

# Biomass Gasification R&D Activities in North America



**IEA Task 33  
Workshop  
Pitea, Sweden**

**Richard L. Bain**

**Oct 19, 2011**

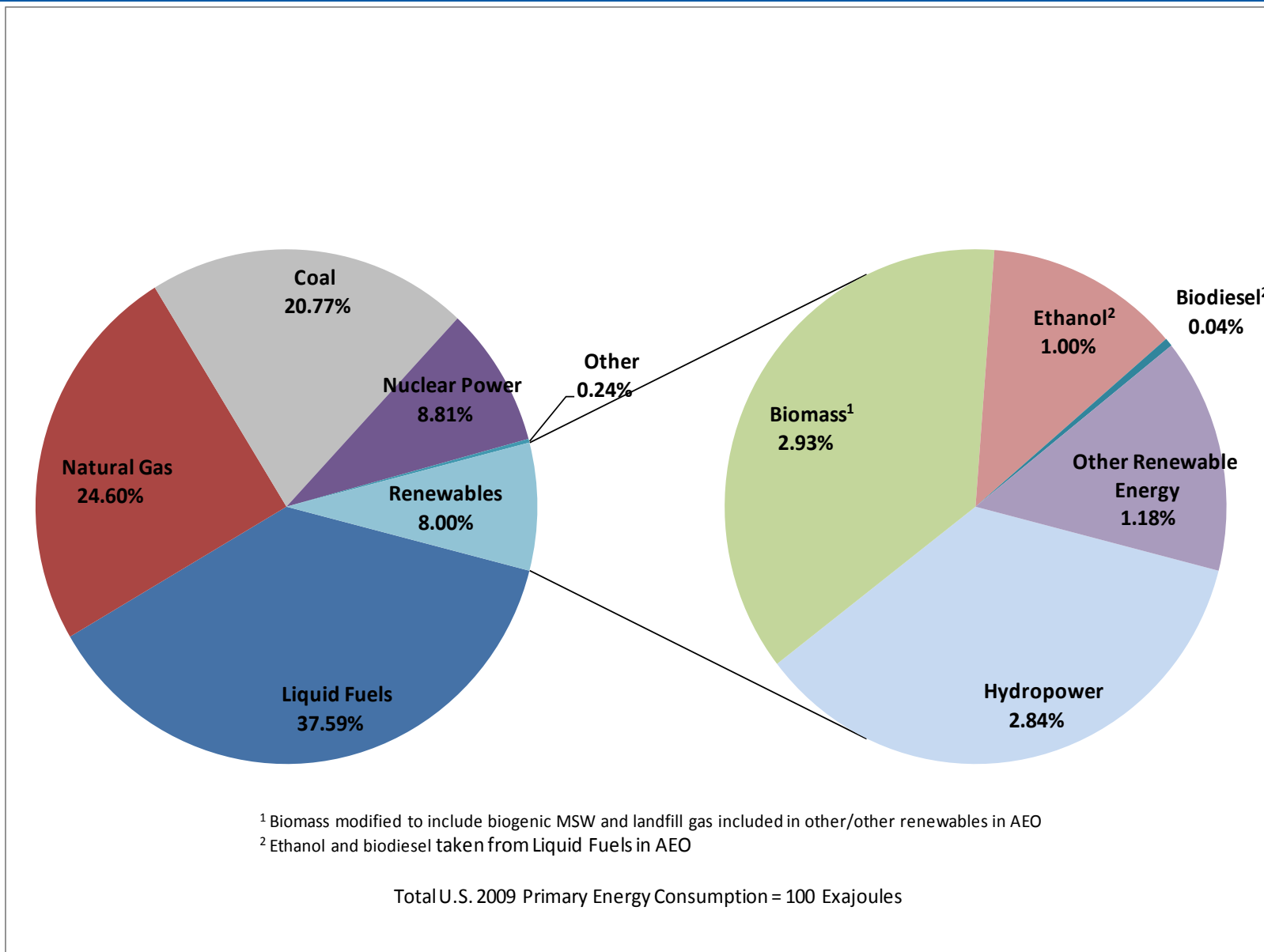
# Presentation Outline

- **Biopower and Biofuels Status**
- **Biomass Resource Potential**
- **U.S. Gasifier Developers**
- **USDOE Projects**
- **Gasification Technologies**
  - **Canadian Developers**
  - **U.S. Developers**



Photo Credit: Chariton Valley RC&D

# U.S. Primary Energy Consumption in 2009



# Current Biofuels Status

## Biodiesel – 2.85 billion gallons/yr nameplate capacity (April 2011)<sup>1</sup>

- Mar 2011 Rack Price – 478.06 cents/gal

## Corn ethanol

- 218 commercial plants<sup>2</sup>
- 14.554 billion gal/year nameplate capacity
- 11.987 billion gal/yr. production<sup>2</sup>
- Additional 0.27 billion gal/yr planned or under construction
- Mar 2011 Rack Price – 270.48 cents/gal

