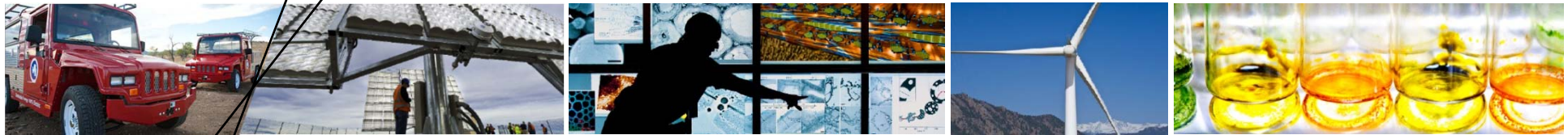


Task 33: USA Update
2013 Meeting 1
May 7, 2013

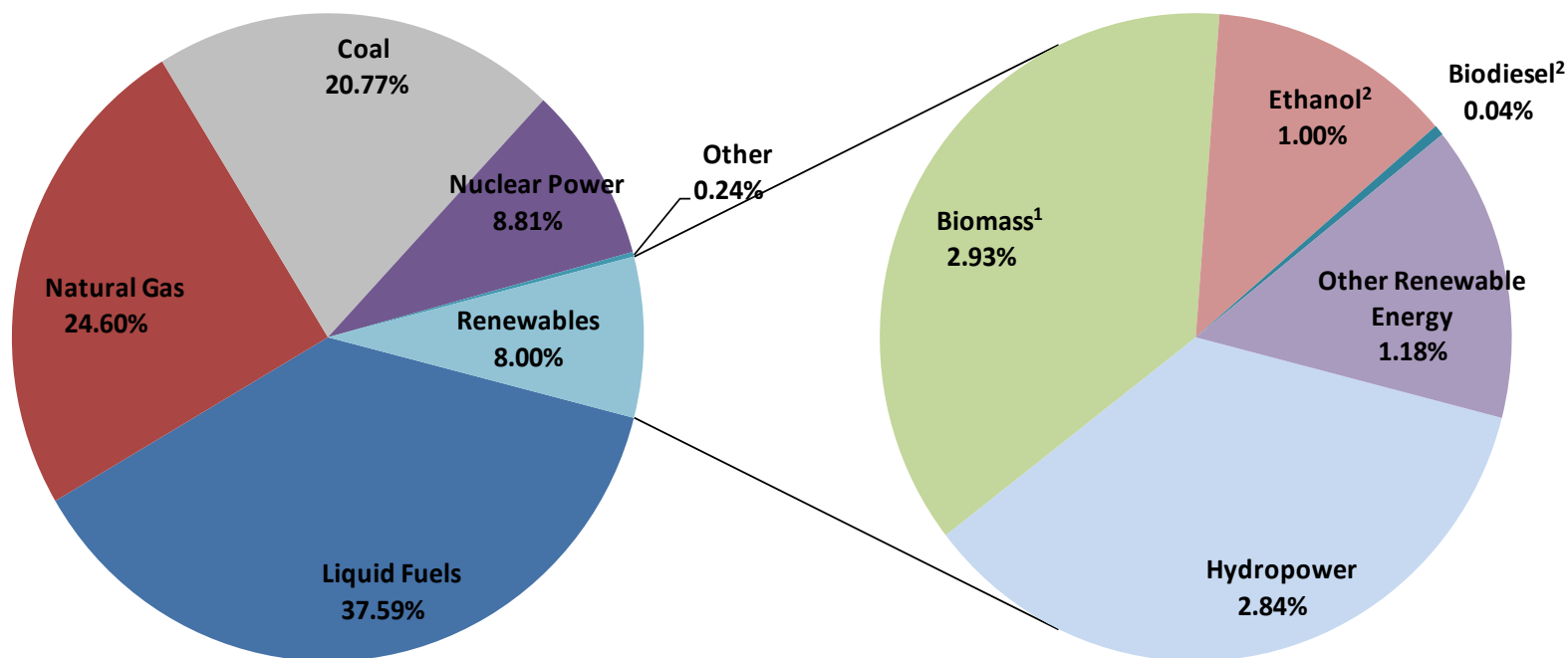
Richard Bain, NREL





Background

U.S. Primary Energy Consumption in 2009

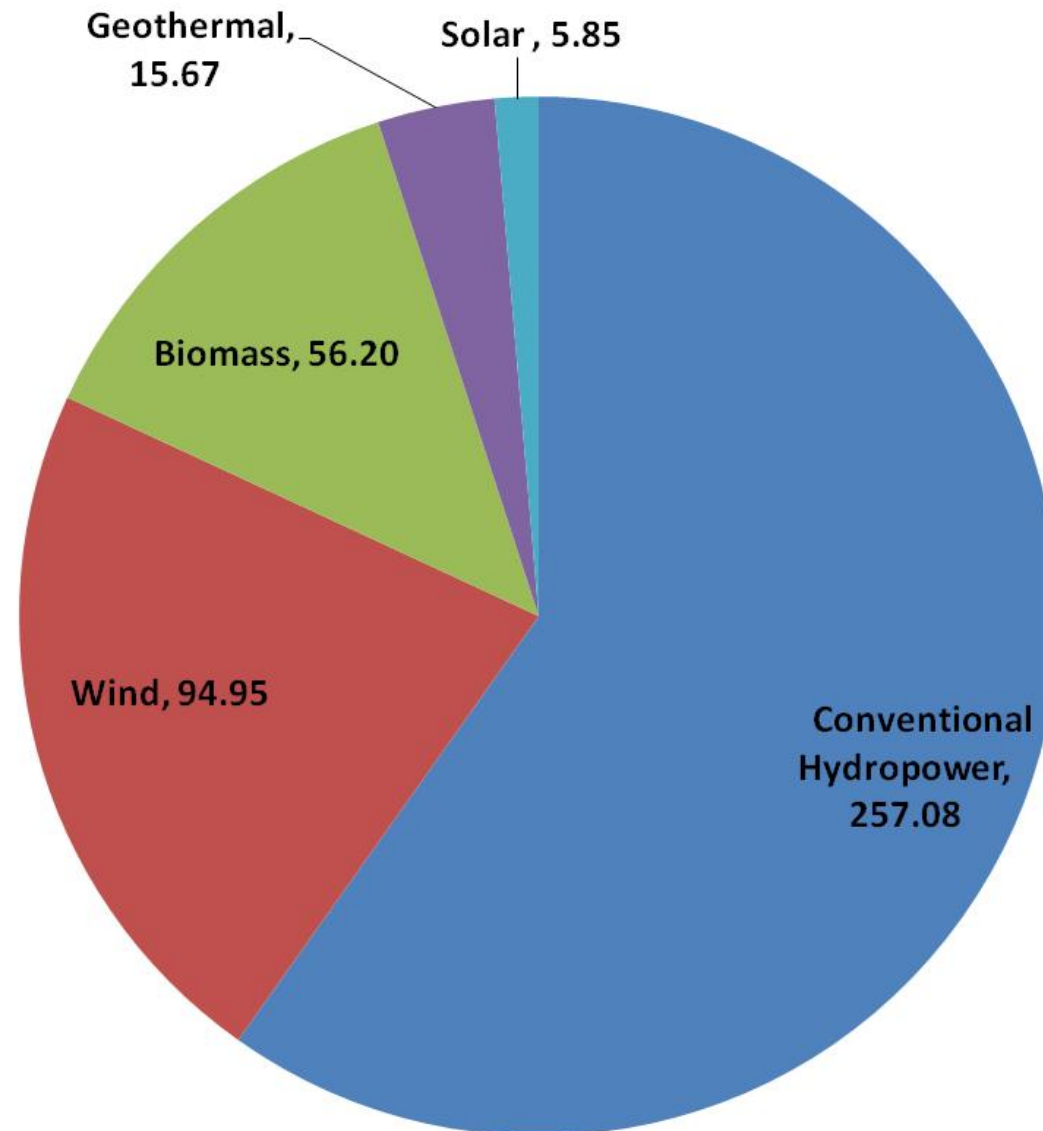


¹ Biomass modified to include biogenic MSW and landfill gas included in other/other renewables in AEO

