrogen Data Book", "Power Technologies Data Book", and "Transportation Energy Data Book".
- KDF:** A logo for the Knowledge Discovery Framework, U.S. Department of Energy.
- Center for Transportation Analysis:** A logo for the Center for Transportation Analysis.
- Biomass Energy Data Book Edition 3:** A large image of the book cover, featuring green leaves and the text "Biomass Energy Data Book Edition 3".
- OAK RIDGE National Laboratory:** The logo for Oak Ridge National Laboratory.

At the bottom of the page, there is a navigation bar with links for "Contact us", "Webmaster", "U.S. Department of Energy", "EERE Home", and "Disclaimer".

Project Overview - 5

- For this Fiscal Year and beyond:
 - Continue compiling and creating biomass energy data tabulations and graphs
 - Expand content as the biomass industry grows and changes
 - Update content several times a year
 - Make the data available in the Knowledge Discovery Framework (KDF)



Approach

- **Sections of the book include:**

CONTENTS	
Introduction to Biomass	6 tables; 4 figures; 2 text pages
Biofuels	
Overview	1 table, 1 figure, 1 text page
Ethanol	13 tables, 6 figures, 1 text page
Biodiesel	4 tables, 4 figures, 1 text page
Bio-oil	4 tables, 1 figure, 1 text page
Taxes and Incentives	2 tables
Biopower	18 tables, 6 figures, 2 text pages
Biorefineries	6 tables, 1 figure, 1 text page
Feedstocks	
Primary Biomass Feedstocks	33 tables, 16 figures, 1 text page
Secondary Biomass Feedstocks	3 tables, 3 figures, 1 text page
Tertiary Biomass Feedstocks	1 table, 1 figure, 1 text page
Conversions	24 tables
Feedstock Characteristics	1 table, 1 text page
Sustainability	1 text page
Glossary	About 275 terms defined

Currently:	
Tables	116
Figures	43
Text pages	14
Glossary terms	275

Approach - 2

- Serve data in Excel and pdf formats

Biomass Energy Data Book

U.S. DEPARTMENT OF **ENERGY** | Energy Efficiency & Renewable Energy

BIOREFINERIES

Contents	Data Type	Format	Updated
Brief Overview	Text	html pdf	12/16/2010
Lignocellulosic Biorefineries by Scale and Stage of Development	Table	xls pdf	12/16/2010
Lignocellulosic Biorefineries by State	Table	xls pdf	12/16/2010
Major DOE Biofuels Project Locations	Figure-Map	xls pdf	12/16/2010
Fuels, Technologies and Feedstocks in Planned Biorefineries as of 2008	Table	xls pdf	12/16/2010
Federal and State Investments in Lignocellulosic Biorefineries as of 2008	Table	xls pdf	12/16/2010
State and Private Investment in Biorefineries for Biofuels and Bioproducts	Table	xls pdf	12/16/2010
Recently Completed U.S. Department of Energy Biorefinery Projects	Table	xls pdf	12/16/2010

[INTRODUCTION](#) | [BIOFUELS](#) | [BIOPOWER](#) | [BIOREFINERIES](#) | [FEEDSTOCKS](#)
[Acronyms](#) | [Glossary](#) | [Conversions](#) | [Characteristics](#) | [Sustainability](#)



[Contact us](#) [Webmaster](#) [U.S. Department of Energy](#) [EERE Home](#) [Disclaimer](#)

Approach - 3

• Data mined from available sources

Table 1.3 Primary Energy Consumption by Source
(Quadrillion Btu)

	Fossil Fuels				Nuclear Electric Power ¹	Renewable Energy ²							Total ³
	Coal	Natural Gas ⁴	Petro- leum ⁵	Total ⁶		Hydro- electric Power ⁷	Geo- thermal	Solar/ PV ⁸	Wind	Bio- mass	Total		
1972 Total	12,871	22,512	34,837	70,314	9,919	2,861	0,043	NA	NA	1,529	4,433	75,706	
1975 Total	12,483	19,849	37,272	63,347	1,800	1,155	670	NA	NA	1,499	4,723	72,601	
1980 Total	16,173	22,512	34,837	70,314	9,919	2,861	0,043	NA	NA	1,529	4,433	75,706	
1985 Total	17,478	22,512	34,837	70,314	9,919	2,861	0,043	NA	NA	1,529	4,433	75,706	
1990 Total	20,889	22,512	34,837	70,314	9,919	2,861	0,043	NA	NA	1,529	4,433	75,706	
1995 Total	21,602	22,512	34,837	70,314	9,919	2,861	0,043	NA	NA	1,529	4,433	75,706	
2000 Total	21,445	22,512	34,837	70,314	9,919	2,861	0,043	NA	NA	1,529	4,433	75,706	
2005 Total	21,823	22,512	34,837	70,314	9,919	2,861	0,043	NA	NA	1,529	4,433	75,706	
2006 Total	21,914	22,512	34,837	70,314	9,919	2,861	0,043	NA	NA	1,529	4,433	75,706	
2007 Total	22,321	22,512	34,837	70,314	9,919	2,861	0,043	NA	NA	1,529	4,433	75,706	
2008 Total	22,447	22,512	34,837	70,314	9,919	2,861	0,043	NA	NA	1,529	4,433	75,706	
2009 Total	22,797	22,512	34,837	70,314	9,919	2,861	0,043	NA	NA	1,529	4,433	75,706	
2010 Total	22,447	22,512	34,837	70,314	9,919	2,861	0,043	NA	NA	1,529	4,433	75,706	
2011 Total	22,749	22,512	34,837	70,314	9,919	2,861	0,043	NA	NA	1,529	4,433	75,706	

Table 10.1 Renewable Energy Production and Consumption by Source
(Trillion Btu)