## Key DOE Goals

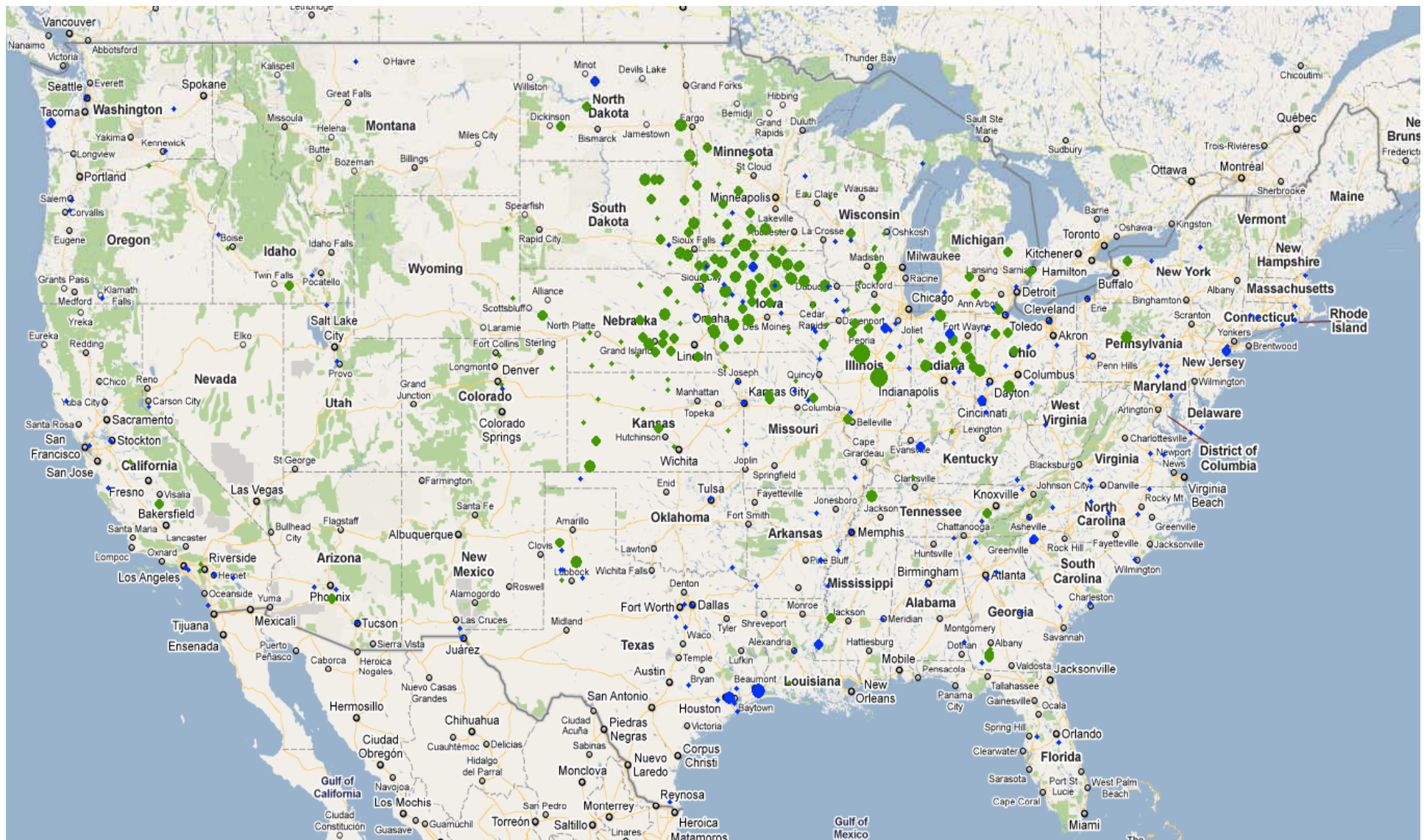
- 2012 goal: cellulosic ethanol \$1.51/ETOH gallon
- 2022 goal: 36B gal Renewable Fuel; 21B gal “Advanced Renewable Fuel”– 2007 Energy Independence and Security Act
- 2030 goal: 60 billion gal ethanol (30% of 2004 gasoline)



Updated Apr 2011

Sources: 1- National Biodiesel Board, 2 - Renewable Fuels Association, all other information based on DOE and USDA sources

