Biomass Energy Data Book

April 4, 2011
Analysis Platform Review

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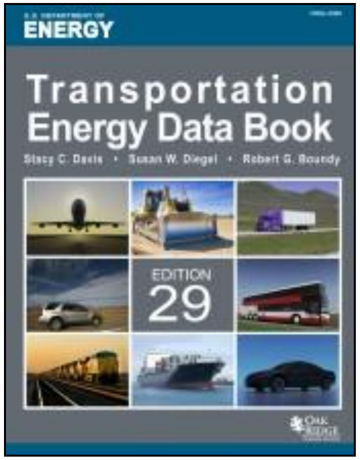
This presentation does not contain any proprietary, confidential, or otherwise restricted information

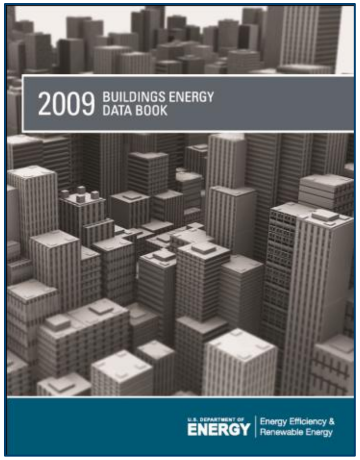
Goal Statement

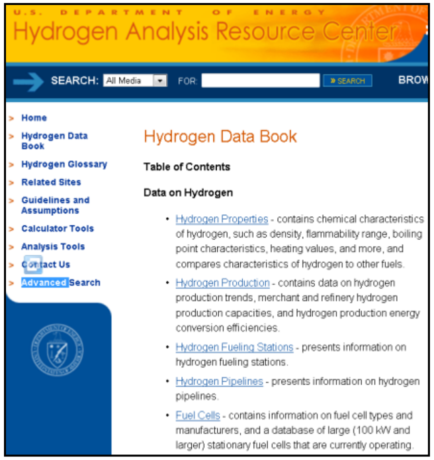
The objective is to create tabulations and graphics from existing biomass data sources to produce a comprehensive compilation of data and information that supports anyone with an interest or stake in the biomass industry.

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:

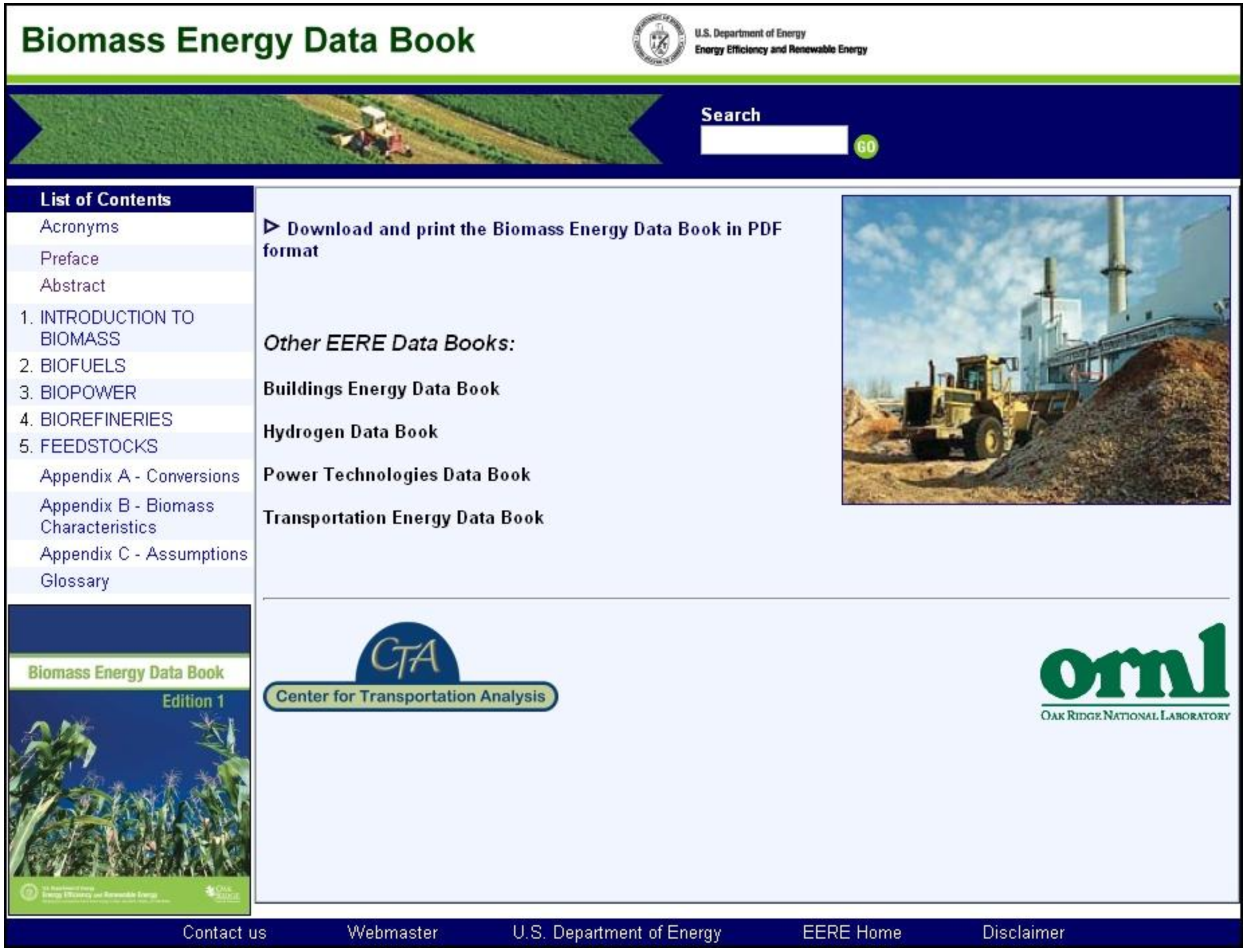






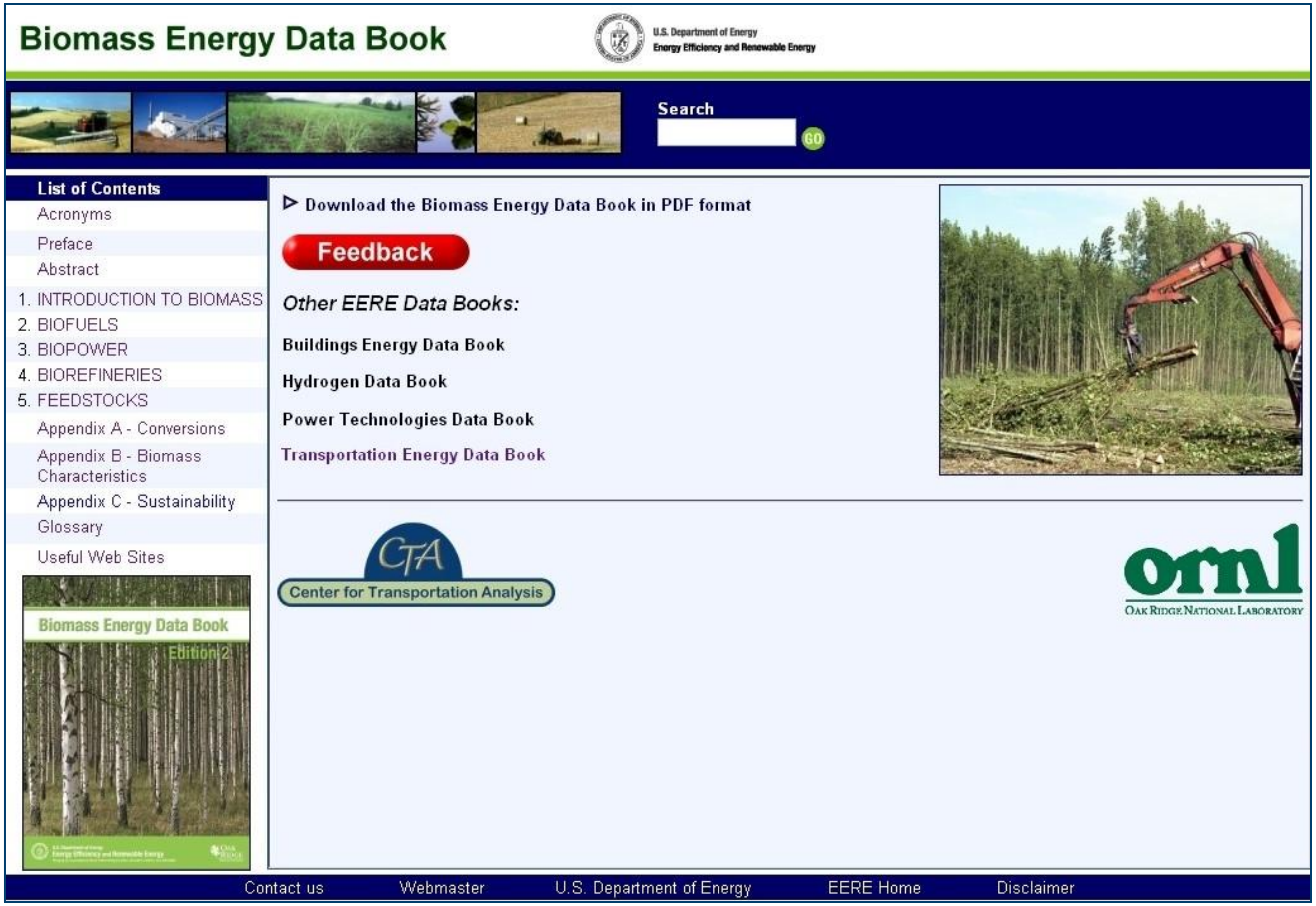
Project Overview - 2

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



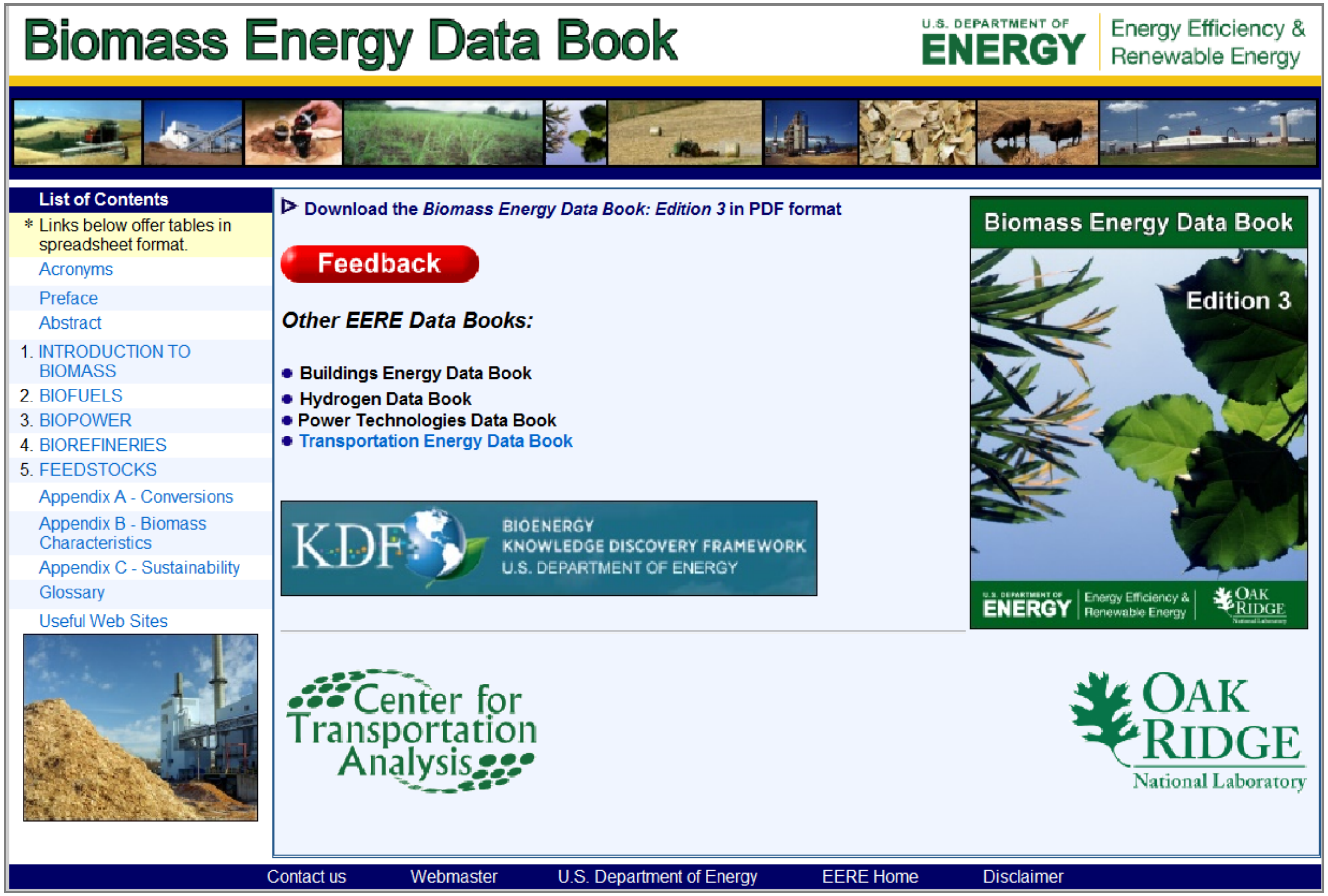
Project Overview - 3

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