² Ethanol and biodiesel taken from Liquid Fuels in AEO

Total U.S. 2009 Primary Energy Consumption = 100 Exajoules

2010 U.S. Renewable Electricity Generation, TWh



EIA, 2012 Annual Energy Outlook,

Biopower Status

2010 U.S. Renewable Electricity Generation, TW

- 2010 Capacity – 10.7 GW
 - 5.8 GW Electric Power Sector
 - 4.9 GW End Use Generators
- 2010 Generation – 56TWh
- Cost – 0.08 – 0.12 USD/kWh

Potential – Electric Sector

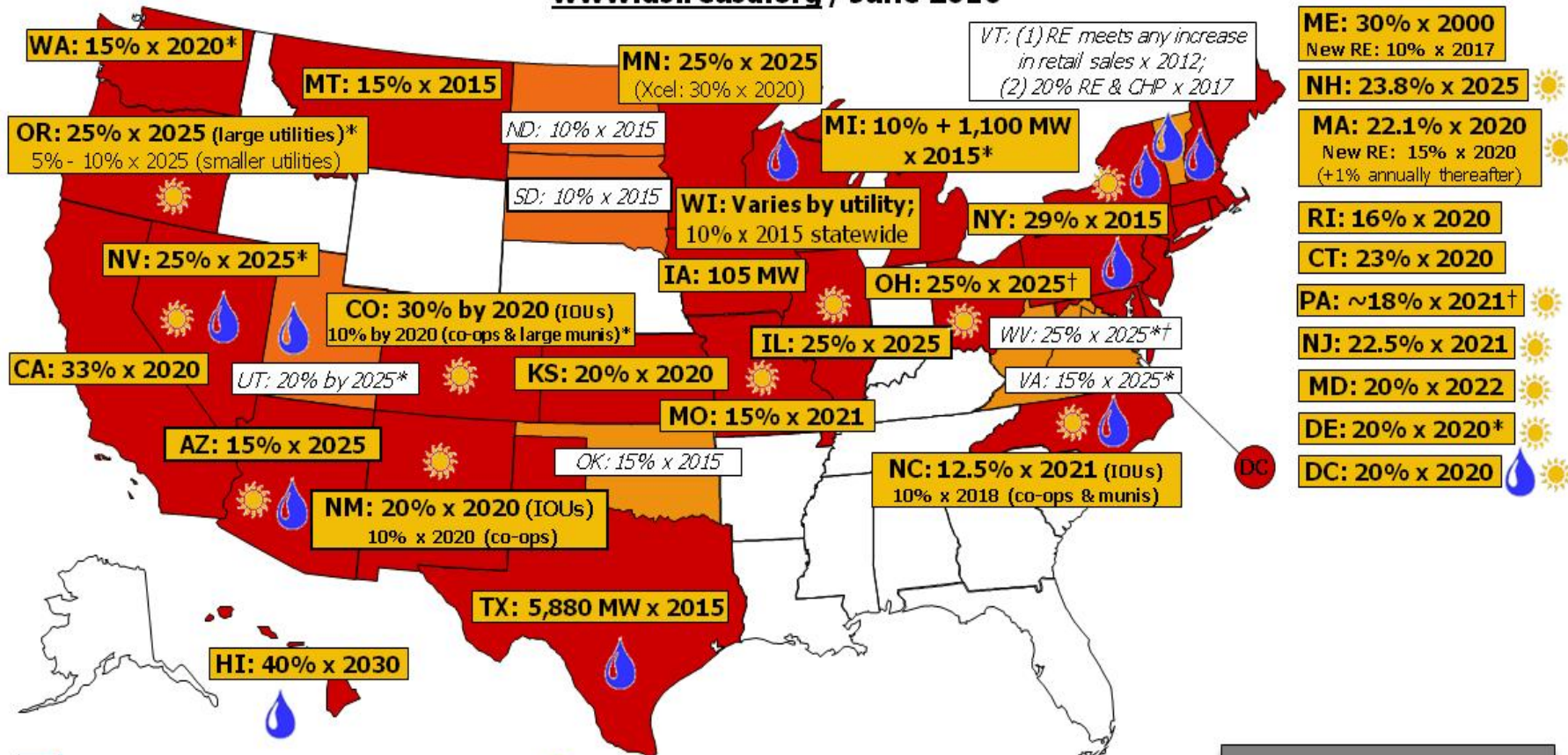
2022 -	22 GW
2035 -	48 GW
2050 -	91 GW



Sources: DOE EIA Annual Energy Outlook, Table A16 (year-by-year) , NREL Renewable Electricity Futures Study (2010) – Preliminary Data
EIA Form 860 (Capacity), EIA Form 923 (Generation)

Renewable Portfolio Standards

www.dsireusa.org / June 2010



- State renewable portfolio standard
- State renewable portfolio goal
- 💧 Solar water heating eligible

- ☀️ Minimum solar or customer-sited requirement
- ✳️ Extra credit for solar or customer-sited renewables
- † Includes non-renewable alternative resources

29 states + DC have an RPS
(7 states have goals)

Biomass Power – Priority Issues

- **Biomass Supply**

- Long term security, multiple supply chains
- Energy crops
- Competition for feedstock for liquid fuels

- **Power Generation**

- Impact on emissions control (cofiring)
- Costs of technology
- Ash utilization
- Torrefied wood tests (cofiring)
- Increase co-firing percentage

- **Environmental**

- Life cycle analysis
- Land use change – direct and indirect
- Water use implications
- Emissions (EPA MACT rules)
 - PM, CO, Mercury, HCl, Dioxins
- GHG (EPA “Tailoring Rule”)
 - EPA Call for Information: GHG Associated with Bioenergy – technical issues related to GHG accounting
 - Due Sep 13, 2010
 - EPA-HQ-OAR-2010-0560
 - Federal Register, July 15, 2010