# Existing Biofuels Facilities



# Biopower Status

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**2010 Capacity – 10.5 GW**

- **5.6 GW Electric Power Sector**
- **5.2 GW End Use Generators**

**2010 Generation – 55TWh**

**Cost – 0.08 – 0.12 USD/kWh**

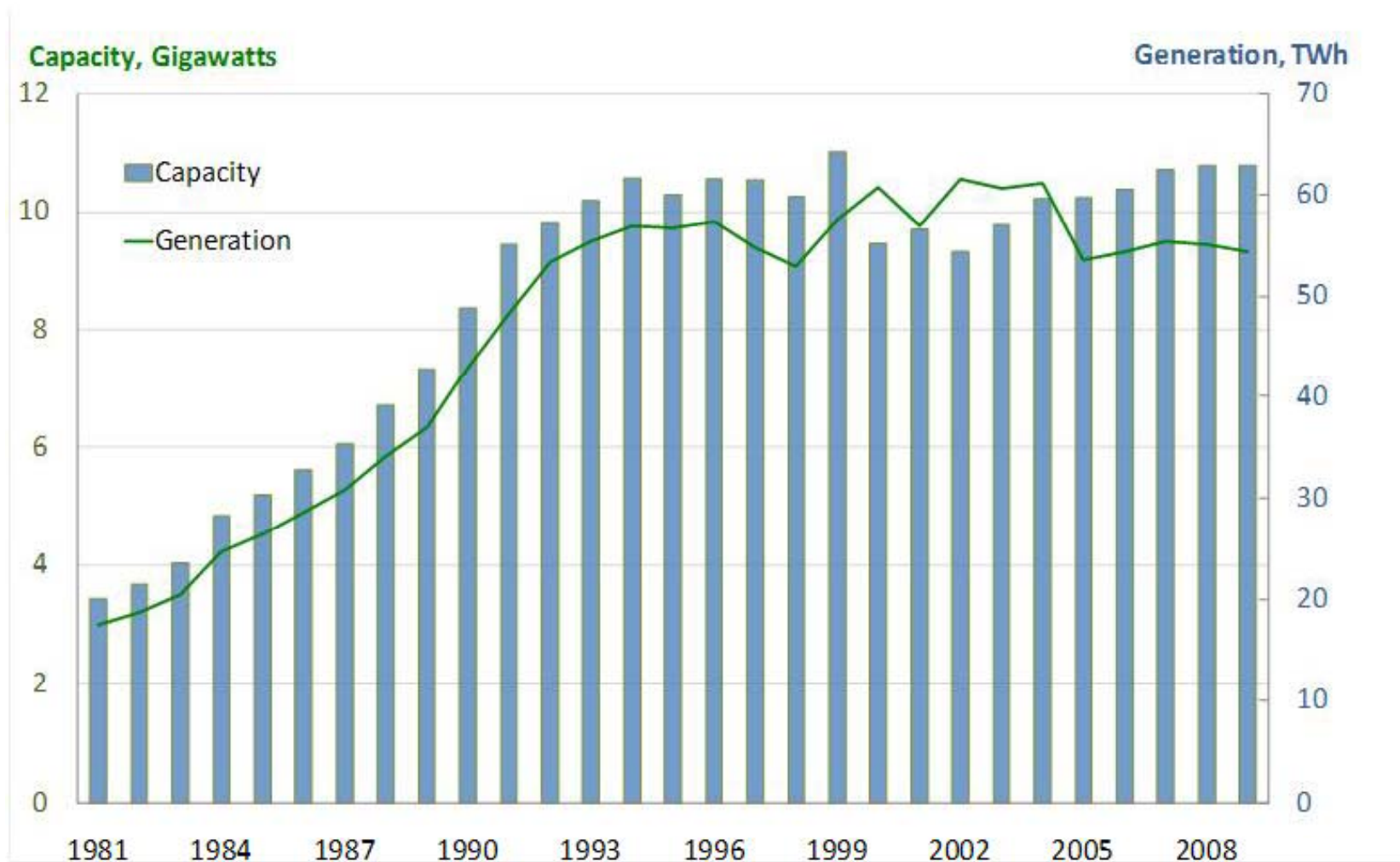
**Potential – Electric Sector**

<b>2022 -</b>	<b>22 GW</b>
<b>2035 -</b>	<b>48 GW</b>
<b>2050 -</b>	<b>91 GW</b>

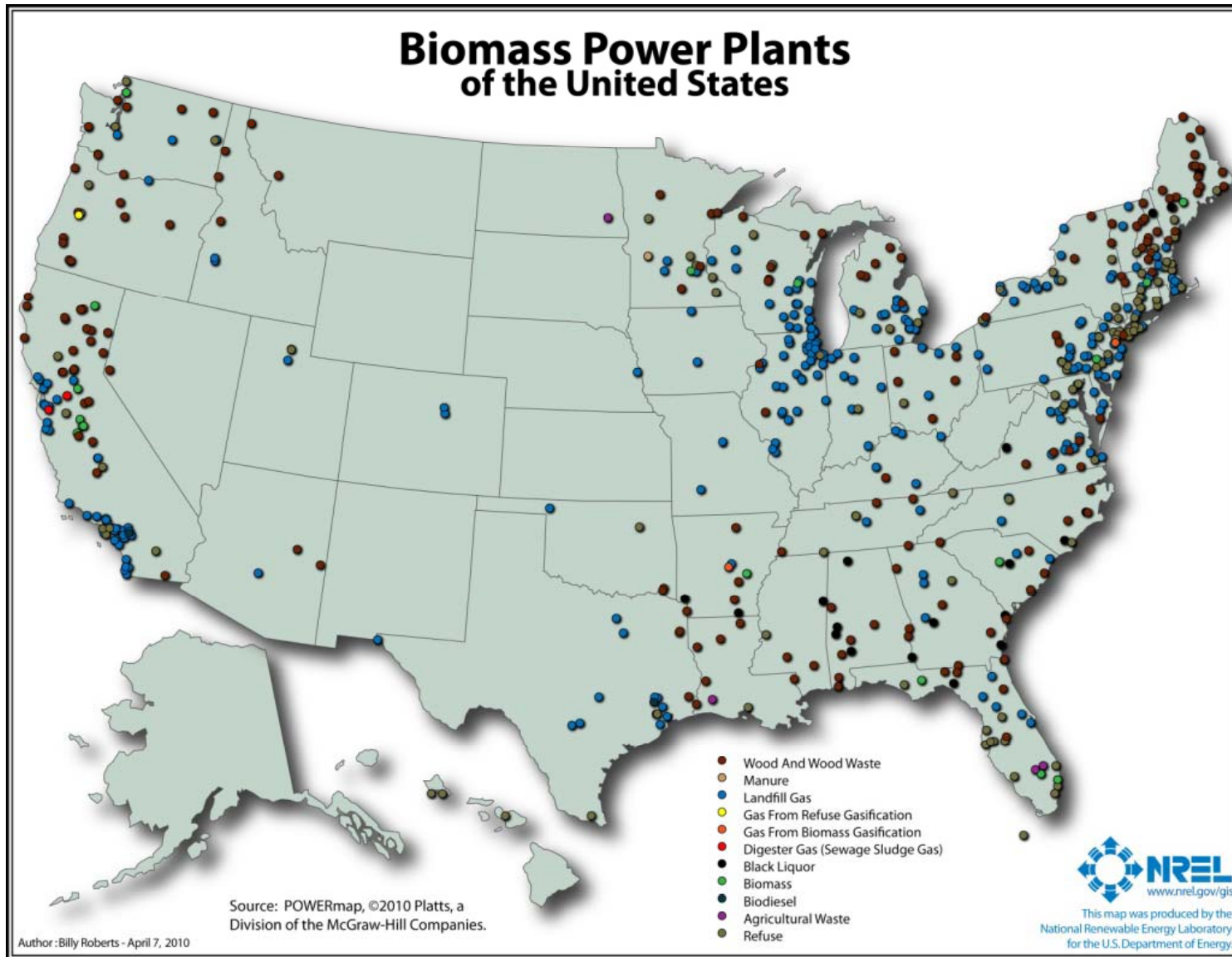


Sources: DOE EIA Annual Energy Outlook, Table A16 (year-by-year) , NREL Renewable Electricity Futures Study (2010) – **Preliminary Data**  
EIA Form 860 (Capacity), EIA Form 923 (Generation)