Project Overview - 4

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



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

Home

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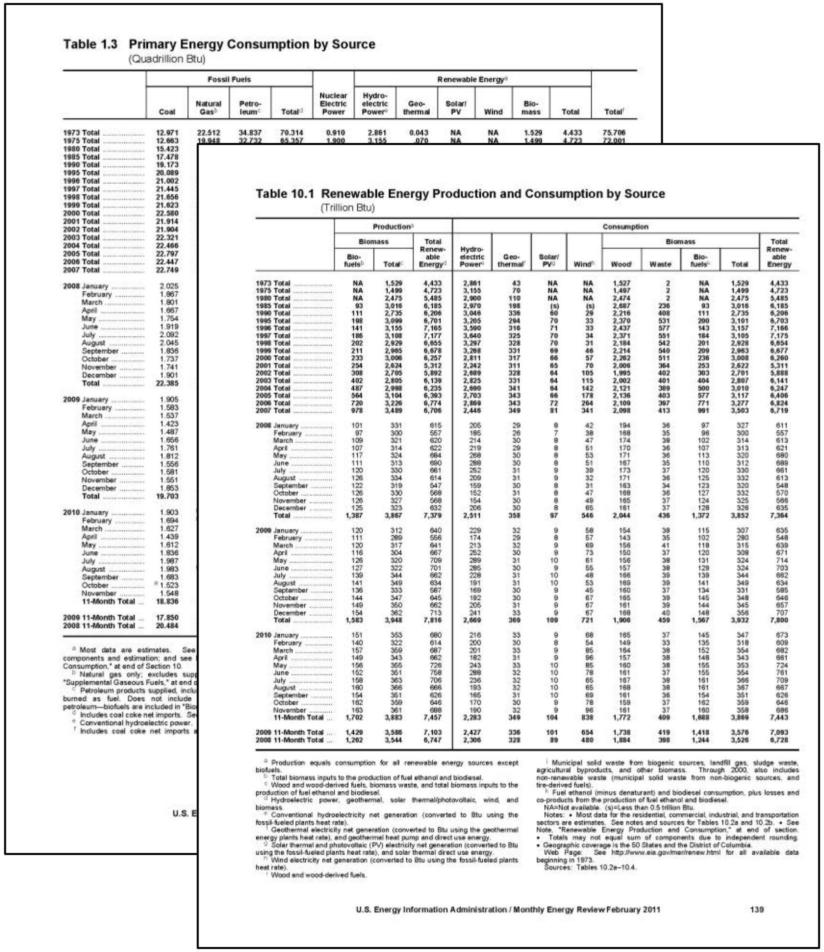
Approach - 3