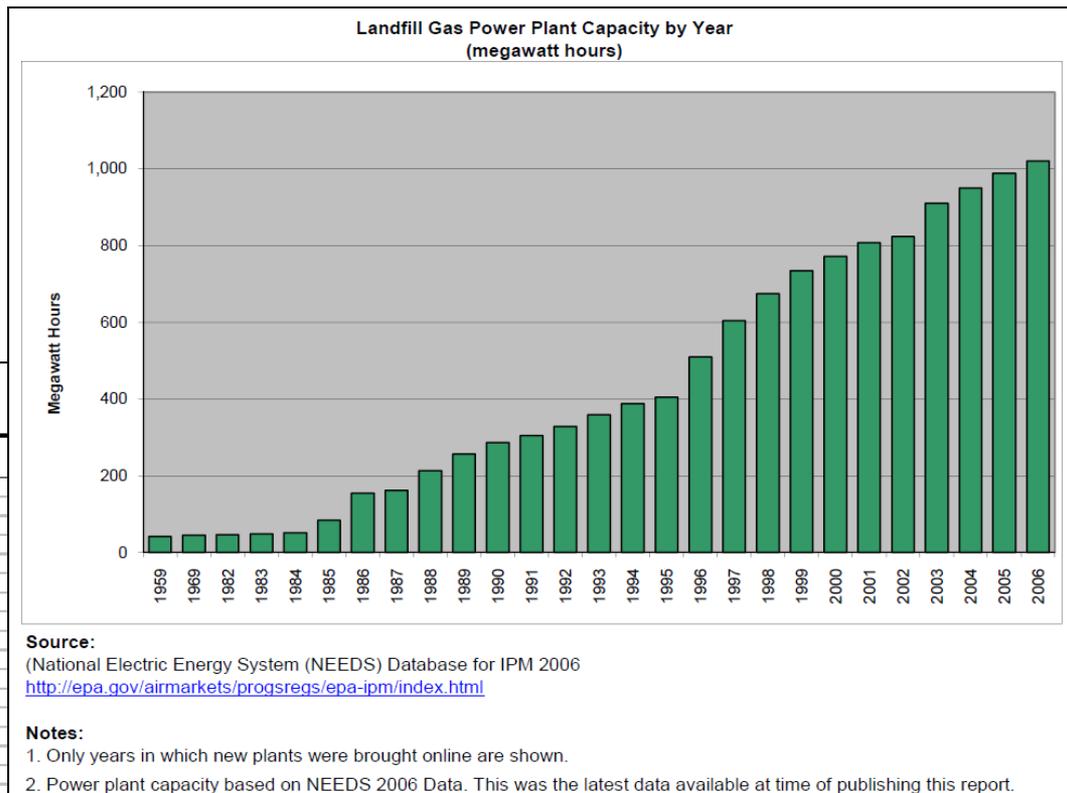
	Production ¹			Consumption										Total Renew- able Energy	
	Biomass	Total ²	Total Renew- able Energy ³	Hydro- electric Power ⁴	Geo- thermal	Solar/ PV ⁵	Wind ⁶	Wood		Waste		Biomass			Total
								Bio- fuels ⁷	Total	Wood	Waste	Bio- fuels ⁷	Total		
1972 Total	NA	1,529	4,433	2,861	43	NA	NA	1,527	2	NA	1,529	4,433	2,861	4,433	
1975 Total	NA	1,499	4,723	2,861	78	NA	NA	1,497	2	NA	1,499	4,723	2,861	4,723	
1980 Total	NA	2,475	4,485	2,800	110	NA	NA	2,474	2	NA	2,475	5,485	2,800	5,485	
1985 Total	61	2,516	6,185	2,819	168	69	39	2,687	238	93	2,616	6,185	2,819	6,185	
1990 Total	111	3,099	7,006	3,049	256	129	59	2,776	280	111	2,730	8,206	3,049	8,206	
1995 Total	189	3,699	6,791	3,265	284	70	33	2,370	531	208	3,101	6,793	3,265	6,793	
2000 Total	181	3,159	6,189	3,369	216	100	40	2,437	481	117	2,150	6,189	3,369	6,189	
2005 Total	185	3,198	7,177	3,640	225	70	34	2,371	551	184	3,105	7,175	3,640	7,175	
2006 Total	203	2,909	6,853	3,217	228	64	105	1,895	602	303	2,911	6,853	3,217	6,853	
2007 Total	211	2,985	6,878	3,288	331	69	48	2,214	549	289	2,983	6,877	3,288	6,877	
2008 Total	457	2,498	6,255	2,680	341	64	142	2,121	399	309	3,010	6,257	2,680	6,257	
2009 Total	254	2,824	5,212	2,242	311	85	76	2,085	364	253	2,822	5,211	2,242	5,211	
2010 Total	298	2,150	3,952	2,689	328	64	105	1,895	402	303	2,911	3,952	2,689	3,952	
2011 Total	402	2,895	6,139	2,825	331	64	115	2,022	491	484	2,987	6,141	2,825	6,141	
2006 Total	457	2,498	6,255	2,680	341	64	142	2,121	399	309	3,010	6,257	2,680	6,257	
2007 Total	594	3,104	6,393	2,793	343	66	178	2,136	403	377	3,117	6,406	2,793	6,406	
2008 Total	728	3,487	7,744	3,884	343	72	164	2,189	397	771	3,277	6,824	3,884	6,824	
2009 Total	973	3,489	6,708	2,446	349	81	341	2,098	413	991	3,593	6,719	2,446	6,719	
2010 Total	104	331	615	295	29	8	42	184	56	97	327	611	295	611	
2011 Total	97	300	627	305	29	7	38	188	35	98	320	627	305	627	
2012 Total	105	321	620	305	29	8	42	188	35	98	320	627	305	627	
2013 Total	107	314	622	319	29	8	51	172	36	107	313	621	319	621	
2014 Total	111	324	694	289	30	9	53	171	36	113	320	693	289	693	
2015 Total	111	313	680	288	30	8	51	187	35	110	312	689	288	689	
2016 Total	120	320	691	282	31	9	39	173	37	120	320	691	282	691	
2017 Total	126	324	614	209	31	9	32	171	36	126	322	613	209	613	
2018 Total	122	319	647	254	30	9	31	163	34	123	320	648	254	648	
2019 Total	126	320	598	152	31	8	47	189	39	127	332	570	152	570	
2020 Total	126	327	568	154	30	8	48	185	37	124	325	568	154	568	
2021 Total	125	323	632	206	30	9	65	181	37	129	329	635	206	635	
2022 Total	1387	3,378	7,378	2,411	358	87	348	2,044	436	1,372	3,852	7,384	2,411	7,384	
2009 January	151	353	680	216	33	9	68	185	37	145	347	673	216	673	
2009 February	149	327	614	200	30	8	54	188	33	155	318	608	200	608	
2009 March	151	359	687	201	33	9	65	184	38	152	354	672	201	672	
2009 April	149	345	682	182	31	8	66	187	38	148	343	661	182	661	
2009 May	152	361	728	289	32	10	78	181	37	155	354	781	289	781	
2009 June	150	355	729	285	32	10	76	185	39	151	356	779	285	779	
2009 July	150	344	682	239	31	10	48	186	39	139	344	682	239	682	
2009 August	141	349	634	191	31	10	53	189	39	141	349	634	191	634	
2009 September	136	333	687	189	30	9	45	188	37	134	331	685	189	685	
2009 October	144	347	646	182	30	9	67	180	39	140	348	646	182	646	
2009 November	149	350	682	205	31	9	67	181	39	144	345	687	205	687	
2009 December	154	362	715	241	32	9	67	180	39	148	356	707	241	707	
2009 11-Month Total	1,583	3,948	7,816	2,869	369	721	1,908	459	1,067	1,067	3,932	7,800	2,869	7,800	
2009 January	151	353	680	216	33	9	68	185	37	145	347	673	216	673	
2009 February	149	327	614	200	30	8	54	188	33	155	318	608	200	608	
2009 March	151	359	687	201	33	9	65	184	38	152	354	672	201	672	
2009 April	149	345	682	182	31	8	66	187	38	148	343	661	182	661	
2009 May	152	361	728	289	32	10	78	181	37	155	354	781	289	781	
2009 June	150	355	729	285	32	10	76	185	39	151	356	779	285	779	
2009 July	150	344	682	239	31	10	48	186	39	139	344	682	239	682	
2009 August	141	349	634	191	31	10	53	189	39	141	349	634	191	634	
2009 September	136	333	687	189	30	9	45	188	37	134	331	685	189	685	
2009 October	144	347	646	182	30	9	67	180	39	140	348	646	182	646	
2009 November	149	350	682	205	31	9	67	181	39	144	345	687	205	687	
2009 December	154	362	715	241	32	9	67	180	39	148	356	707	241	707	
2009 11-Month Total	1,429	3,598	7,193	2,427	328	101	604	1,728	419	1,419	3,576	7,093	2,427	7,093	
2008 11-Month Total	1,290	3,541	6,741	2,366	328	98	488	1,884	398	1,284	3,536	6,728	2,366	6,728	