# United States Biopower 1981 - 2009

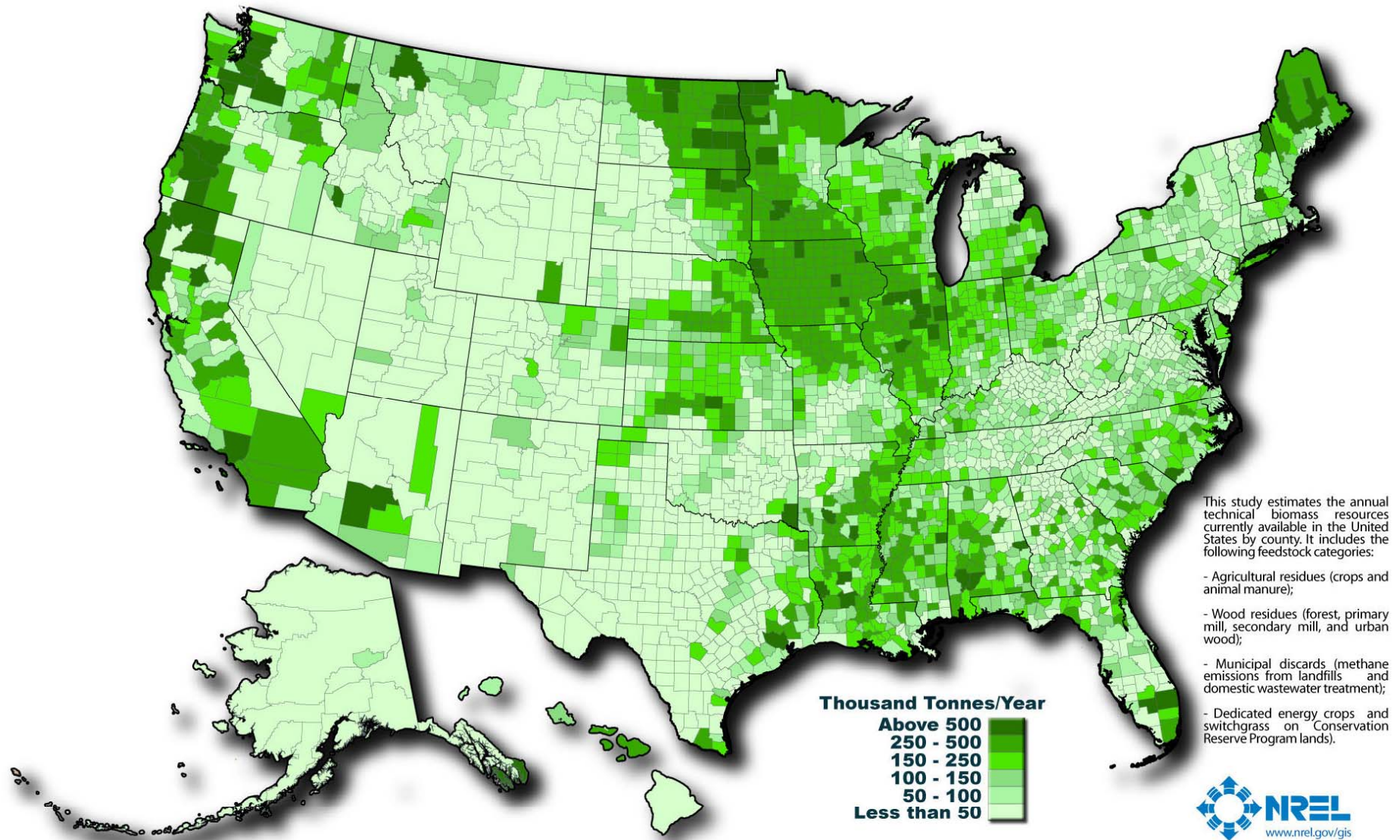


# U.S. Existing Biopower Plants