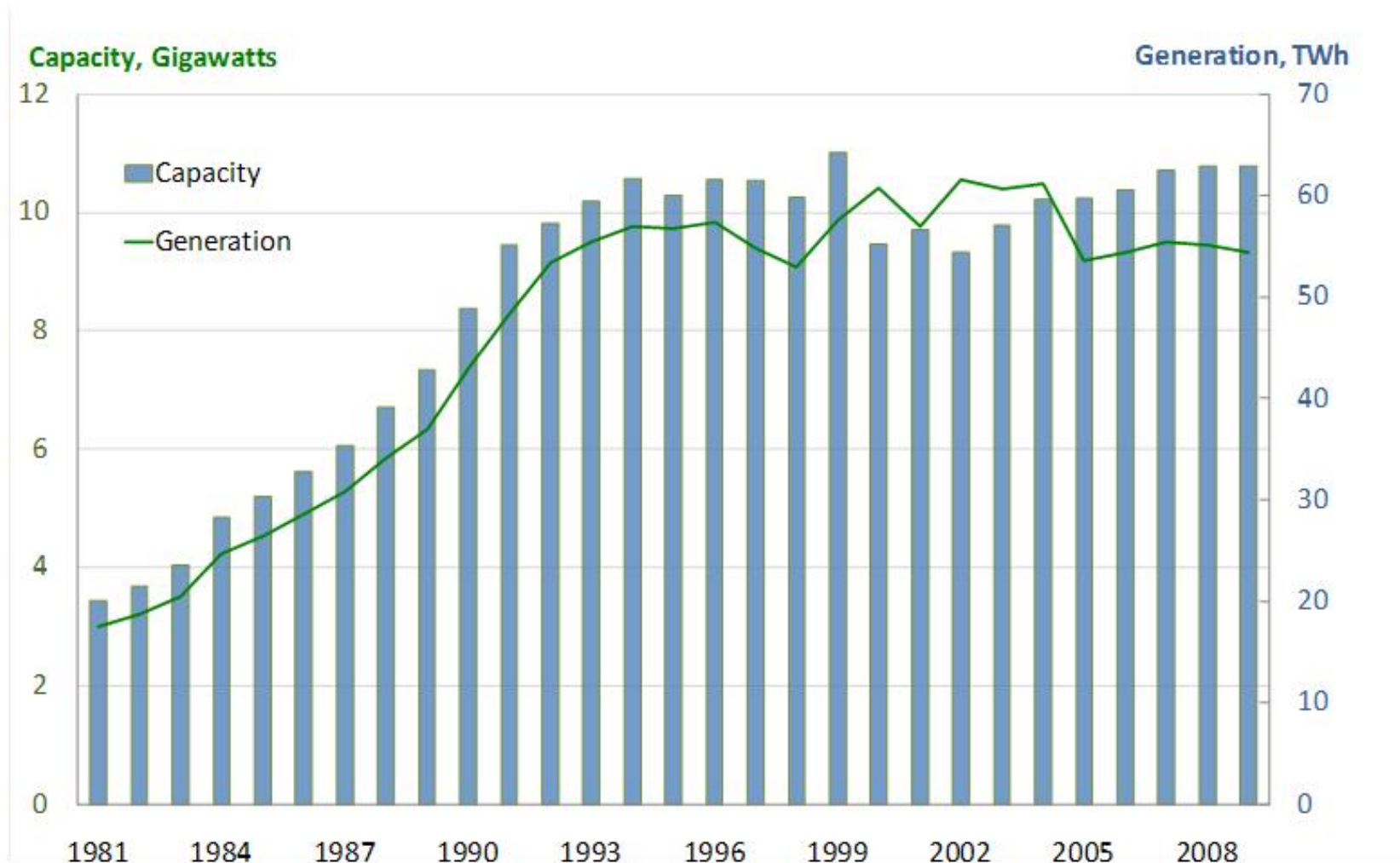
Areas of Short Term

Research Interest

- Supply chain hardening
 - Fuel upgrading may expand supply distance (torrefaction, pelletizing, drying, pyrolysis oils)
- Repowering older coal units
 - Develop information on technology/fuel selections
 - Barriers and advantages of various options
- Cofiring in existing coal units
 - Long term impacts: catalyst degradation, corrosion, slagging, fouling, environmental control
 - Testing for co-firing torrefied wood