- **Data mined from available sources**



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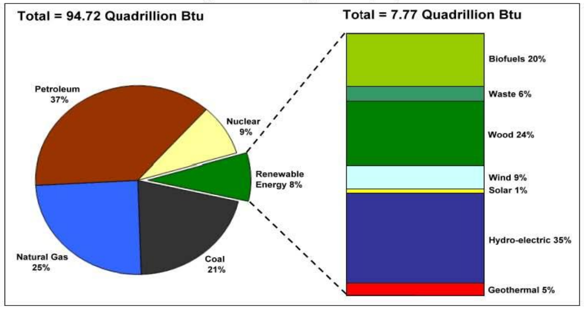
Biomass is the single largest source of renewable energy in the United States. Biomass, which includes biofuels, waste and woody materials, surpassed hydroelectric power in 2005 and by 2009 accounted for half of all renewable energy consumption. In 2009, biomass contributed about 4.1% of the total U.S. energy consumption of about 95 quadrillion Btu. Wood, wood waste, and black liquor from pulp mills is the single largest source, accounting for almost two-thirds of total biomass energy consumption. Wastes (which include municipal solid waste, landfill gas, sludge waste, tires, agricultural by-products, and other secondary and tertiary sources of biomass) accounts for about 12% of total biomass consumption. The remaining share is alcohol fuel derived principally from corn grain.

Section: INTRODUCTION
Summary of Biomass Energy Consumption, 2009



Source:
Energy Information Administration, *Monthly Energy Review*, September 2010, Table 1.3 *Primary Energy Consumption by Source* and Table 10.1 *Renewable Energy Production and Consumption by Source*.
http://www.eia.doe.gov/emeu/mer/contents.html

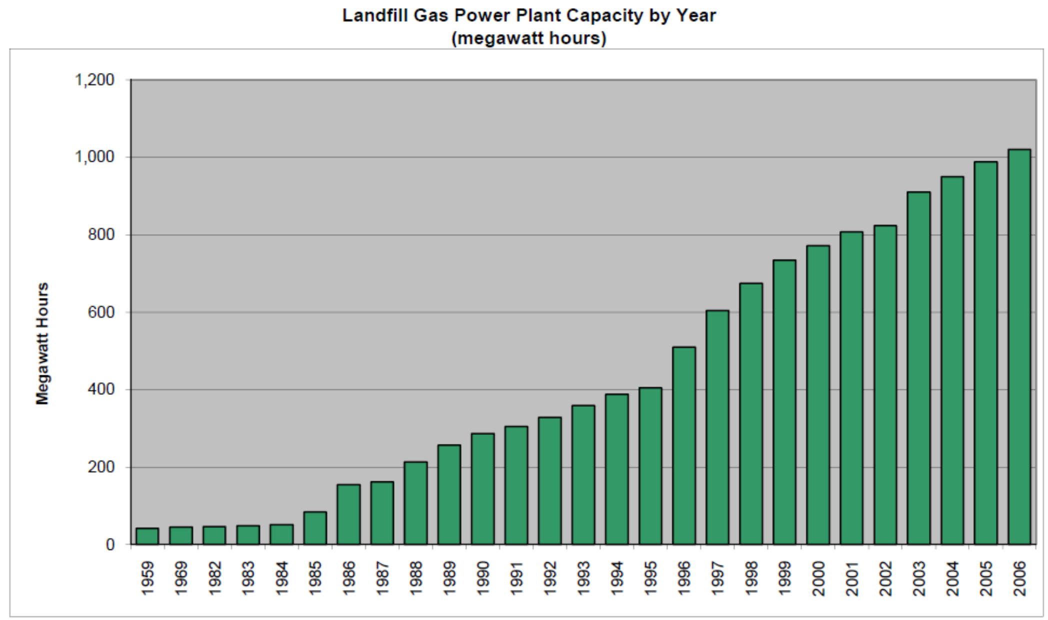
Biomass Energy Data Book -- 2010 -- http://cta.ornl.gov/bedb