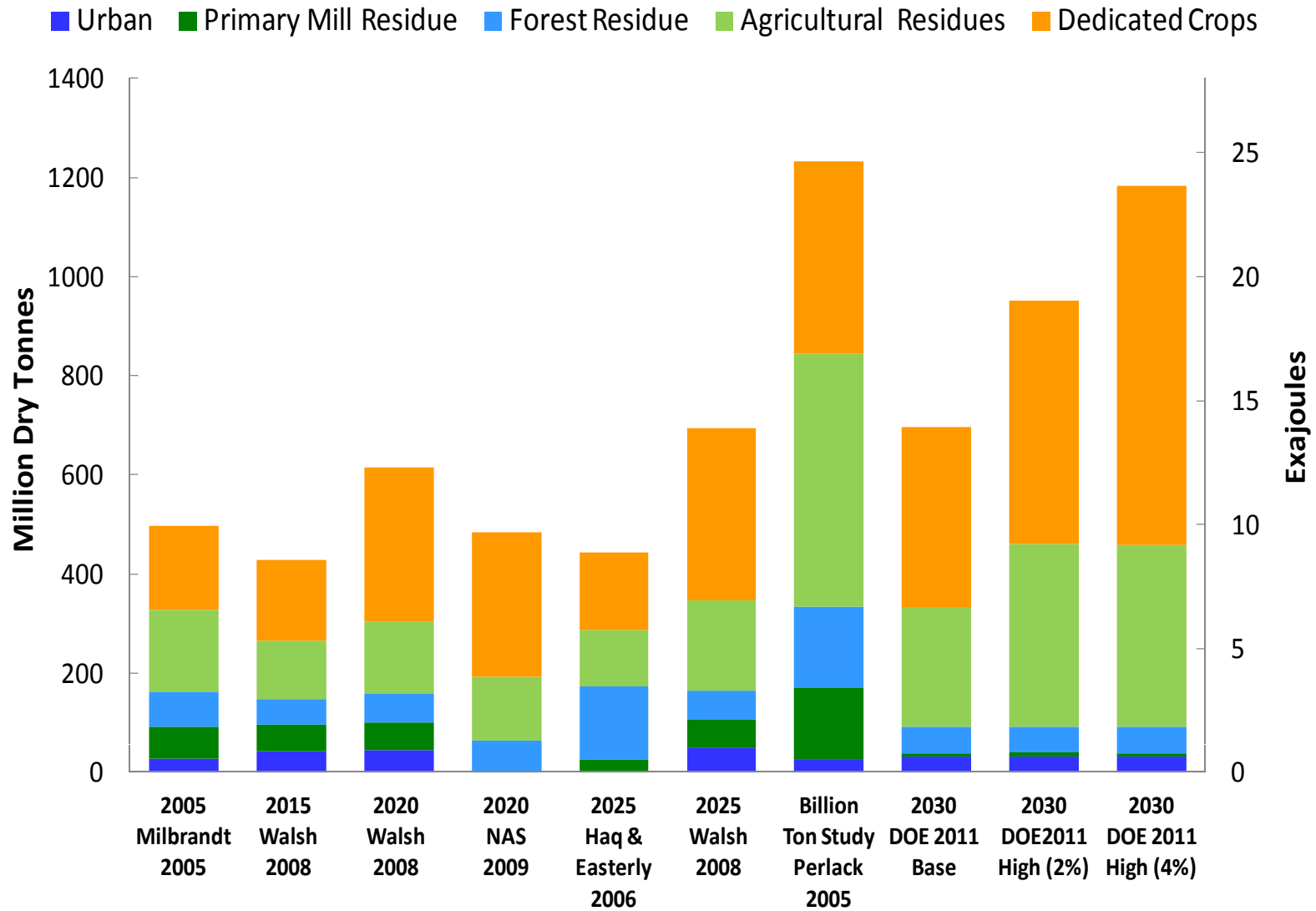
# U.S. Biomass Resource



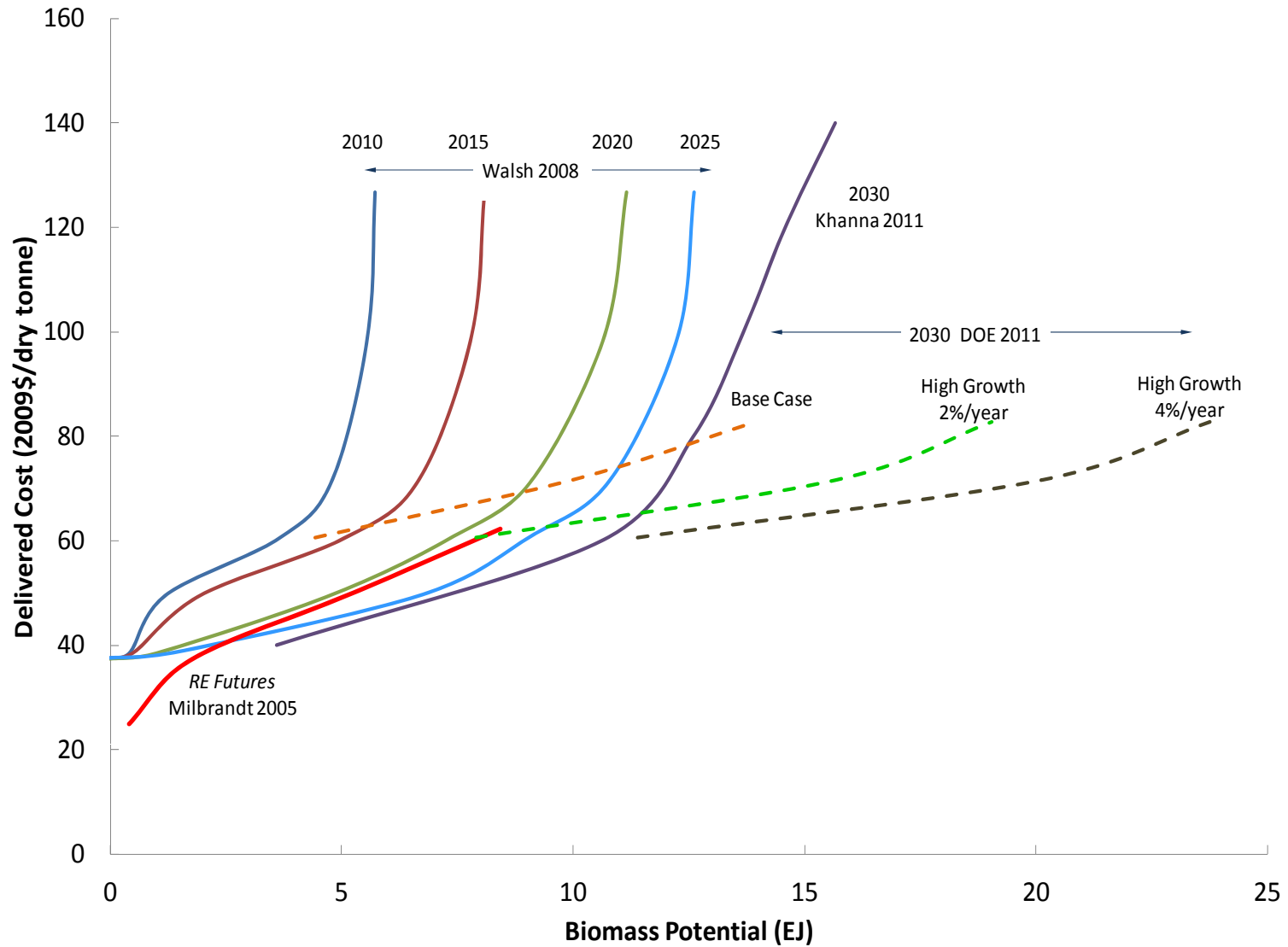
Author : Billy Roberts - October 20, 2008