¹ Production equals consumption for all renewable energy sources except biofuels.
² Total biomass inputs to the production of fuel and alcohol.
³ Wood and wood-derived fuels, biomass waste, and total biomass inputs to the production of ethanol, agricultural bioproducts, and bioenergy.
⁴ Hydroelectric power, geothermal, solar thermal, photovoltaic, wind, and hydrokinetic power.
⁵ Conventional hydroelectricity net generation (converted to Btu using the fossil-fueled plants heat rate).
⁶ Geothermal electricity net generation (converted to Btu using the geothermal energy plants heat rate), and geothermal heat and direct use energy.
⁷ Solar thermal and photovoltaic (PV) electricity net generation (converted to Btu using the fossil-fueled plants heat rate).
⁸ Wind electricity net generation (converted to Btu using the fossil-fueled plants heat rate).
⁹ Wood and wood-derived fuels.

¹⁰ Municipal solid waste from biogenic sources, landfill gas, sludge waste, agricultural hydrolyzates, and other biomass. Through 2000, bioenergy non-renewable waste (municipal solid waste from non-biogenic sources, and fire-derived fuels).
¹¹ Municipal solid waste from biogenic sources, landfill gas, sludge waste, agricultural hydrolyzates, and other biomass. Through 2000, bioenergy non-renewable waste (municipal solid waste from non-biogenic sources, and fire-derived fuels).
¹² Includes coal coke net imports.
¹³ Includes coal coke net imports.
¹⁴ Includes coal coke net imports.
¹⁵ Includes coal coke net imports.
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³⁸ Includes coal coke net imports.
³⁹ Includes coal coke net imports.
⁴⁰ Includes coal coke net

Approach - 4

- Data pulled from large databases



**Section: BIOPOWER
Current Biomass Power Plants**

Plant Name	Boiler/Generator/ Committed Unit	State Name	County
Pacific Lumber	G	California	Humboldt
French Island	B	Wisconsin	La Crosse
French Island	B	Wisconsin	La Crosse
Berlin Gorham	B	New Hampshire	Cooos
Bay Front	B	Wisconsin	Ashland
East Millinocket Mill	B	Maine	Penobscot
Bay Front	B	Wisconsin	Ashland
Schiller	B	New Hampshire	Rockingham
Medford Operation	G	Oregon	Jackson
Bryant Sugar House	B	Florida	Palm Beach
Bryant Sugar House	B	Florida	Palm Beach
Bryant Sugar House	B	Florida	Palm Beach
Bryant Sugar House	B	Florida	Palm Beach
Stone Container Florence Mill	B	South Carolina	Florence
Medford Operation	G	Oregon	Jackson
Rapids Energy Center	B	Minnesota	Itasca
Rapids Energy Center	B	Minnesota	Itasca
Somerset Plant	B	Maine	Somerset
Century Flooring Co	G	Arkansas	Izard
Forster Strong Mill	G	Maine	Franklin
American Ref-Fuel of Niagara	B	New York	Niagara
Stone Container Hopewell Mill	B	Virginia	Hopewell
Diamond Walnut	G	California	San Joaquin
Plummer Forest Products	G	Idaho	Benewah
S D Warren Somerset	B	Maine	Cumberland
Tamarack Energy Partnership	G	Idaho	Adams
Snider Industries	G	Texas	Harrison
Kettle Falls Generating Station	G	Washington	Stevens
Agrilectric Power Partners Ltd	B	Louisiana	Calcasieu
J C McNeil	B	Vermont	Chittenden
Wheelabrator Martell	G	California	Amador
Pacific Oroville Power	B	California	Butte
Pacific Oroville Power	B	California	Butte
Mt Lassen Power	B	California	Lassen
Sierra Pacific Susanville	B	California	Lassen
Collins Pine Project	B	California	Plumas
Burney Mountain Power	B	California	Shasta
Sierra Power	G	California	Tulare
Ultrapower Chinese Station	B	California	Tuolumne
Biomass One LP	B	Oregon	Jackson
Biomass One LP	B	Oregon	Jackson
Fairhaven Power	B	California	Humboldt
Sierra Pacific Quincy Facility	B	California	Plumas

Approach - 5

- Data compiled from a myriad of sources
- Have active links to help user
- Many footnotes help further understanding of the data

Section: BIOPOWER
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 kWt 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 pyrolysis	Variety of wood and agricultural resources	0.04-0.25 in (1-6 mm)	< 10%	~ 2.5 MWe Example 1 Example 2
Aerobic 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 10 ³ kWhr/yr Example 1 Example 2

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

^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.

Approach - 6

- Text boxes on many pages add value
- Tables pulled from long documents are easier to locate
- User can jump to source document easily

It is extremely important to realize that vegetable oils are mixtures of tryglycerides from various fatty acids. The composition of vegetable oils varies with the plant source. The table below indicates the percentages of each type of fatty acid that is in common vegetable oils or animal fats. The two numbers at the top of each column represents the number of carbon atoms and double bonds (e.g. 16:0 refers to the 16 carbon atoms and 0 double bonds found in the long chain of Palmitic acid). See text on Typical Proportions of Chemicals Used to Make Biodiesel (Commercial Biodiesel Production Methods) for a description of several types of tryglycerides that are found in vegetable oils.

Section: BIOFUELS
Composition of Various Oils and Fats Used for Biodiesel
 (percentage of each type of fatty acid common to each type of feedstock)

Oil or fat	14:0	16:0	18:0	18:1	18:2	18:3	20:0	22:1
Soybean		6-10	2-5	20-30	50-60	5-11		
Corn	1-2	8-12	2-5	19-49	34-52	trace		
Peanut		8-9	2-3	50-60	20-30			
Olive		9-10	2-3	73-84	10-12	trace		
Cottonseed	0-2	20-25	1-2	23-35	40-50	trace		
Hi Linoleic Safflower		5.9	1.5	8.8	83.8			
Hi Oleic Safflower		4.8	1.4	74.1	19.7			
Hi Oleic Rapeseed		4.3	1.3	59.9	21.1	13.2		
Hi Erucic Rapeseed		3.0	0.8	13.1	14.1	9.7	7.4	50.7
Butter	7-10	24-26	10-13	28-31	1-2.5	.2-.5		
Lard	1-2	28-30	12-18	40-50	7-13	0-1		
Tallow	3-6	24-32	20-25	37-43	2-3			
Linseed Oil		4-7	2-4	25-40	35-40	25-60		
Yellow grease (typical)	2.43	23.24	12.96	44.32	6.97	0.67		
		16:1=3.97						

Source:

J. Van Gerpen, B. Shanks, and R. Pruszko, D. Clements, and G. Knothe, 2004, "Biodiesel Production Technology," National Renewable Energy Laboratory subcontractor report NREL/SR-510-36244, chapter 1, page 1. Please see this document for a full discussion.