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	Coos				
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	34.23	15,826	Yes	1976
Century Flooring Co	G	Arkansas	Izard	1.70	15,826	Yes	1980
Forster Strong Mill	G	Maine	Franklin	0.35	15,826	Yes	1980
American Ref-Fuel of Niagara	B	New York	Niagara	9.00	15,826	Yes	1980
Stone Container Hopewell Mill	B	Virginia	Hopewell	20.35	15,826	Yes	1980
Diamond Walnut	G	California	San Joaquin	4.20	15,826	Yes	1981
Plummer Forest Products	G	Idaho	Benewah	5.77	15,000	Yes	1982
S D Warren Somerset	B	Maine	Cumberland	26.88	15,826	No	1982
Tamarack Energy Partnership	G	Idaho	Adams	5.80	9,650	Yes	1983
Snider Industries	G	Texas	Harrison	5.00	15,826	Yes	1983
Kettle Falls Generating Station	G	Washington	Stevens	50.00	11,860	No	1983
Agrilectric Power Partners Ltd	B	Louisiana	Calcasieu	10.90	17,327	No	1984
J C McNeil	B	Vermont	Chittenden	52.00	21,020	No	1984
Wheelabrator Martell	G	California	Amador	15.00	15,826	Yes	1985
Pacific Oroville Power	B	California	Butte	8.25	20,081	No	1985
Pacific Oroville Power	B	California	Butte	8.25	20,081	No	1985
Mt Lassen Power	B	California	Lassen	10.50	19,607	No	1985
Sierra Pacific Susanville	B	California	Lassen	12.60	15,826	Yes	1985
Collins Pine Project	B	California	Plumas	9.80	15,826	Yes	1985
Burney Mountain Power	B	California	Shasta	9.75	18,938	No	1985
Sierra Power	G	California	Tulare	7.00	15,826	Yes	1985
Ultrapower Chinese Station	B	California	Tuolumne	19.80	20,111	No	1985
Biomass One LP	B	Oregon	Jackson	8.50	19,236	Yes	1985
Biomass One LP	B	Oregon	Jackson	14.00	14,427	Yes	1985
Fairhaven Power	B	California	Humboldt	17.30	21,020	No	1986
Sierra Pacific Quincy Facility	B	California	Plumas	14.50	15,826	Yes	1986



Source:
(National Electric Energy System (NEEDS) Database for IPM 2006
http://epa.gov/airmarkets/progsregs/epa-ipm/index.html

Notes:
1. Only years in which new plants were brought online are shown.
2. Power plant capacity based on NEEDS 2006 Data. This was the latest data available at time of publishing this report.

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 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 pyrolysis	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 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						

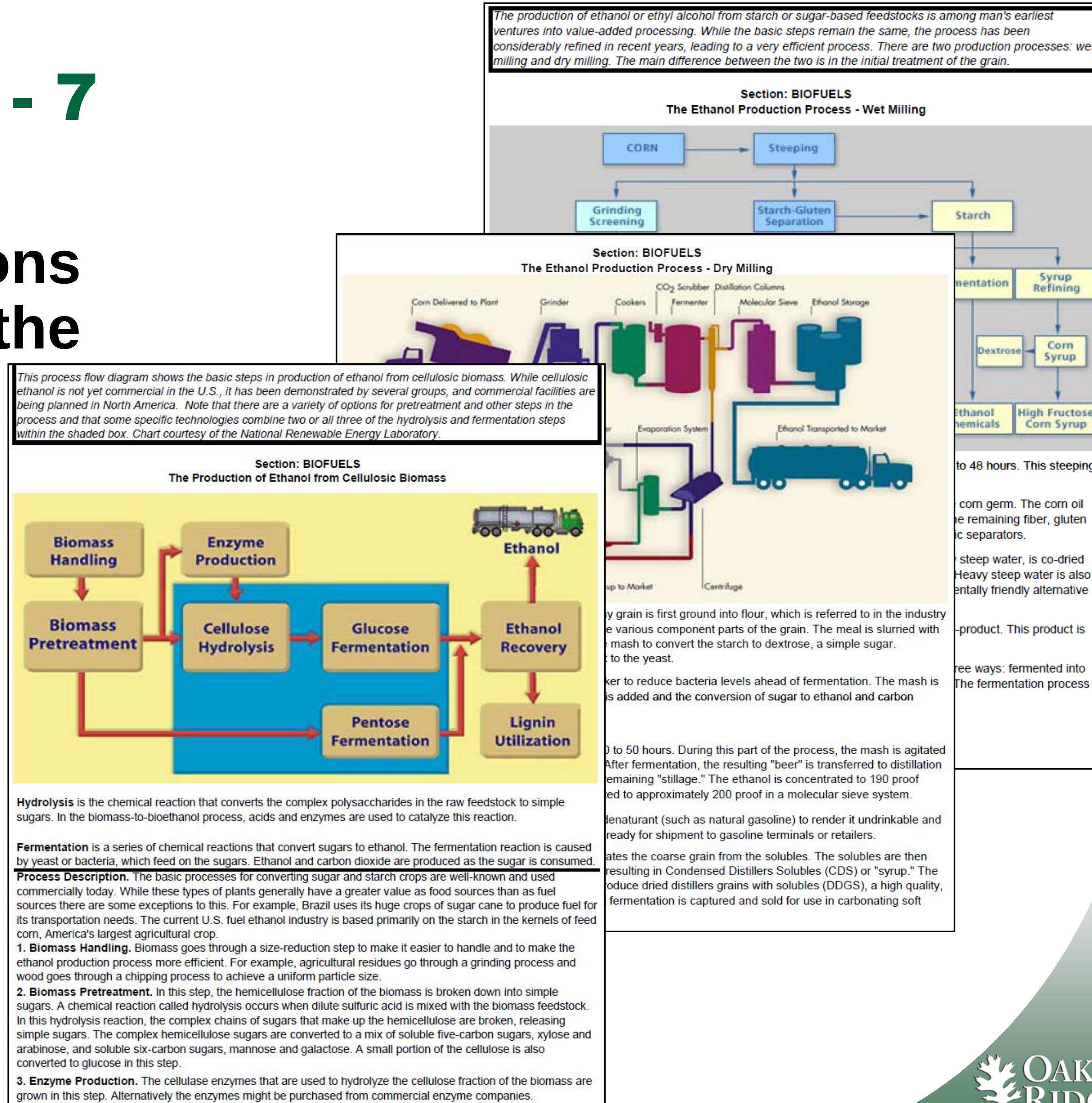
Source:

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.