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>

# USA Biomass Potential



# Supply cost curves for potential delivered biomass, 2005–2030



# Resource References

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[1] Walsh, M.E.; Perlack, R.L.; Turhollow, A.; De La Torre Ugarte, D.G.; Becker, D.A.; Graham, R.L.; Slinsky, S.E.; Ray, D.E. (2000). "Biomass Feedstock Availability in the United States: 1999 State Level Analysis." Oak Ridge, TN: Oak Ridge National Laboratory. <http://bioenergy.ornl.gov/resourcedata/index.html>. Accessed February 11, 201

[1] Perlack, R.; Wright, L.; Turhollow, A.; Graham, R.; Stokes, B.; Erbach, D. (2005). *Biomass as Feedstock for a Bioenergy and BioProducts Industry: The Technical Feasibility of a Billion-Ton Annual Supply*. ORNL/TM-2005/66. Oak Ridge, TN: Oak Ridge National Laboratory

[1] Milbrandt, A. (2005). *Geographic Perspective on the Current Biomass Resource Availability in the United States*. NREL/TP-560-39181. Golden, CO: National Renewable Energy Laboratory. <http://www.nrel.gov/docs/fy06osti/39181.pdf>

[1] NAS (National Academy of Sciences). (2009). *Liquid Transportation Fuels from Coal and Biomass: Technological Status, Costs, and Environmental Impacts*. ISBN-10: 0-309-13712-8. National Academy of Sciences-National Academy of Engineering-National Research Council Report. Washington, DC: The National Academies Press.

[1] Haq, Z.; Easterly, J. (2006). "Agricultural Residue Availability in the United States." *Applied Biochemistry and Biotechnology* (129:1–3); pp. 3–21

Khanna, M., X. Chen, H. Huand, H Önal (2011). "Supply of cellulosic biofuel feedstocks and regional production pattern," *Amer. J. Agr. Econ.*, 1-8; doi:10.1039/ahae/aaq119.

Walsh, M.E. (2008, January). *U.S. Cellulosic Biomass Feedstock Supplies and Distribution*. Oak Ridge, TN: M&E Biomass

[1] DOE (U.S. Department of Energy) (2011).

*U.S. Billion-Ton Update: Biomass Supply for a Bioenergy and Bioproducts Industry*, R.D. Perlack and B.J. Stokes (Leads). ORNL/TM-2011/224. Oak Ridge National Laboratory, TN, 227p.

# U.S. Biomass Gasifier Developers

Company	Gasifier Type	Scale				Status	Contact Information
		kg/hr	Tonnes/d	kWt	kWe		
Adaptive Arc <a href="http://www.adaptivearc.com">www.adaptivearc.com</a>	plasma		25			Pilot	<a href="http://www.adaptive ARC.com/">http://www.adaptive ARC.com/</a>
Advanced Alternative Energy Corp.	Mod-UD		12-200			OP	<a href="http://www.aaecorp.com/power.html">www.aaecorp.com/power.html</a>
Bioten Power & Energy Group Cogentech, Inc	DD-var					Pilot	<a href="http://www.bioten.com">www.bioten.com</a>
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	<a href="http://www.biggreenenergy.com/">http://www.biggreenenergy.com/</a> 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 <a href="http://www.chiptec.com">www.chiptec.com</a>	UD					OP	Robert Bender 48 Helen Ave. South Burlington, VT 05403 Tel 802-658-0956, Fax 802-660-8904 <a href="mailto:chiptec@together.net">chiptec@together.net</a>
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 <a href="http://clenergen.com/">http://clenergen.com/</a>