United States Biopower 1981 - 2009

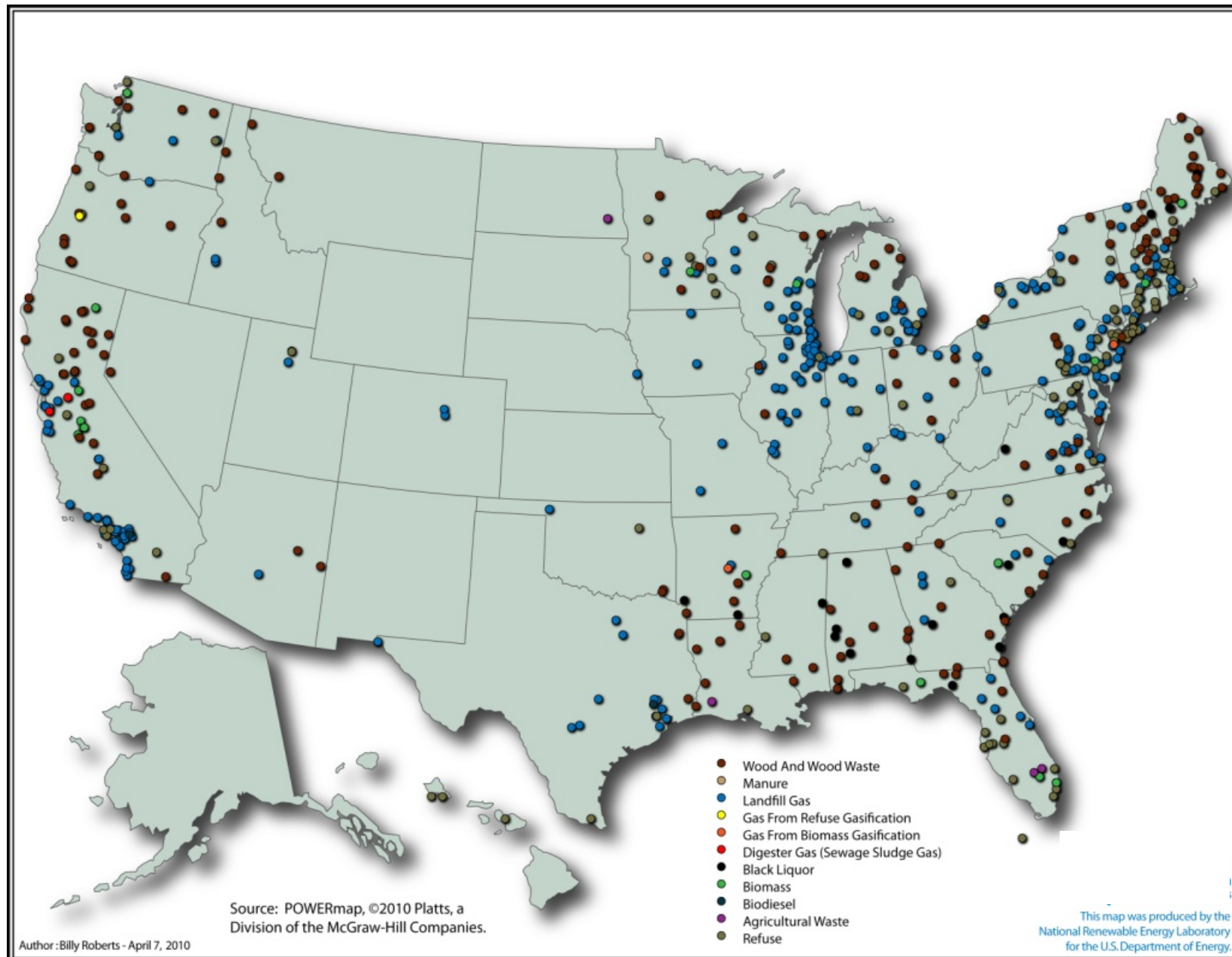


2003-2010 U.S. Biopower Capacity and Generation

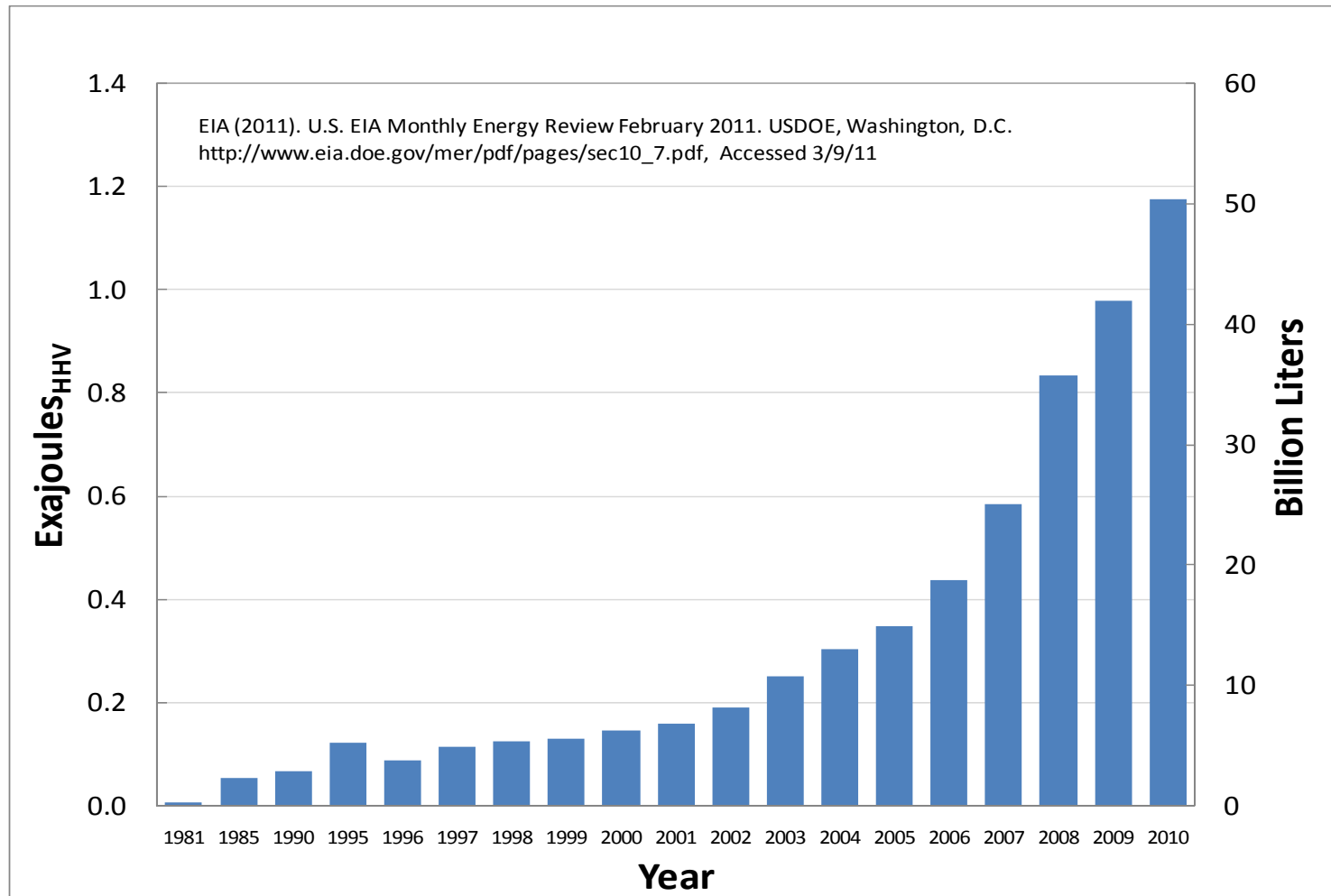
Net Summer Capacity, GW	2003	2004	2005	2006	2007	2008	2009	2010
Electric Power Sector								
Municipal Waste	3.19	3.19	3.21	3.39	3.42	3.43	3.20	3.30
Wood and Other Biomass	2.00	2.04	1.96	2.01	2.09	2.17	2.43	2.45
Total	5.19	5.23	5.17	5.40	5.51	5.60	5.63	5.75
End-Use Generators								
Municipal Waste	0.27	0.33	0.34	0.33	0.33	0.33	0.36	0.35
Biomass	4.32	4.66	4.72	4.64	4.88	4.86	4.56	4.56
Total	4.59	4.99	5.06	4.97	5.21	5.19	4.92	4.91
Total, All Sectors								
Municipal Wastes	3.46	3.52	3.55	3.72	3.75	3.76	3.56	3.65
Biomass	6.32	6.70	6.68	6.65	6.97	7.03	6.99	7.01
Total	9.78	10.22	10.23	10.37	10.72	10.79	10.55	10.66
Generation, TWh								
Electric Power Sector								
Biogenic Municipal Wastes	20.84	19.86	12.70	13.71	13.88	14.49	16.10	16.56
Wood and Other Biomass								
Dedicated Plants	9.53	8.54	8.60	8.42	8.65	9.00	9.68	10.15
Cofiring	0.00	1.19	1.97	1.91	1.94	1.90	1.06	1.36
Total	30.37	29.59	23.27	24.04	24.47	25.39	26.84	28.07
End-Use Generators								
Municipal Wastes	2.22	2.64	1.95	1.98	2.01	2.02	2.07	2.02
Biomass	28.00	28.90	28.33	28.32	28.43	27.89	25.31	26.10
Total	30.22	31.54	30.28	30.30	30.44	29.91	27.38	28.12
Total, All Sectors								
Municipal Wastes	23.06	22.50	14.65	15.69	15.89	16.51	18.17	18.58
Biomass	37.53	38.63	38.90	38.65	39.02	38.79	36.05	37.61
Total	60.59	61.13	53.55	54.34	54.91	55.30	54.22	56.19
EIA Form 923 Actual Generation					55.40	55.06	54.34	