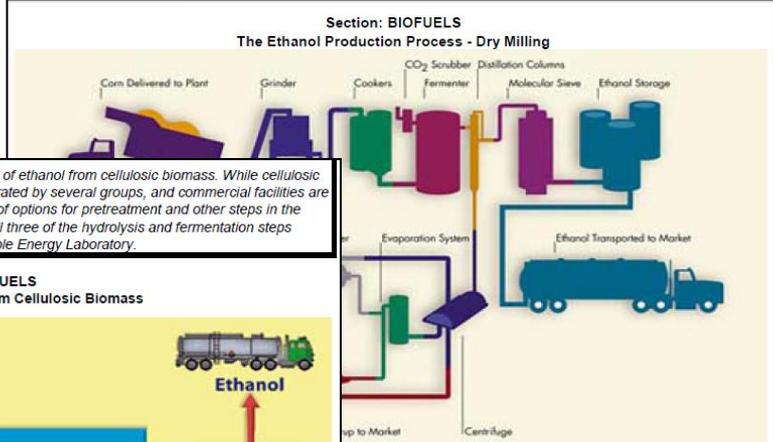
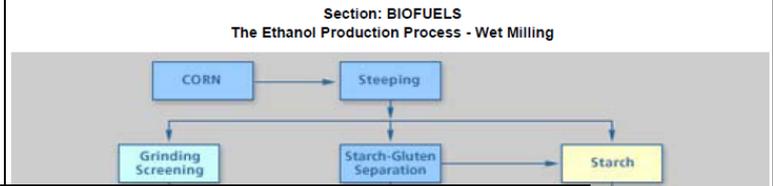
Available on-line at:

www.nrel.gov/docs/fy04osti/36244.pdf

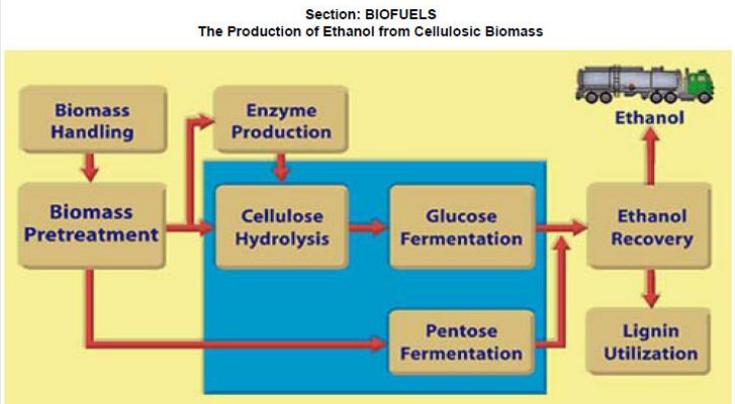
Approach - 7

- Include explanations to inform the general public

The production of ethanol or ethyl alcohol from starch or sugar-based feedstocks is among man's earliest ventures into value-added processing. While the basic steps remain the same, the process has been considerably refined in recent years, leading to a very efficient process. There are two production processes: wet milling and dry milling. The main difference between the two is in the initial treatment of the grain.



This process flow diagram shows the basic steps in production of ethanol from cellulosic biomass. While cellulosic ethanol is not yet commercial in the U.S., it has been demonstrated by several groups, and commercial facilities are being planned in North America. Note that there are a variety of options for pretreatment and other steps in the process and that some specific technologies combine two or all three of the hydrolysis and fermentation steps within the shaded box. Chart courtesy of the National Renewable Energy Laboratory.



Hydrolysis is the chemical reaction that converts the complex polysaccharides in the raw feedstock to simple sugars. In the biomass-to-ethanol process, acids and enzymes are used to catalyze this reaction.

Fermentation is a series of chemical reactions that convert sugars to ethanol. The fermentation reaction is caused by yeast or bacteria, which feed on the sugars. Ethanol and carbon dioxide are produced as the sugar is consumed.

Process Description. The basic processes for converting sugar and starch crops are well-known and used commercially today. While these types of plants generally have a greater value as food sources than as fuel sources there are some exceptions to this. For example, Brazil uses its huge crops of sugar cane to produce fuel for its transportation needs. The current U.S. fuel ethanol industry is based primarily on the starch in the kernels of feed corn, America's largest agricultural crop.

- 1. Biomass Handling.** Biomass goes through a size-reduction step to make it easier to handle and to make the ethanol production process more efficient. For example, agricultural residues go through a grinding process and wood goes through a chipping process to achieve a uniform particle size.
- 2. Biomass Pretreatment.** In this step, the hemicellulose fraction of the biomass is broken down into simple sugars. A chemical reaction called hydrolysis occurs when dilute sulfuric acid is mixed with the biomass feedstock. In this hydrolysis reaction, the complex chains of sugars that make up the hemicellulose are broken, releasing simple sugars. The complex hemicellulose sugars are converted to a mix of soluble five-carbon sugars, xylose and arabinose, and soluble six-carbon sugars, mannose and galactose. A small portion of the cellulose is also converted to glucose in this step.
- 3. Enzyme Production.** The cellulase enzymes that are used to hydrolyze the cellulose fraction of the biomass are grown in this step. Alternatively the enzymes might be purchased from commercial enzyme companies.

to 48 hours. This steeping
corn germ. The corn oil
the remaining fiber, gluten
ic separators.
steep water, is co-dried
Heavy steep water is also
entally friendly alternative
y grain is first ground into flour, which is referred to in the industry
e various component parts of the grain. The meal is slurried with
 mash to convert the starch to dextrose, a simple sugar.
t to the yeast.
ker to reduce bacteria levels ahead of fermentation. The mash is
is added and the conversion of sugar to ethanol and carbon

0 to 50 hours. During this part of the process, the mash is agitated
After fermentation, the resulting "beer" is transferred to distillation
remaining "stillage." The ethanol is concentrated to 190 proof
ed to approximately 200 proof in a molecular sieve system.

denaturant (such as natural gasoline) to render it undrinkable and
ready for shipment to gasoline terminals or retailers.
ates the coarse grain from the solubles. The solubles are then
resulting in Condensed Distillers Solubles (CDS) or "syrup." The
oduce dried distillers grains with solubles (DDGS), a high quality,
fermentation is captured and sold for use in carbonating soft