# 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	<a href="http://www.gulfcoastenergy.net/">http://www.gulfcoastenergy.net/</a>
Hamilton Mauer International/ MIFGA (HMI, Inc.)	UD					?	Rolf Mauer Tel 713-468-6805 Fax 713-468-0761
HTI - Heat Transfer International	UD					?	<a href="http://www.heatxfer.com/products/fixedbed.html">http://www.heatxfer.com/products/fixedbed.html</a>
ICM Inc.	Air-blown Auger		136 - 181			Demo	<a href="http://www.icminc.com/services/gasifiers">http://www.icminc.com/services/gasifiers</a>
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	<a href="http://www.redlionbio-energy.com">www.redlionbio-energy.com</a>
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 <a href="http://www.thermogenetics.com">www.thermogenetics.com</a>	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	<a href="http://www.tri-inc.net">www.tri-inc.net</a> 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	<a href="http://www.westinghouse-plasma.com">www.westinghouse-plasma.com</a>
Ze-Gen	Molten Salt		ca. 10			?	Ze-Gen 1380 Soldiers Field Road Boston, MA 02135 617.674.2442



# 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"> <li>o Biomass facility operating in Pennsylvania</li> <li>o WTE facilities operating in Japan and India</li> <li>o Proposed tipping fee of \$100/ton if \$.15/kWh received for electricity.</li> </ul>
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"> <li>o Operating a 100 TPD unit in South Korea, fueled by industrial waste (mainly fabric, wood, plastic, packaging materials)</li> </ul>
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"> <li>o Operating 30 TPD unit in Mecca, CA</li> <li>o Finalist for LA County WTE projects</li> </ul>
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"> <li>o WTE facilities operating in Ontario, Canada since 2001</li> <li>o 25 TPD and 50 TPD modules</li> <li>o 94.9% conversion claim</li> <li>o Performance guarantee offered</li> <li>o \$7-9 million turnkey installation and \$700K-900K O&amp;M costs estimated</li> <li>* NREL estimate using \$.15/kWh is \$130/ton tipping fee</li> </ul>
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"> <li>o 250 TPD WTE facility operating in Iowa</li> <li>o 20 TPD WTE facility in planning stages in Florida</li> <li>o WTE facilities operating in Europe and Asia</li> <li>o Capital cost of \$19 million and O&amp;M costs of \$237K estimated</li> <li>* NREL estimate using \$.15/kWh is \$110/ton</li> </ul>
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"> <li>o 30-60 TPD WTE facilities operating in Japan</li> <li>o 30 years of experience in this field</li> <li>o Capital cost of \$8 million and O&amp;M cost of \$200K estimated</li> <li>* NREL estimate using \$.15/kWh is \$60/ton</li> </ul>
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"> <li>o 10.5 TPD unit operating at Hurlburt Air Field, Florida</li> <li>o Capital cost \$9 million, O&amp;M unknown</li> </ul>
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"> <li>o 300 TPD unit operating in Inez, KY</li> <li>o Capital cost \$8-10 million, O&amp;M unknown</li> </ul>
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"> <li>o No WTE facility in operation</li> <li>o Claim of 60% Hydrogen content in syngas</li> <li>o 30 TPD and 75 TPD size units</li> <li>o \$8 million capital cost and \$500K O&amp;M costs estimated</li> <li>* NREL estimate using \$.15/kWh is \$95/ton tipping fee</li> </ul>
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*