Note: In 2003, cofiring plants classified as coal

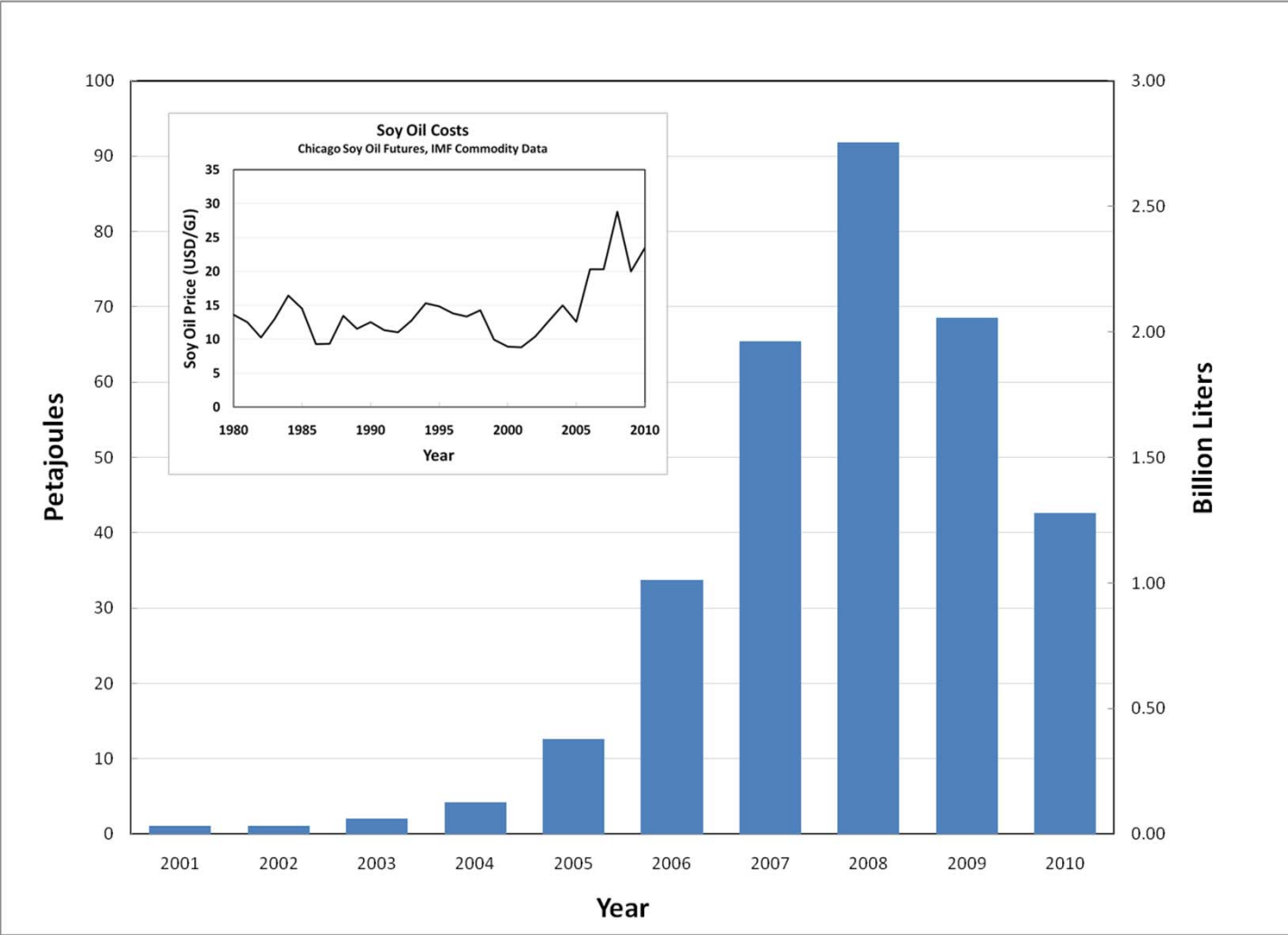
U.S. Existing Biopower Plants

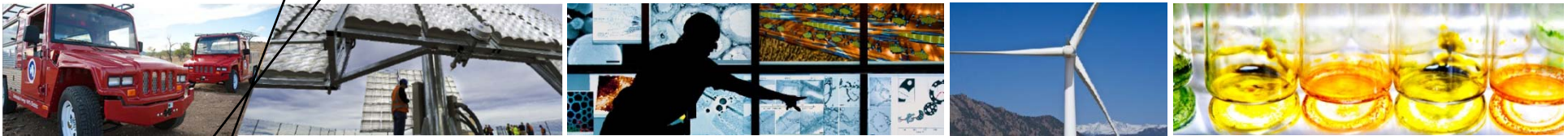


Historical U.S. Ethanol Production



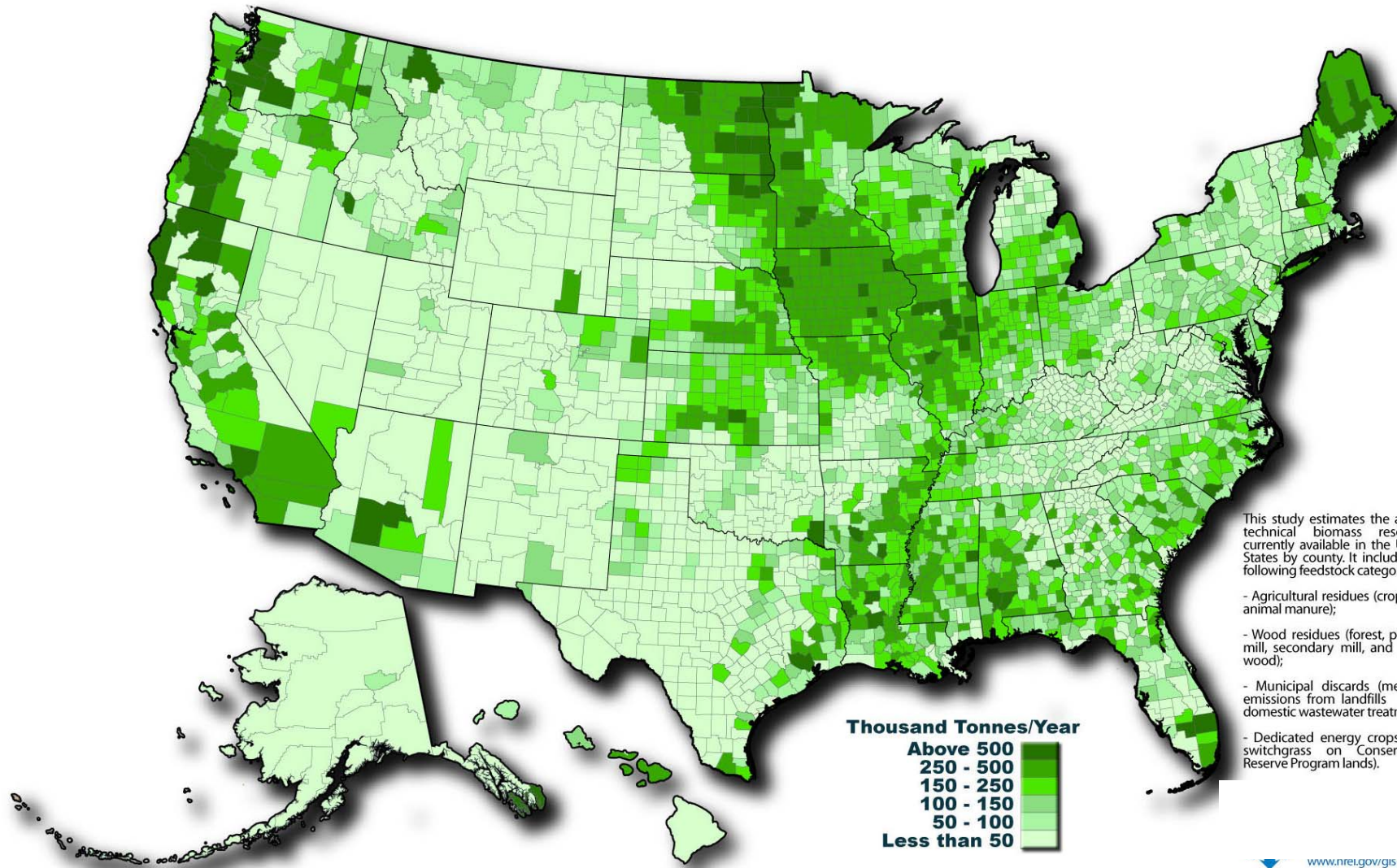
Historical U.S. Biodiesel Production





Biomass Resource

U.S. Biomass Resource



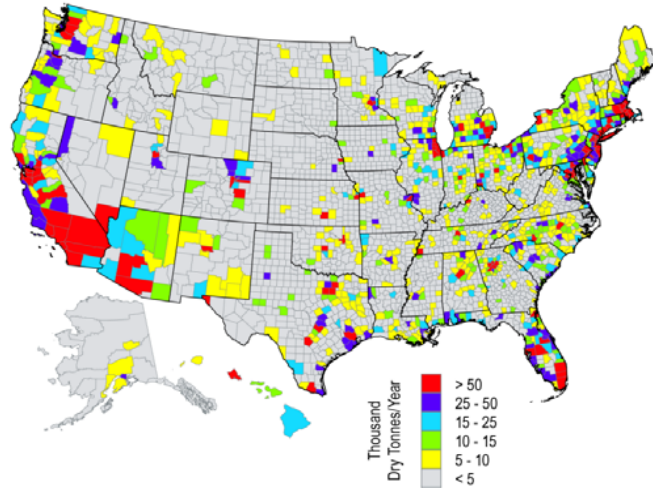
This study estimates the annual technical biomass resources currently available in the United States by county. It includes the following feedstock categories:

- Agricultural residues (crops and animal manure);
- Wood residues (forest, primary mill, secondary mill, and urban wood);
- Municipal discards (methane emissions from landfills and domestic wastewater treatment);
- Dedicated energy crops and switchgrass on Conservation Reserve Program lands.

www.nrel.gov/gis

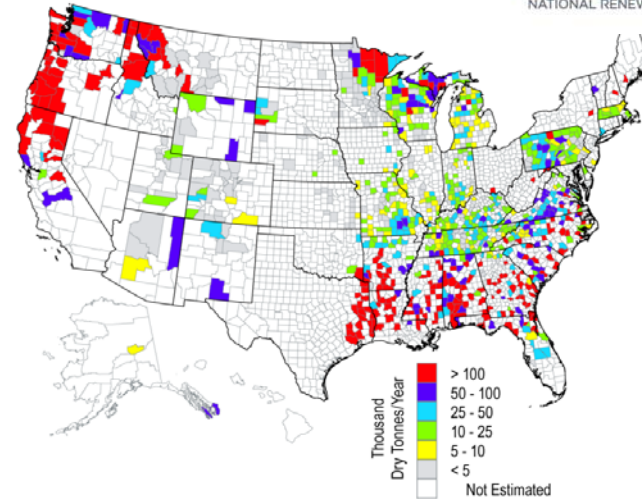
This map was produced by the National Renewable Energy Laboratory for the U.S. Department of Energy. See additional documentation for more information at <http://www.nrel.gov/docs/fy06osti/39181.pdf>