Approach - 8

- Very proud of our conversion tables

Biomass Energy Data Book		U.S. DEPARTMENT OF ENERGY		Energy Efficiency & Renewable Energy
Appendix A - Conversions				
Contents	Data Type	Format	Updated	
Lower and Higher Heating Values of Gas, Liquid and Solid Fuels	Table	xls pdf	11/15/2010	
Heat Content Ranges for Various Biomass Fuels	Table	xls pdf	11/15/2010	
Average Heat Content for Selected Waste Fuels	Table	xls pdf	11/17/2010	
The Effect of Fuel Moisture Content on Wood Heat Content	Table	xls pdf	11/15/2010	
Forestry Volume Unit to Biomass Weight Considerations	Table	xls pdf	11/15/2010	
Forestry Volume Unit to Biomass Weight Equations	Table	xls pdf	11/15/2010	
Forestry Volume Unit to Biomass Weight Examples	Table	xls pdf	11/15/2010	
Stand Level Biomass Estimation	Table	xls pdf	11/15/2010	
Number of Trees per Acre and Hectare by Tree Spacing Combination	Table	xls pdf	11/15/2010	
Wood and Log Volume to Volume Conversion Factors	Table	xls pdf	11/15/2010	
Estimating Tons of Wood Residues Per Thousand Board Feet of Lumber Produced by Sawmills	Table	xls pdf	11/15/2010	
Estimating Tons of Wood Residue Per Thousand Board Feet of Wood Used for Selected Products	Table	xls pdf	11/15/2010	
Area and Length Conversions	Table	xls pdf	11/15/2010	
Mass Units and Mass per Unit Area Conversions	Table	xls pdf	11/15/2010	
Distance and Velocity Conversions	Table	xls pdf	11/15/2010	
Capacity, Volume and Specific Volume Conversions	Table	xls pdf	11/15/2010	
Power Conversions	Table	xls pdf	11/15/2010	
Small Energy Unit and Energy Unit per Weight Conversions	Table	xls pdf	11/15/2010	
Large Energy Unit Conversions	Table	xls pdf	11/15/2010	
Alternative Measures of Greenhouse Gases	Table	xls pdf	11/15/2010	
Fuel Efficiency Conversions	Table	xls pdf	11/15/2010	
SI Prefixes and Their Values	Table	xls pdf	11/15/2010	
Metric Units and Abbreviations	Table	xls pdf	11/15/2010	
Cost per Unit Conversions	Table	xls pdf	11/15/2010	

Approach - 9

Example:

To use these conversion factors, first decide the mill type, which is based on equipment; then determine the average scaling diameter of the logs. If the equipment indicates a mill type B and the average scaling diameter is 13 inches, then look in section B, line 2. This line shows that for every thousand board feet of softwood lumber sawed, 0.42 tons of bark, 1.18 tons of chippable material, and 0.92 tons of fines are produced, green weight. Equivalent hard hardwood and soft hardwood data are also given. Converting factors for shavings are omitted as they are zero for sawmills.

Section: Appendix A

Estimating Tons of Wood Residue Per Thousand Board Feet of Lumber Produced by Sawmills, by Species and Type of Residue

Mill Type ^a	Small end diameter ^b	Softwood ^c						Hard hardwood ^c						Soft hardwood ^c					
		Bark		Chippable		Fine ^f		Bark		Chipable		Fine		Bark		Chipable		Fine	
		G ^d	OD ^e	G	OD	G	OD	G	OD	G	OD	G	OD	G	OD	G	OD	G	OD
A, B, C, H, and I	1	0.46	0.31	1.57	0.78	0.98	0.48	0.84	0.59	1.84	1.04	1.26	0.71	0.58	0.41	1.27	0.72	0.86	0.49
	2	0.42	0.29	1.18	0.58	0.92	0.45	0.72	0.51	1.53	0.87	1.34	0.76	0.50	0.35	1.06	0.60	0.91	0.52
	3	0.41	0.28	1.07	0.53	1.00	0.49	0.56	0.39	1.17	0.66	1.08	0.61	0.39	0.27	0.81	0.46	0.74	0.42
	4	0.31	0.21	0.88	0.43	0.91	0.45	0.49	0.35	1.03	0.58	1.05	0.60	0.34	0.24	0.72	0.41	0.72	0.41
D and E	1	0.29	0.20	1.57	0.78	0.90	0.45	0.84	0.59	1.84	1.04	0.92	0.52	0.58	0.41	1.27	0.72	0.63	0.36
	2	0.29	0.20	1.18	0.58	0.76	0.38	0.72	0.51	1.53	0.87	0.84	0.48	0.50	0.35	1.06	0.60	0.58	0.33
	3	0.29	0.20	1.07	0.53	0.71	0.35	0.56	0.39	1.17	0.66	0.84	0.48	0.39	0.27	0.81	0.46	0.58	0.33
	4	0.29	0.20	0.88	0.43	0.64	0.32	0.49	0.35	1.03	0.58	0.80	0.45	0.34	0.24	0.72	0.41	0.55	0.31
F	1	0.29	0.20	1.57	0.78	0.98	0.48	0.84	0.59	1.84	1.04	1.26	0.71	0.58	0.41	1.27	0.72	0.86	0.49
	2	0.29	0.20	1.18	0.58	0.92	0.45	0.72	0.51	1.53	0.87	1.34	0.76	0.50	0.35	1.06	0.60	0.91	0.52
	3	0.29	0.20	1.07	0.53	1.00	0.49	0.56	0.39	1.17	0.66	1.08	0.61	0.39	0.27	0.81	0.46	0.74	0.42
	4	0.29	0.20	0.88	0.43	0.91	0.45	0.49	0.35	1.03	0.58	1.05	0.60	0.34	0.24	0.72	0.41	0.72	0.41
G	1	0.29	0.20	1.90	0.94	0.57	0.28	0.84	0.59	2.23	1.28	0.53	0.28	0.58	0.41	1.54	0.88	0.36	0.20
	2	0.29	0.20	1.34	0.66	0.60	0.30	0.72	0.51	1.72	0.98	0.65	0.37	0.50	0.35	1.19	0.68	0.45	0.25
	3	0.29	0.20	1.17	0.58	0.61	0.30	0.56	0.39	1.29	0.73	0.72	0.41	0.39	0.27	0.89	0.51	0.50	0.28
	4	0.29	0.20	0.98	0.48	0.54	0.28	0.49	0.35	1.15	0.65	0.68	0.38	0.34	0.24	0.80	0.46	0.47	0.26

^a Mill Type

- A. Circular headsaw with or without trim saw
- B. Circular headsaw with edger and trim saw.
- C. Circular headsaw with vertical band resaw, edger, trim saw.
- D. Band headsaw with edger, trim saw.
- E. Band headsaw with horizontal band resaw, edger, trim saw.
- F. Band headsaw with cant gangsaw, edger, trim saw.
- G. Chipping head rig.
- H. Round log mill.
- I. Scragg mill.

^b Average small-end log (scaling) diameter classes.

- 1. 5-10 inches.
- 2. 11-13 inches.
- 3. 14-16 inches.
- 4. 17 inches and over

^c See Appendix A for species classification, i.e., softwood, hard hardwood, and soft hardwood.