Section: BIOFUELS
The Ethanol Production Process - Wet Milling

Section: BIOFUELS
The Ethanol Production Process - Dry Milling

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.

Section: BIOFUELS
The Production of Ethanol from Cellulosic Biomass

Hydrolysis is the chemical reaction that converts the complex polysaccharides in the raw feedstock to simple sugars. In the biomass-to-bioethanol 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.

Oak Ridge National Laboratory

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

		Softwood[c]						Hard hardwood[c]						Soft hardwood[c]					
		Bark		Chippable		Fine[f]		Bark		Chippable		Fine		Bark		Chipable		Fine	
Mill Type[a]	Small end diameter[b]	G[d]	OD[e]	G	OD	G	OD	G	OD	G	OD	G	OD	G	OD	G	OD	G	OD
	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
A, B, C, H, and I	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
	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
D and E	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
	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
F	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
	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
G	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

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.

[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.

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 clarifys the issue further by defining what is included in each catagory of volume or biomass units.

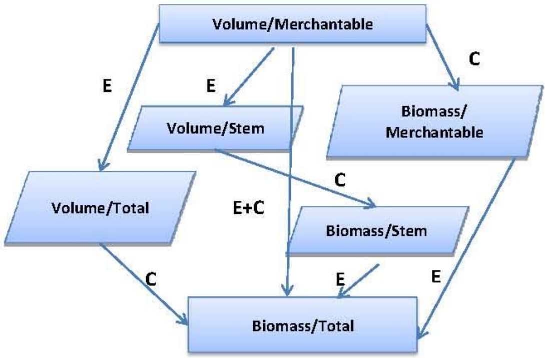


Figure 1 Source: Somogyi Z. et al. Indirect methods of large-scale biomass estimation. Eur J Forest Res (2006) DOI 10.1007/s10342-006-0125-7

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 <u>merchantable volume</u> 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 <u>total volume or biomass</u> 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) .

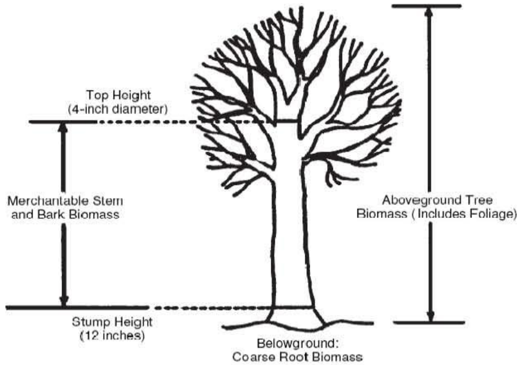


Figure 2 Source: Jenkins, JC, Chojnacky DC, Heath LS, Birdsey RA. Comprehensive Database of Diameter-based Biomass Regressions for North American Tree Species. United States Department of Agriculture, Forest Service General Technical Report NE-319, pp 1-45 (2004)

Biomass Energy Data Book -- 2010 -- http://cta.ornl.gov/bedb

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.

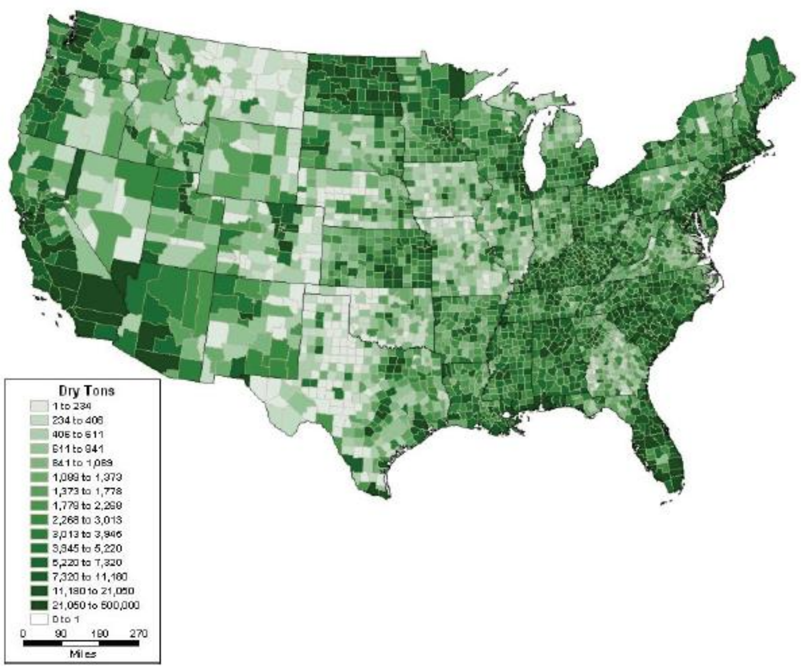
ASABE Standard X593 - The American Society of Agricultural and Biological Engineers (ASABE) in 2005 produced a new standard (Standard X593) entitled "Terminology and Definitions for Biomass Production, Harvesting and Collection, Storage, Processing, Conversion and Utilization." The purpose of the standard 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