Biomass Resource Distribution by Class



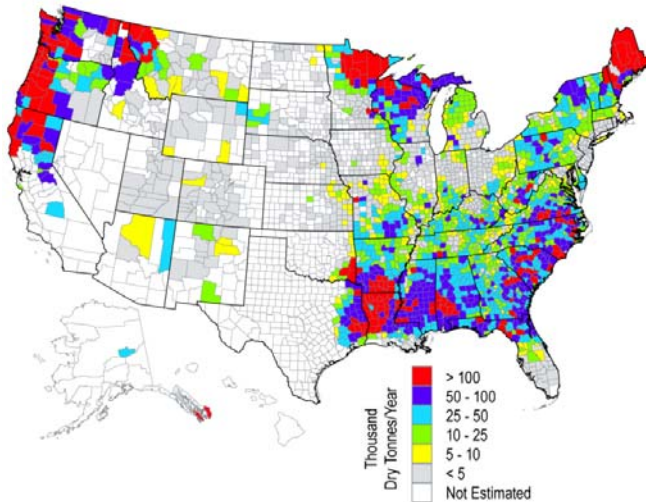
Distribution of urban wood residues

Sources: U.S. Census Bureau, 2000 population data, BioCycle Journal, State of Garbage in America, January 2004; County Business Patterns 2002.



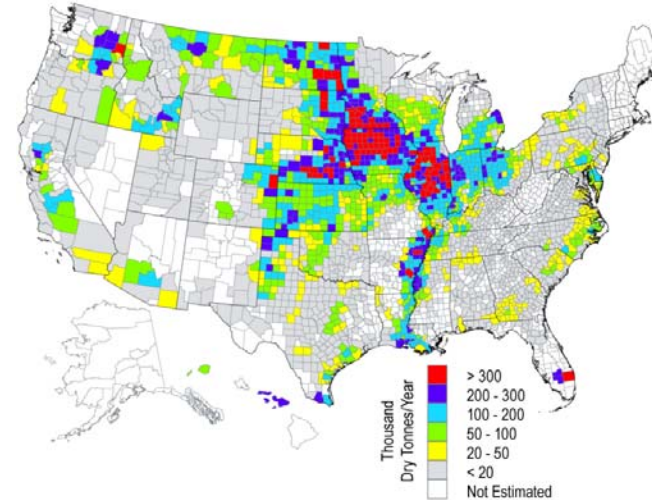
Distribution of primary wood mill residues

Source: USDA, Forest Service's Timber Product Output database, 2007.



Distribution of forest residues

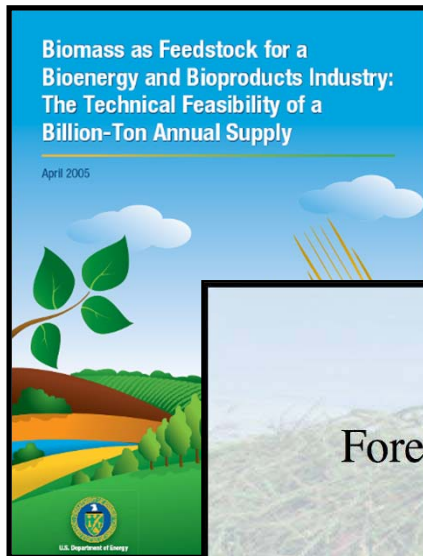
Source: USDA, Forest Service's Timber Product Output database, 2007.



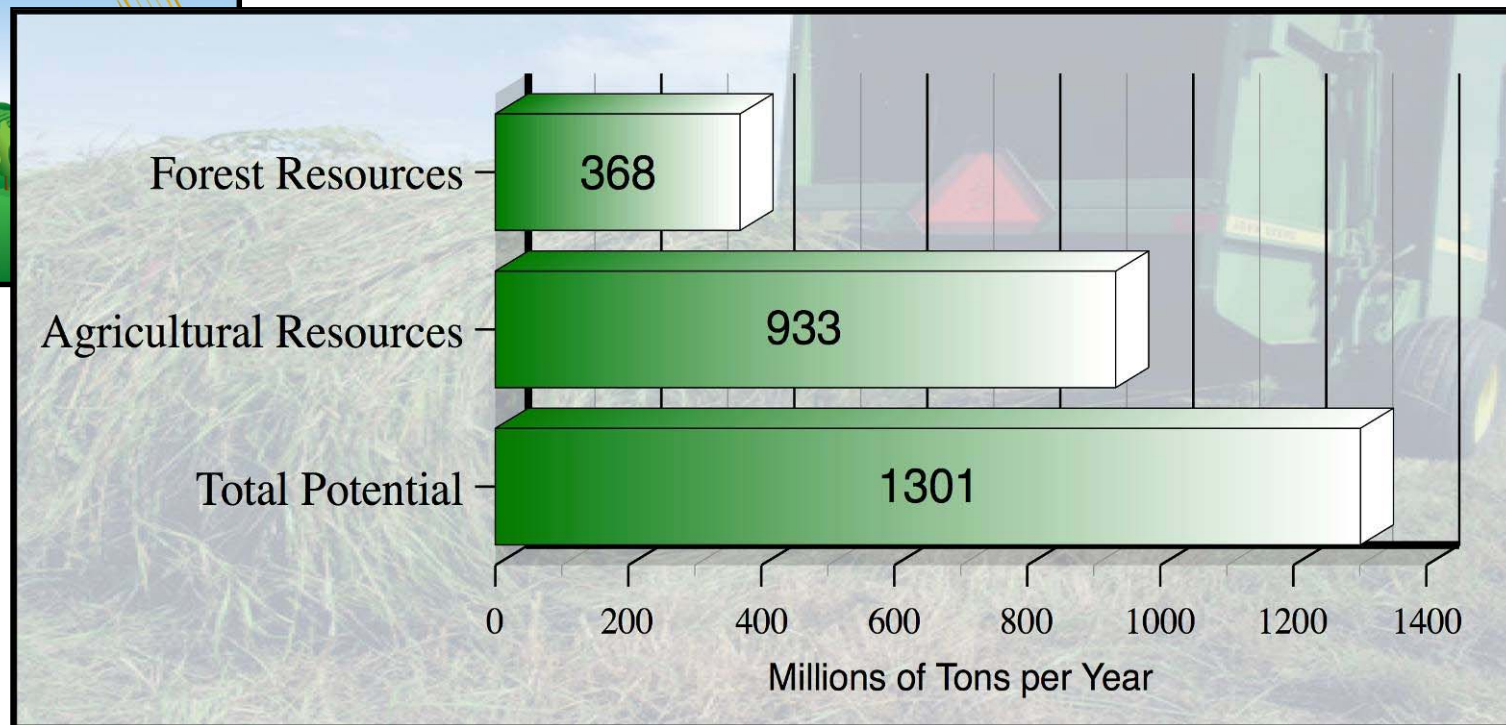
Distribution of crop residues

Source: USDA, National Agricultural Statistics Service; 5-year average: 2003–2007 data.