^d G = green weight, or initial condition, with the moisture content of the wood as processed

^e OD = Oven Dry. It is the weight at zero percent moisture.

^f Fine is sawdust and other similar size material.

Source:

Ellis, Bridgette K. and Janice A. Brown, Tennessee Valley Authority. "Production and Use of Industrial Wood and Bark Residues in the Tennessee Valley Region," August 1984.

Approach - 10

- Combine two sources on a page to give a more complete picture
- Additional text explanation alerts reader to important points

Section: Appendix A Forestry Volume Unit to Biomass Weight Considerations

Biomass is frequently estimated from forestry inventory merchantable volume data, particularly for purposes of comparing regional and national estimates of aboveground biomass and carbon levels. Making such estimations can be done several ways but always involves the use of either conversion factors or biomass expansion factors (or both combined) as described by figure 1 below. Figure 2 clarifies the issue further by defining what is included in each category of volume or biomass units.

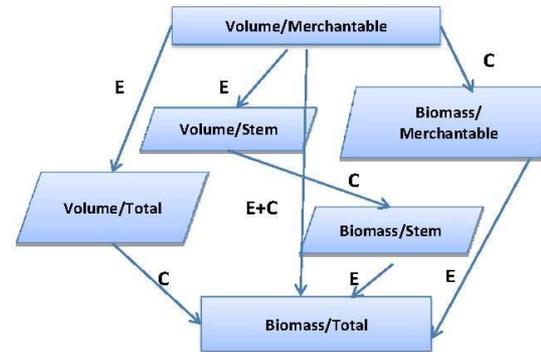


Figure 1 Source: Somogyi Z. et al. Indirect methods of large-scale biomass estimation. Eur J Forest Res (2006) DOI 10.1007/s10342-006-0125-7

Unfortunately definitions used in figure 1 are not standardized worldwide, but figure 2 below demonstrates definitions used in the United States for forest inventory data. The merchantable volume provided by forest inventory reports commonly refers only to the underbark volume or biomass of the main stem above the stump up to a 4 inch (10 cm) top. Merchantable stem volume can be converted (symbolized by C in Fig. 1) to merchantable biomass. Both merchantable volume and biomass must be expanded (symbolized by E on the diagram) to include the bark for stem volume or biomass. Further expansion is needed to obtain the total volume or biomass which includes stem, bark, stump, branches and foliage, especially if evergreen trees are being measured. When estimating biomass available for bioenergy, the foliage is not included and the stump may or may not be appropriate to include depending on whether harvest occurs at ground level or higher. Both conversion and expansion factors can be used together to translate directly between merchantable volumes per unit area and total biomass per unit area (see table A5, Appendix A) .

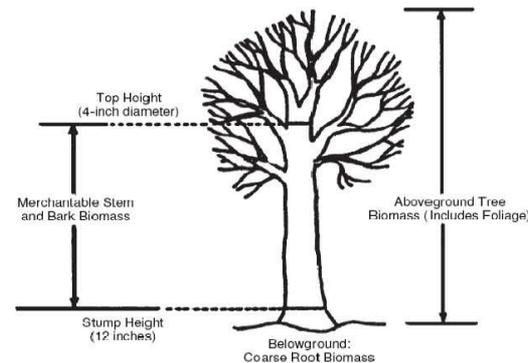


Figure 2 Source: Jenkins, JC, Chojnacky DC, Heath LS, Birdsey RA. Comprehensive Database of Diameter-based Biomass Regressions for North American Tree Species. United States Department of Agriculture, Forest Service General Technical Report NE-319, pp 1-45 (2004)

Approach - 11

- The Glossary is helpful

Biomass Energy Data Book

U.S. DEPARTMENT OF **ENERGY** | Energy Efficiency & Renewable Energy

Glossary

A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z

A

Agricultural Residue - Agricultural crop residues are the plant parts, primarily stalks and leaves, not removed from the fields with the primary food or fiber product. Examples include corn stover (stalks, leaves, husks, and cobs); wheat straw; and rice straw. With approximately 80 million acres of corn planted annually, corn stover is expected to become a major biomass resource for bioenergy applications.

Air dry - The state of dryness at equilibrium with the water content in the surrounding atmosphere. The actual water content will depend upon the relative humidity and temperature of the surrounding atmosphere.

Alcohol - The family name of a group of organic chemical compounds composed of carbon, hydrogen, and oxygen. The molecules in the series vary in chain length and are composed of a hydrocarbon plus a hydroxyl group. Alcohol includes methanol and ethanol.

Alkaline metals - Potassium and sodium oxides ($K_2O + NaO_2$) that are the main chemicals in biomass solid fuels that cause slagging and fouling in combustion chambers and boilers.

Anaerobic digestion - Decomposition of biological wastes by micro-organisms, usually under wet conditions, in the absence of air (oxygen), to produce a gas comprising mostly methane and carbon dioxide.

Annual removals - The net volume of growing stock trees removed from the inventory during a specified year by harvesting, cultural operations such as timber stand improvement, or land clearing.