Figure 5.9
Total Construction and Demolition Residues

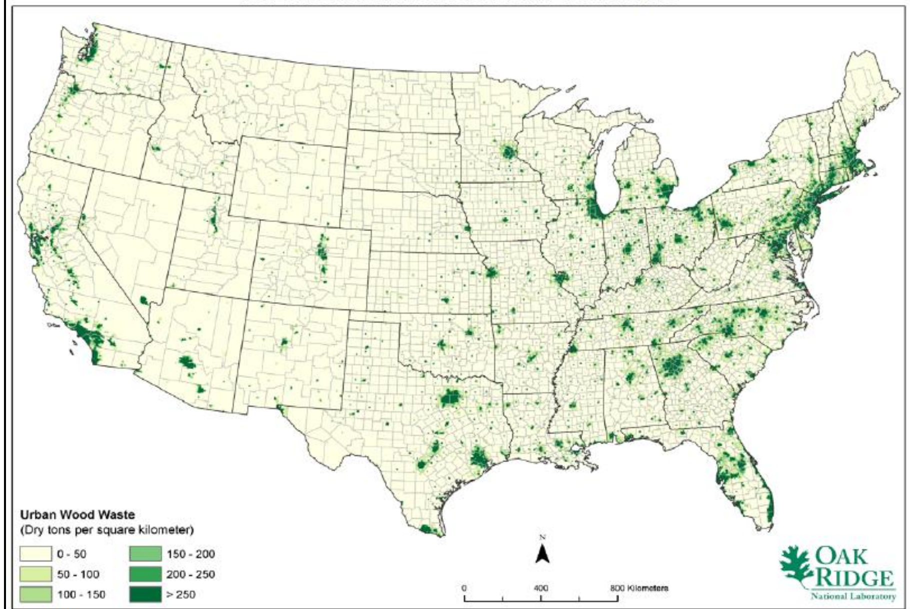


Source:
Bioenergy Resource and Engineering Systems Program, Oak Ridge National Laboratory.

Note: For information on estimation methods used, see: Appendix C - Estimation Methods for Urban Wood Residues.

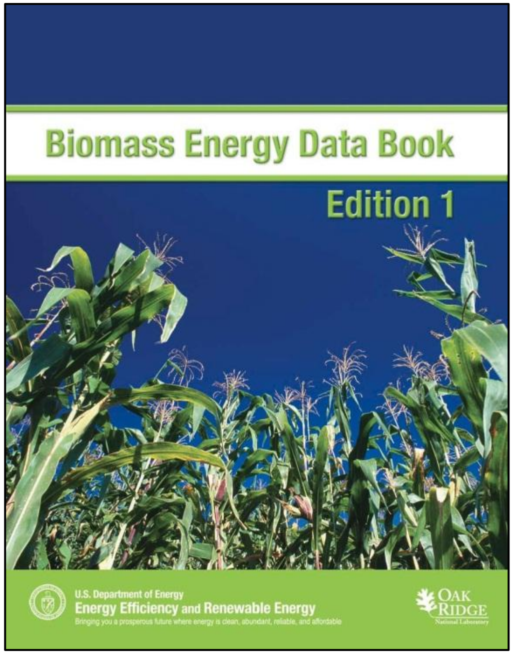
Improved in Edition 3 thanks to a user's comment

Section: FEEDSTOCKS
Total Construction and Demolition Debris Wood Residues

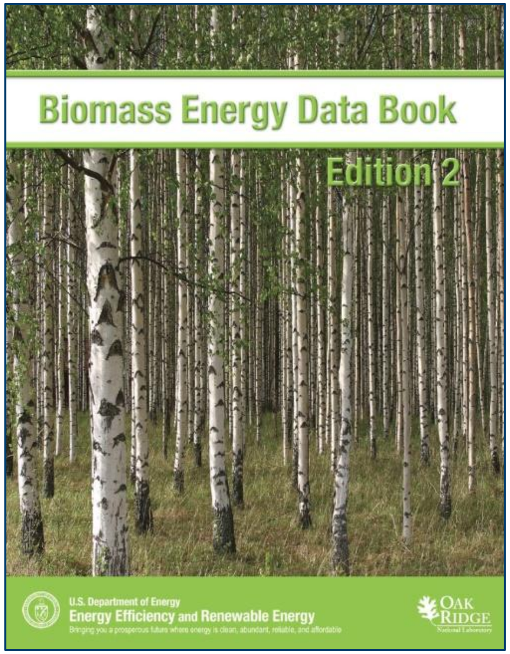


Sources:
Map created by Bioenergy Resources and Engineering Systems Program, 2010, Oak Ridge National Laboratory.
http://www.esd.ornl.gov/eess/bioenergy/
McKeever, D. 2004. "Inventories of Woody Residues and Solid Wood Waste in the United States, 2002." Ninth International Conference, Inorganic-Bonded Composite Materials. Vancouver, British Columbia. October 10-13.