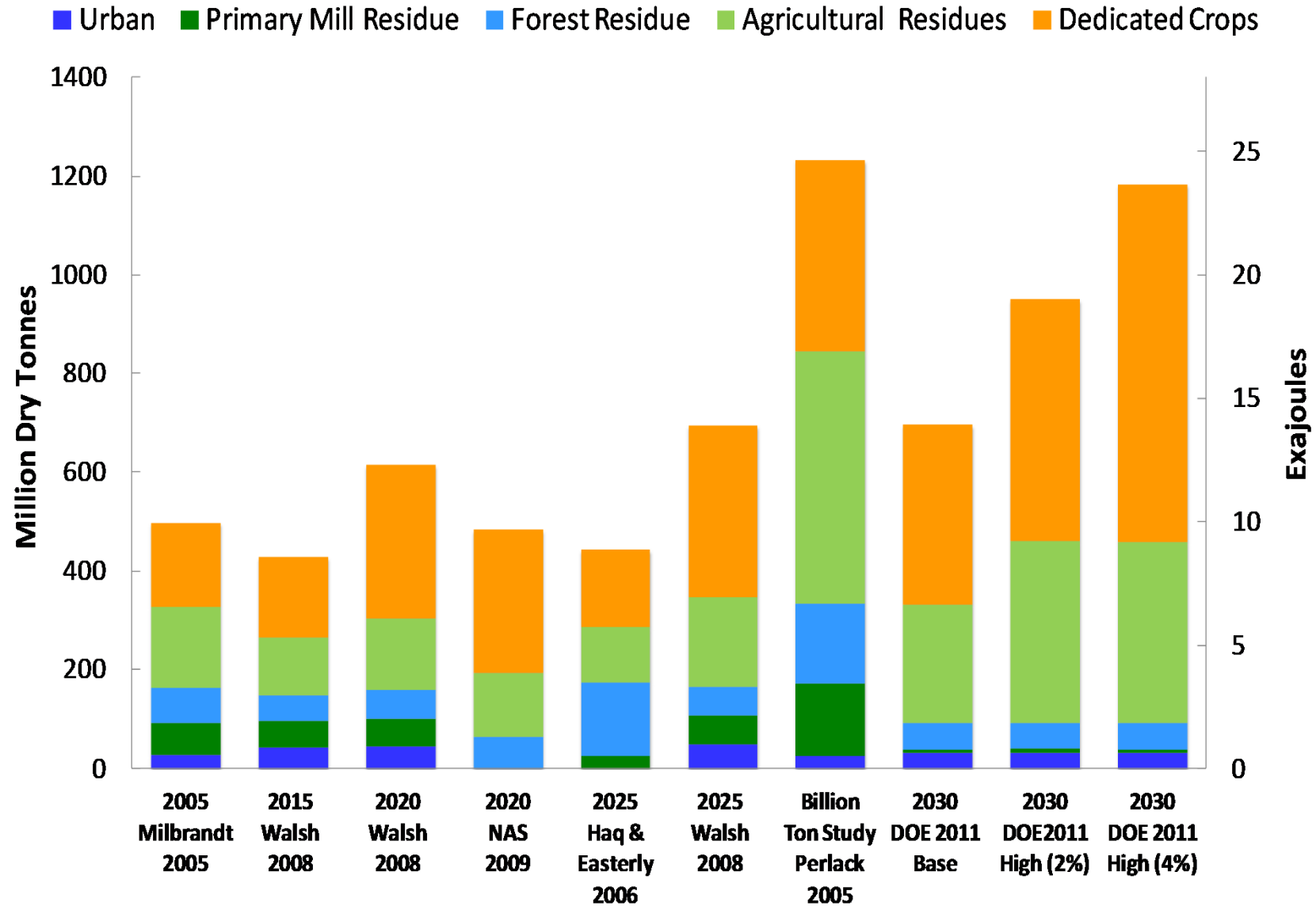
U.S. Biomass Resource Assessment



- Updated resource assessment - April 2005
- Jointly developed by U.S. DOE and USDA
- Referred to as the “Billion Ton Study”



USA Biomass Potential



U.S. Biomass Gasifier Developers

Company	Gasifier Type	Scale				Status	Contact Information
		kg/hr	Tonnes/d	kWt	kWe		
Adaptive Arc www.adaptivearc.com	plasma		25			Pilot	http://www.adaptive ARC.com/
Advanced Alternative Energy Corp.	Mod-UD		12-200			OP	www.aecorp.com/power.html
<i>Bioten Power & Energy Group</i> <i>Cogentech, Inc</i>	DD-var					Pilot	www.bioten.com
Bioconversion Technology, LLC	Mixed	25			1000	Demo	Robert (Bud) Klepper 6535 N. Washington St, #B Denver, CO 80229 303-287-5001, 303-287-5318 (FAX)
Biomass Gas & Electric, LLC	Indirect - dual CFB					Design	http://www.biggreenenergy.com/ Power project with city of Tallahassee, FL uses silvagas gasifier
Black and Veatch	Dry ash entrained flow					?	Jon C. Erickson 913-458-2293
Carbona Corp	FB				5000	OP	Jim Patel President P.O. Box 7067 Napa, CA 94558 Tel 707-553-9800, Fax 707-553-9820
Chiptec www.chiptec.com	UD					OP	Robert Bender 48 Helen Ave. South Burlington, VT 05403 Tel 802-658-0956, Fax 802-660-8904 chiptec@together.net
Clear Fuels	Dry ash indirect entrained flow		18			Const	ClearFuels Technology, Inc. Hawaii Agriculture Research Center 99-193 Aiea Heights Drive, Suite 308 Aiea, HI, 96701 (Can also contact Rentech)
Clenergen						?	Clenergen Corporation (USA) 5379 Lyons Road, Suite 301 Coconut Creek, Florida 33073 http://clenergen.com/

U.S. Biomass Gasifier Developers

Company	Gasifier Type	Scale				Status	Contact Information
		kg/hr	Tonnes/d	kWt	kWe		
Foster Wheeler www.fwe.com	CFB					Comm	Neil Raskin Director, Global New Products Foster Wheeler Development Corporation Perryville Corporate Park Clinton, NJ 08890-4000
FrontLine Bioenergy, LLC	FB		68			Comm	Jerod Smeenk John Reardon fronlinebioenergy.com
GAZOGEN	rotary hearth				100	OP	Carl Bielenberg, President 1915 East Hill Rd Marshfield VT 05658-8901 Tel 802-456-8993 Fax 802-456-7476 gazogen@yahoo.com
GTI Flex-Fuel Gasification Test Facility http://www.gastechnology.org	FB	375-750				Pilot	Mr. P. Vann Bush Executive Director, Gasification & Gas Processing Gas Technology Institute 1700 S. Mount Prospect Rd Des Plaines, IL 60018-1804 Tel 847-768-0973, Fax 847-768-0507 email: vann.bush@gastechnology.org
GTS Duratek						OP	Bob Hensel - V-P International 6 Stoneridge Drive Barrington, IL 60010 Tel 847-304-9646 Fax 847-304-5889
Gulf Coast Energy	indirect entrained flow					Pilot	http://www.gulfcoastenergy.net/
Hamilton Mauer International/ MIFGA (HMI, Inc.)	UD					?	Rolf Mauer Tel 713-468-6805 Fax 713-468-0761
HTI - Heat Transfer International	UD					?	http://www.heatxfer.com/products/fixbed.html
ICM Inc.	Air-blown Auger		136 - 181			Demo	http://www.icminc.com/services/gasifiers
InEnTec	Plasma		Various			Pilot	Phone (509)946-5700 info@inentec.com

U.S. Biomass Gasifier Developers

Company	Gasifier Type	Scale				Status	Contact Information
		kg/hr	Tonnes/d	kWt	kWe		
Intellergy - Rockwell	rotary kiln					?	David March 704.665.6001 damarch@ra.rockwell.com
Mississippi Ethanol	IND-E		40			?	Rockwell Automation
Nexterra	UD					OP	Philip Beaty Ste 950 - 650 W. Georgia St PO Box 11582 Vancouver, BC 604-637-2501
Pearson Technologies of Mississippi No web site.	IND-E		27.3			OP	Stanley R. Pearson 20088 Norm Cromwell Drive Aberdeen, MS 39730 Tel 662-369-1168
Planet Green Solutions	DD	< 160			20-120	OP	Planet Green Solutions PO Box 507 Fairfield, FL 352-351-5783
PHG Energy	DD		44			OP	
Powerhouse Energy Pyromex	Inductively heated rotary drum					pilot	David Moard pres & ceo 145 N, Sierra Madre, Blvd, Ste 4 Pasadena, CA 91107
Primenergy, LLC www.primenergy.com	Mod-UD		27.3			OP	Kevin McQuigg Vice President P.O. Box 581742 Tulsa, OK 74185 Tel 918-835-1011, Fax 918-835-1058
PRME	Mod-UD					OP	Ron Bailey Jr, President PRM Energy Systems 504 Windamere Terrace Hot Springs, AK 71913 501-767-2100
Range Fuels	2-stage indirect					shut down	11101 W. 120th Avenue, Suite 200; Broomfield, CO 80021