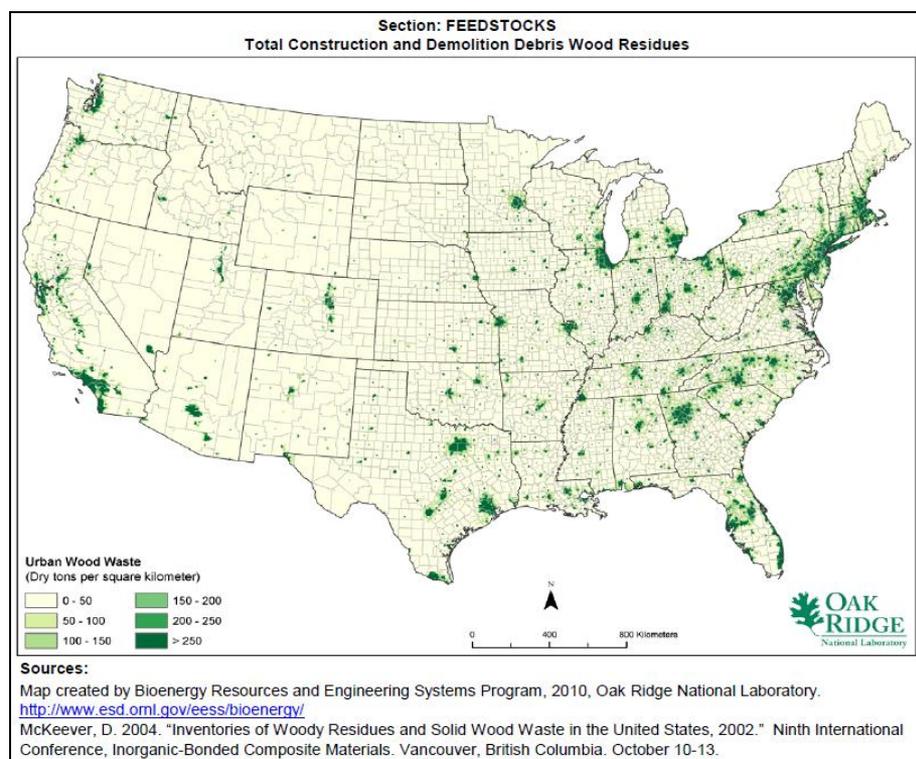
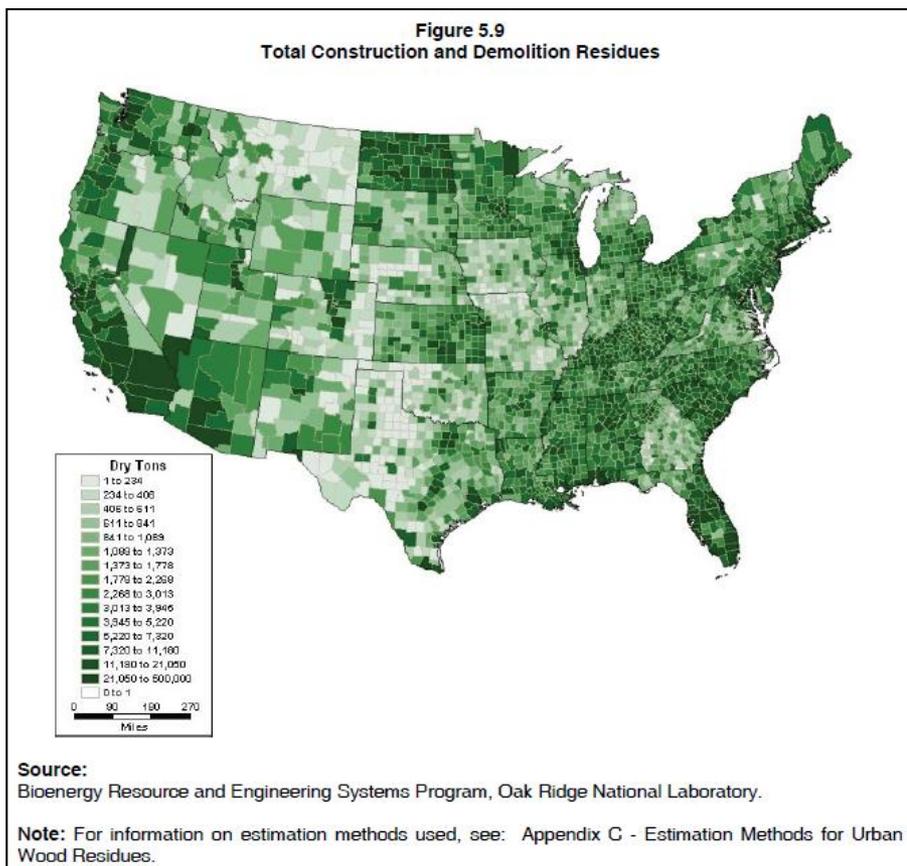
ASABE Standard X593 - The American Society of Agricultural and Biological Engineers (ASABE) in 2005 produced a new standard (Standard X593) entitled "Terminology and Definitions for Biomass Production, Harvesting and Collection, Storage, Processing, Conversion and Utilization." The purpose of the standard is to provide uniform terminology and definitions in the general area of biomass production and utilization. This standard includes many terminologies that are used in biomass feedstock production, harvesting, collecting, handling, storage, pre-processing and conversion, bioenergy, biopower and bioproducts. The terminologies were reviewed by many experts from all of the different fields of biomass and bioenergy before being accepted as part of the standard. The full-text is included on the online Technical Library of ASABE (<http://asae.frymulti.com>); members and institutions holding a site license can access the online version. Print copies may be ordered for a fee by calling 269-429-0300, e-mailing martin@asabe.org, or by mail at: ASABE, 2950 Niles Rd., St. Joseph, MI 49085.

Approach - 12

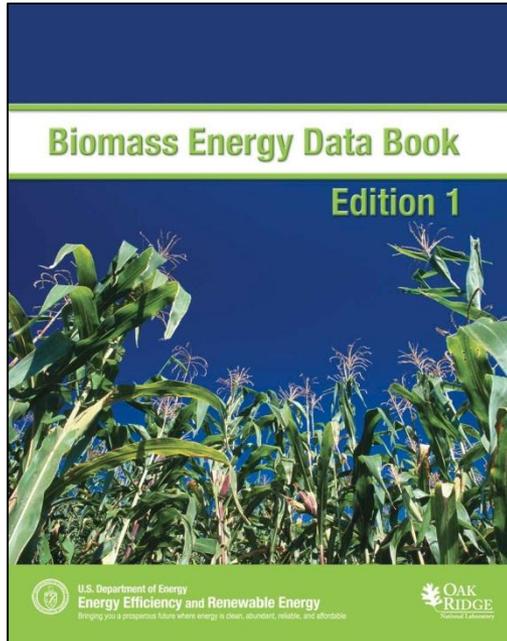
- Users help us improve

From Edition 1

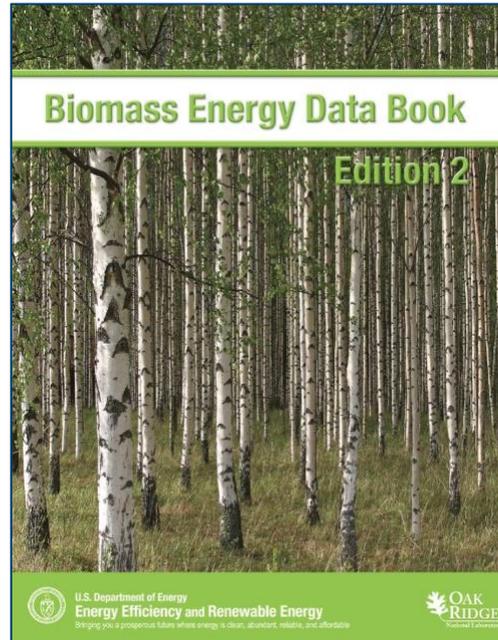
Improved in Edition 3
thanks to a user's comment