Technical Accomplishments



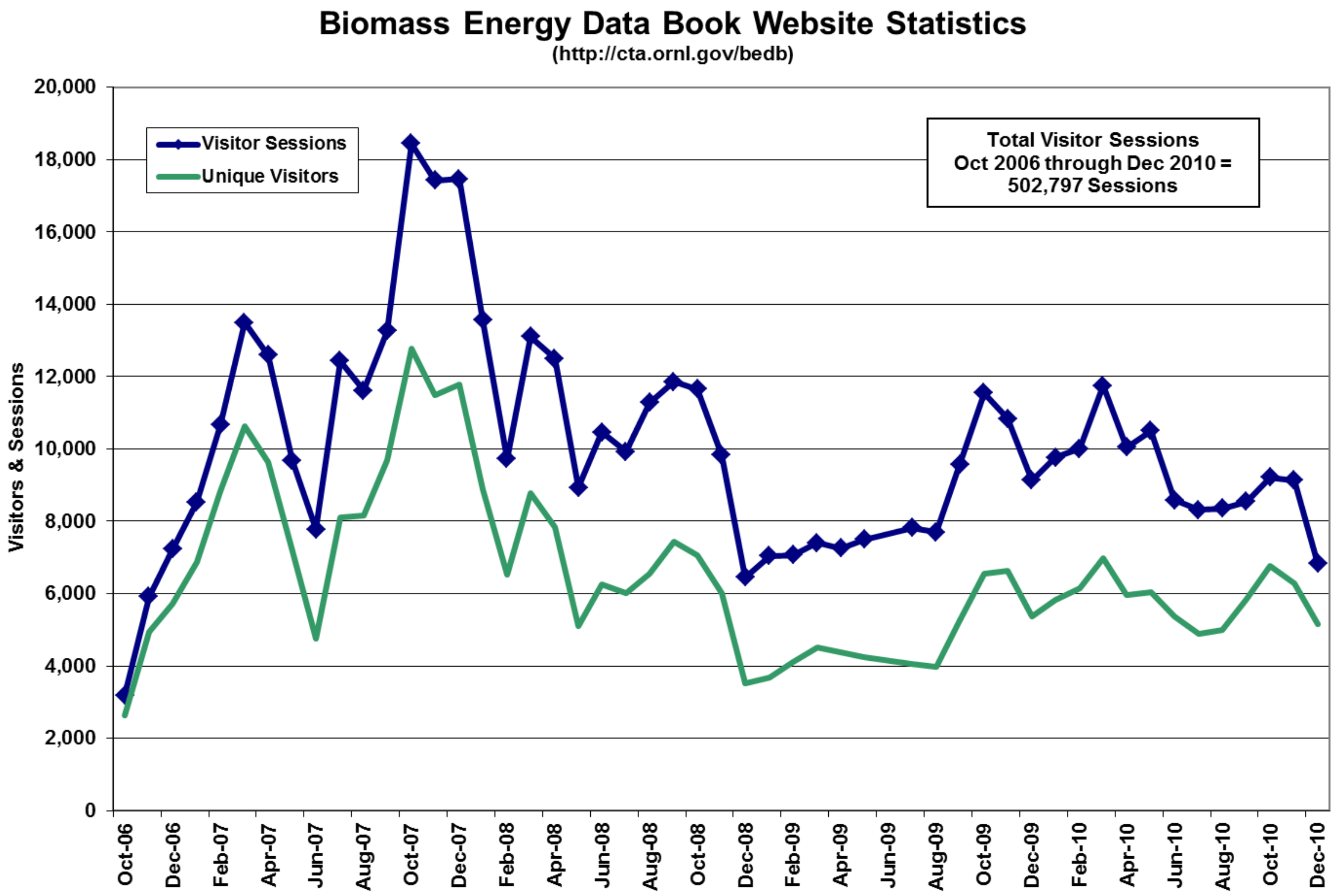
Website launch:
October 2006



Website update:
December 2009

Website update:
December 2010

Technical Accomplishments - 2



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.

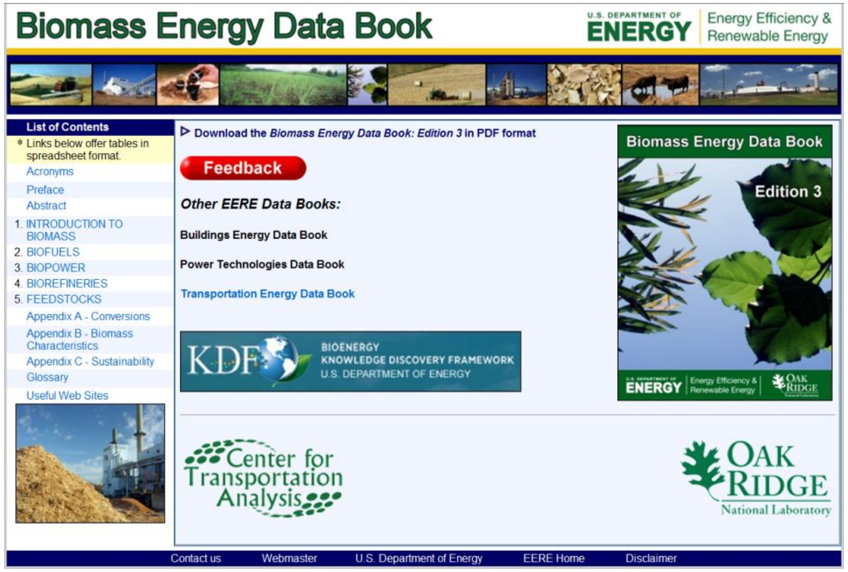
- **Supports stakeholder and policy analysis**
- **Informs the general public**
- **Provides accurate, consistent data and information**
- **Uses a wide variety of sources, including data and analysis generated by the Biomass Program**

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



- 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