U.S. Biomass Gasifier Developers

Company	Gasifier Type	Scale				Status	Contact Information
		kg/hr	Tonnes/d	kWt	kWe		
Red Lion Bioenergy	2-stage indirect		25			OP	www.redlionbio-energy.com
Rentech	Indirect: Dual CFB		320			design	Rentech, Inc 10877 Wilshire Blvd, Suite 600 Los Angeles, Ca 90024 PH: 310.571.9800 ir@rentk.com
SunDrop Fuels	Solar Heated			1000		Pilot	Sundrop Fuels, Inc 1722 Boxelder Street, Suite 101 Louisville, Colorado 80027 Ph: 720.890.6501 email: infor@sundropfuels.com
Taylor Biomass						Design	Mark Paisley Taylor Biomass 350 Nellytown Rd Montgomery, NY 614-893-7312, FAX 614-459-8579
Thermo Technologies LLC also SynGasCo & Wiley Consulting	IND	250 TPD				OP	Marcus A. Wiley P.O.Box 4027, Englewood, CO 80155 303-267-0791 mark@wileyconsulting.com
Thermochem	IND	1,800-18,900 dry solids				OP	Lee Rockvam Thermochem (MTCI) 6004 Chemical Road Baltimore, MD 21226 Tel 410-354-9890
Thermogenics www.thermogenetics.com	DD-var	455-2730				Pilot	Tom Taylor, President 7100 F St NW Albuquerque, NM 87107 Tel 505-761-5633
TRI (Commercial Arm of Thermochem)						Pilot & Comm	www.tri-inc.net Dan Burciaga dburciaga@tri-inc.net
Viresco						pilot ?	Viresco Energy 1451 Research Park Drive, Ste 200 Riverside, CA 92507 951-784-7238
Vista International Technologies (formerly Nathaniel Energy)						?	Jeffrey M. Bell 8310 South Valley Highway, Suite 300 Englewood, CO 80112
West Biofuels	Indirect		5			pilot	Woodland Biomass Research Center 14958 County Road 100B Woodland, CA 95776
Westinghouse Plasma now Alter NRG	Plasma					OP	www.westinghouse-plasma.com
Ze-Gen	Molten Salt		ca. 10			?	Ze-Gen 1380 Soldiers Field Road Boston, MA 02135 617.674.2442

National Renewable Energy Laboratory
Innovation for Our Energy Future

WTE Gasifier Developers

Company	Contact	Technology	Notes
AlternNRG-Westinghouse Plasma Corp.	Mark A. Wright 770-696-7698 wrightm@westinghouse-plasma.com	Plasma arc gasification	<ul style="list-style-type: none"> o Biomass facility operating in Pennsylvania o WTE facilities operating in Japan and India o Proposed tipping fee of \$100/ton if \$.15/kWh received for electricity.
Biomass Energy Systems, Inc. (BESI)	Tony Calenda 100 Overlook Center 2nd Floor Princeton, NJ 08540 321-795-3107 tony.calenda@biomassenergysystems.net	Rotary kiln gasification	<ul style="list-style-type: none"> o Operating a 100 TPD unit in South Korea, fueled by industrial waste (mainly fabric, wood, plastic, packaging materials)
International Environmental Solutions (IES)	Karen Bertram 714.372.2272 Facsimile 714.372.2221 karenbertram@wastetopower.com	Horizontal auger-fed gasification	<ul style="list-style-type: none"> o Operating 30 TPD unit in Mecca, CA o Finalist for LA County WTE projects
Organic Energy Gasification	Mr. Jan d'Ailly 32 Academy Crescent Waterloo, Ontario, N2L 5H7 519-884-9170 jadilly@organicenergy.ca	Low temperature gasification	<ul style="list-style-type: none"> o WTE facilities operating in Ontario, Canada since 2001 o 25 TPD and 50 TPD modules o 94.9% conversion claim o Performance guarantee offered o \$7-9 million turnkey installation and \$700K-900K O&M costs estimated * NREL estimate using \$.15/kWh is \$130/ton tipping fee
Plasma Power LLC	James Juranitch 730 W. McNabb Rd Ft Lauderdale, FL 33309 262-443-9100 Jjuranitch@plasmapowerllc.com	Plasma arc gasification	<ul style="list-style-type: none"> o 250 TPD WTE facility operating in Iowa o 20 TPD WTE facility in planning stages in Florida o WTE facilities operating in Europe and Asia o Capital cost of \$19 million and O&M costs of \$237K estimated * NREL estimate using \$.15/kWh is \$110/ton
Princeton Environmental	Peter Tien 14-58 154th St Whitestone, NY 11357 718-767-7271 peter.tien@princetonenvironmental.com	Gasification	<ul style="list-style-type: none"> o 30-60 TPD WTE facilities operating in Japan o 30 years of experience in this field o Capital cost of \$8 million and O&M cost of \$200K estimated * NREL estimate using \$.15/kWh is \$60/ton
Pyrogenesis	Philippe Chevalier 1744 William St, Ste 200 Montreal, Quebec H3J 1R4 514-937-0002 pchevalier@pyrogenesis.com	Plasma arc gasification	<ul style="list-style-type: none"> o 10.5 TPD unit operating at Hurlburt Air Field, Florida o Capital cost \$9 million, O&M unknown
Recycling Solutions Technology	Steve Jones 31 East 12th St Cincinnati, OH 45202 513-241-2228 steve@jaap-orr.com	Rotary kiln gasification	<ul style="list-style-type: none"> o 300 TPD unit operating in Inez, KY o Capital cost \$8-10 million, O&M unknown
Rockwell - Intellergy	Richard Noling 1400 Hall Ave. Richmond, CA 94804 510-837-6200 Rick_Noling@gmail.com	Rotary gasifier, steam reformer	<ul style="list-style-type: none"> o No WTE facility in operation o Claim of 60% Hydrogen content in syngas o 30 TPD and 75 TPD size units o \$8 million capital cost and \$500K O&M costs estimated * NREL estimate using \$.15/kWh is \$95/ton tipping fee
Thermoselect	THERMOSELECT Headquarters Piazza Pedrazzi 11 CH6600 Locarno, Switzerland PH: +41-91-780.92.20 info@thermoselect.com	IWT currently has several THERMOSELECT facilities in operation throughout Japan. The capacities of the operations range from 95 - 550 tpd.	Interstate Waste Technologies, Inc. 17 Mystic Lane Malvern, PA 19355 Phone: 610-24445-1665 acctdesk@iwtonline.com

DOE Integrated Biorefinery Projects

Biomass Program *Integrated Biorefinery Platform*

IBR PROJECTS

Click on the project locations to see more information and locations are approximate



DOE Integrated Gasification Biorefinery Projects



National Renewable Energy
Laboratory
Innovation for Our Energy
Future

http://www1.eere.energy.gov/biomass/integrated_biorefineries.html

Questions

E-mail: Richard.Bain@nrel.gov

NREL Biomass: <http://www.nrel.gov/biomass/>

DOE Biomass Program <http://www1.eere.energy.gov/biomass/>

IEA Bioenergy: <http://www.ieabioenergy.com/>

IEA Bioenergy Task 33 (Thermal Gasification of Biomass): <http://www.ieatask33.org>