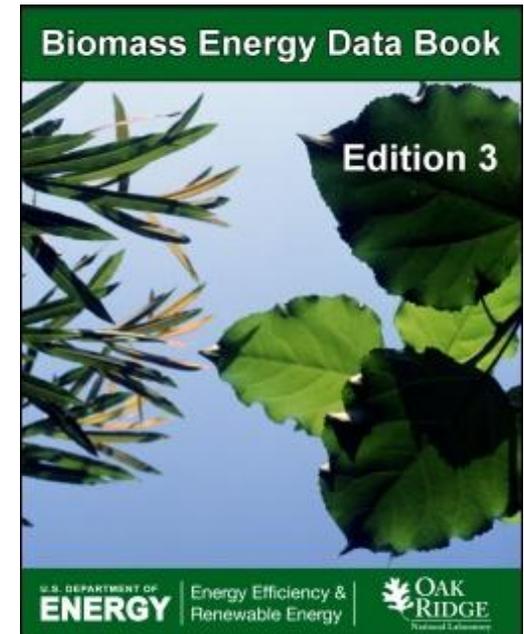
Technical Accomplishments



Website launch:
October 2006



Website update:
December 2009

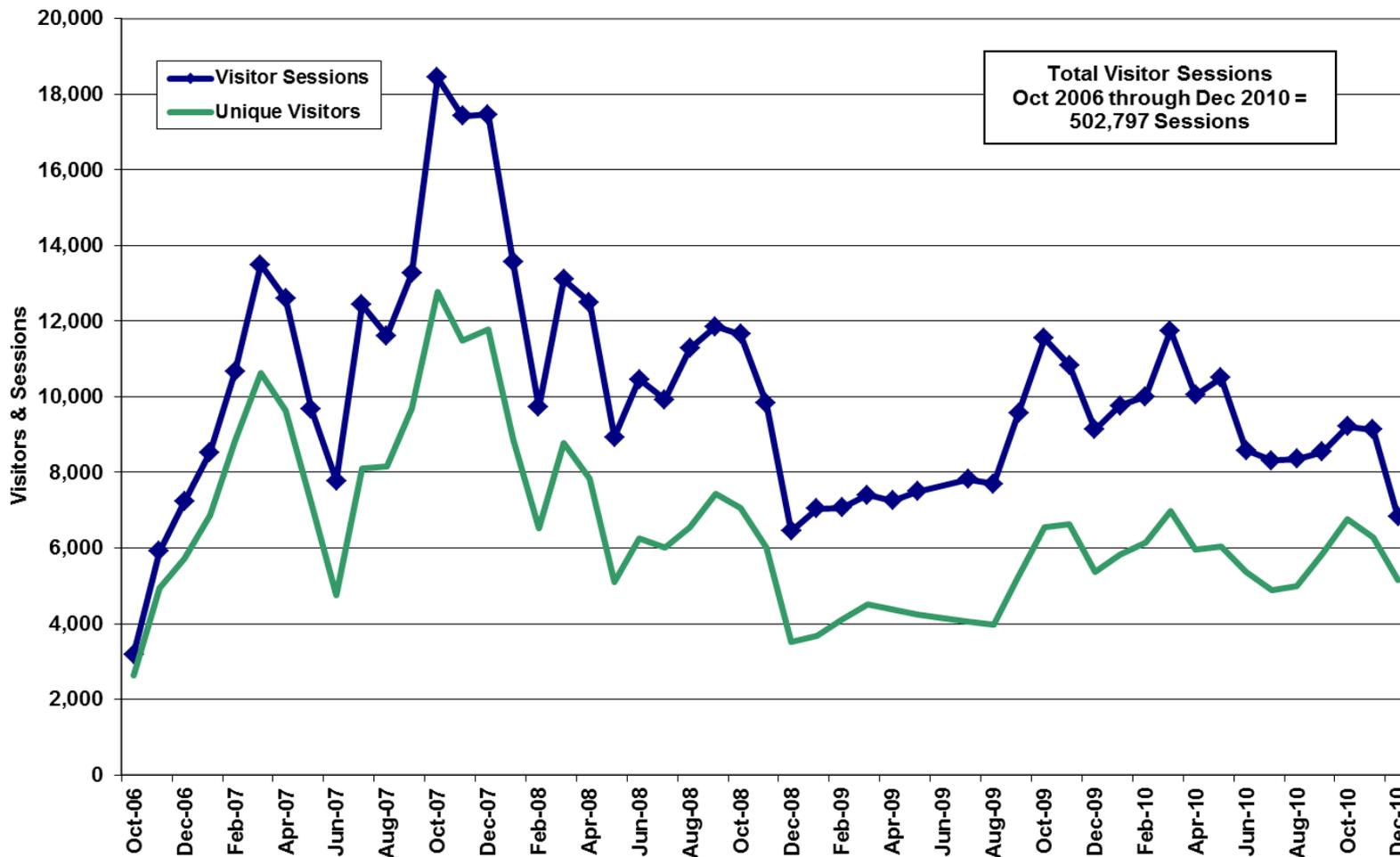


Website update:
December 2010

Technical Accomplishments - 2

Biomass Energy Data Book Website Statistics

(<http://cta.ornl.gov/bedb>)



Relevance

“To fully understand the biomass-to-bioenergy supply chain and its economic, environmental, and other impacts requires complete and comparable data.”

– Biomass Multi-Year Program Plan, November 2010, p. 2-99.

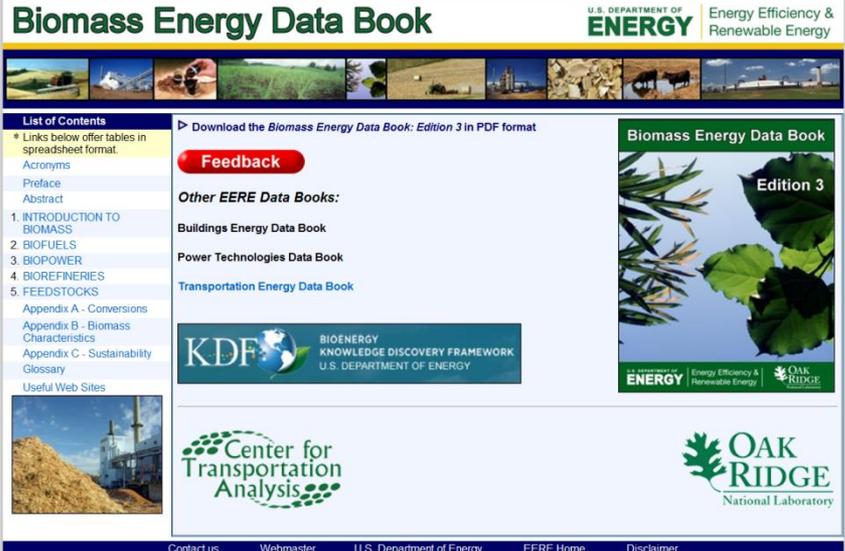
- **Supports stakeholder and policy analysis**
- **Informs the general public**
- **Provides accurate, consistent data and information**
- **Uses a wide variety of sources, including data and analysis generated by the Biomass Program**

Benefits & Expected Outcomes

- **Valuable asset to feed data into the Knowledge Discovery Framework (KDF)**
- **Includes detailed data for industry analysts, but also includes more general information**
- **Creates historical time series not always found in the original source**
- **Leads website users to important data sources**

Summary

- In the last year, the Biomass Energy Data Book has been used by more than 5,000 people each month



Biomass Energy Data Book U.S. DEPARTMENT OF ENERGY Energy Efficiency & Renewable Energy

List of Contents
▼ Links below offer tables in spreadsheet format.
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Abstract
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2. BIOFUELS
3. BIOPOWER
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5. FEEDSTOCKS
Appendix A - Conversions
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Appendix C - Sustainability
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Useful Web Sites

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Center for Transportation Analysis

OAK RIDGE National Laboratory

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- In the next year:
 - the Biomass Energy Data Book will feed data and information into the KDF
 - the data and information will be updated on a more frequent basis
 - the content will be expanded as data allow