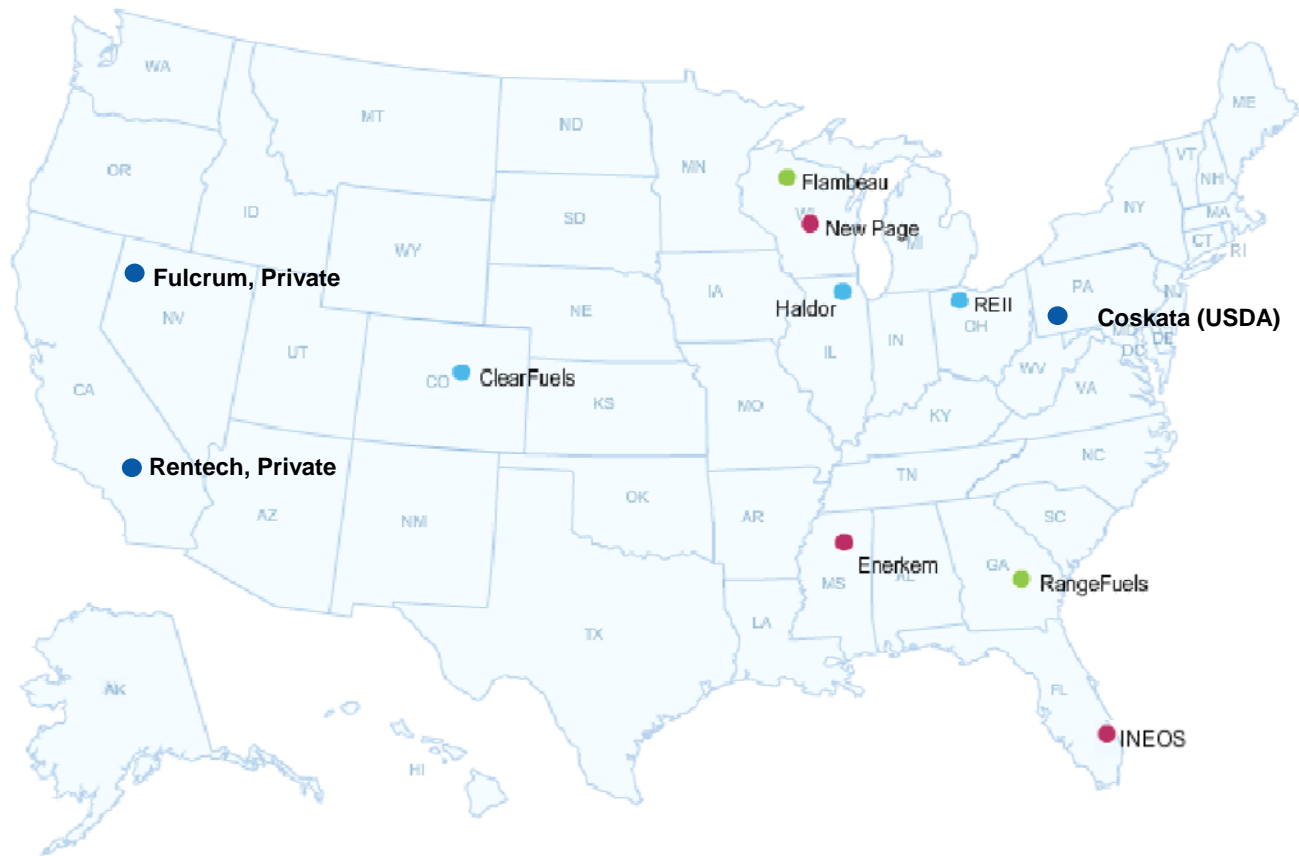
### IBR PROJECTS

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



[http://www1.eere.energy.gov/biomass/integrated\\_biorefineries.html](http://www1.eere.energy.gov/biomass/integrated_biorefineries.html)

# DOE Integrated Gasification Biorefinery Projects



[http://www1.eere.energy.gov/biomass/integrated\\_biorefineries.html](http://www1.eere.energy.gov/biomass/integrated_biorefineries.html)

# DOE Integrated Gasification Biorefinery Projects

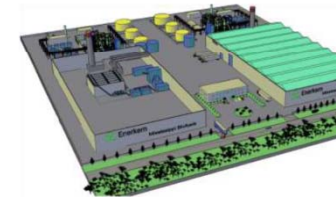


U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy | Biomass Program

### Enerkem to use Sorted Waste as Feedstock in Biorefinery

Enerkem's biorefinery in northern Mississippi will convert heterogeneous (mixed) sorted municipal solid waste into ethanol.

Enerkem will build a 300 short tons (300 metric tons) per day biorefinery in Pontotoc, Mississippi that will produce 10 million gallons of ethanol per year from the post-recycling municipal solid waste. Because the project is located on a portion of a regional landfill, feedstock for the project is already generated in the surrounding counties and delivered to the landfill each day. By converting this waste into transportation fuels, the



CAPTION: 3D Rendering of Enerkem's Pontotoc, Mississippi Biorefinery

by over 90% and at the same time extracts all useful energy from the waste used as feedstock. Enerkem has been developing its technology platform since 2001, and has built and operated both a large pilot plant in Sherbrooke, Quebec, Canada, as well as a demonstration-scale plant (50 tons per day) in Westbury, Quebec.

landfill on which the facility is located. Furthermore, the commercial-scale plant will remove remaining bar commercialization of the technology throughout the U.S.

- ★ Range Fuels, USDA Loan Guarantee
- ★ Enerkem and INEOS Conditional USDA Guarantees;
- ★ Coskata has conditional USDA Loan Guarantee for project in Boligee, AL

[http://www1.eere.energy.gov/biomass/integrated\\_biorefineries.html](http://www1.eere.energy.gov/biomass/integrated_biorefineries.html)

# Gasification Technologies

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# Nexterra Energy Corporation



### JCI/USC Gasification System

**Customer:**  
Johnson Controls Inc. -  
University of South Carolina  
**Location:**  
Columbia, South Carolina  
**Facility Type:**  
University  
**Application:**  
Cogeneration plant to provide heat  
and power for university.  
**Scope of Work:**  
Supply only of gasification system

### Highlights

**Start-up:**  
Q4 2007  
**Capacity:**  
60,000 lbs/hr of high pressure  
steam for district heating  
**Power:**  
1.38 MW of electricity power  
generation  
**Fuel:**  
Wood residue (hog fuel)  
**Fuel moisture content:**  
25 - 55%

### Process

3 gasifiers convert wood  
biomass to combustible syngas.  
Syngas is burned in the oxidizer.  
The hot flue gas is directed  
through heat recovery steam  
generator to produce steam.  
Steam sent to a back pressure  
turbine to produce electricity.  
Turbine exhaust steam is  
distributed to campus heating  
system.



Gasifiers and metering bins at USC plant

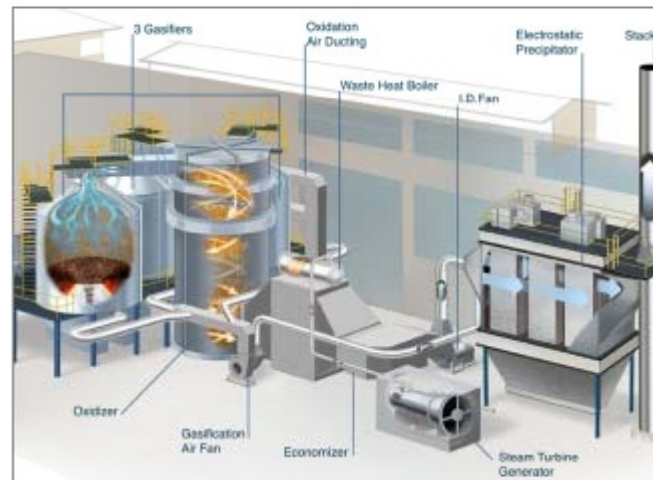


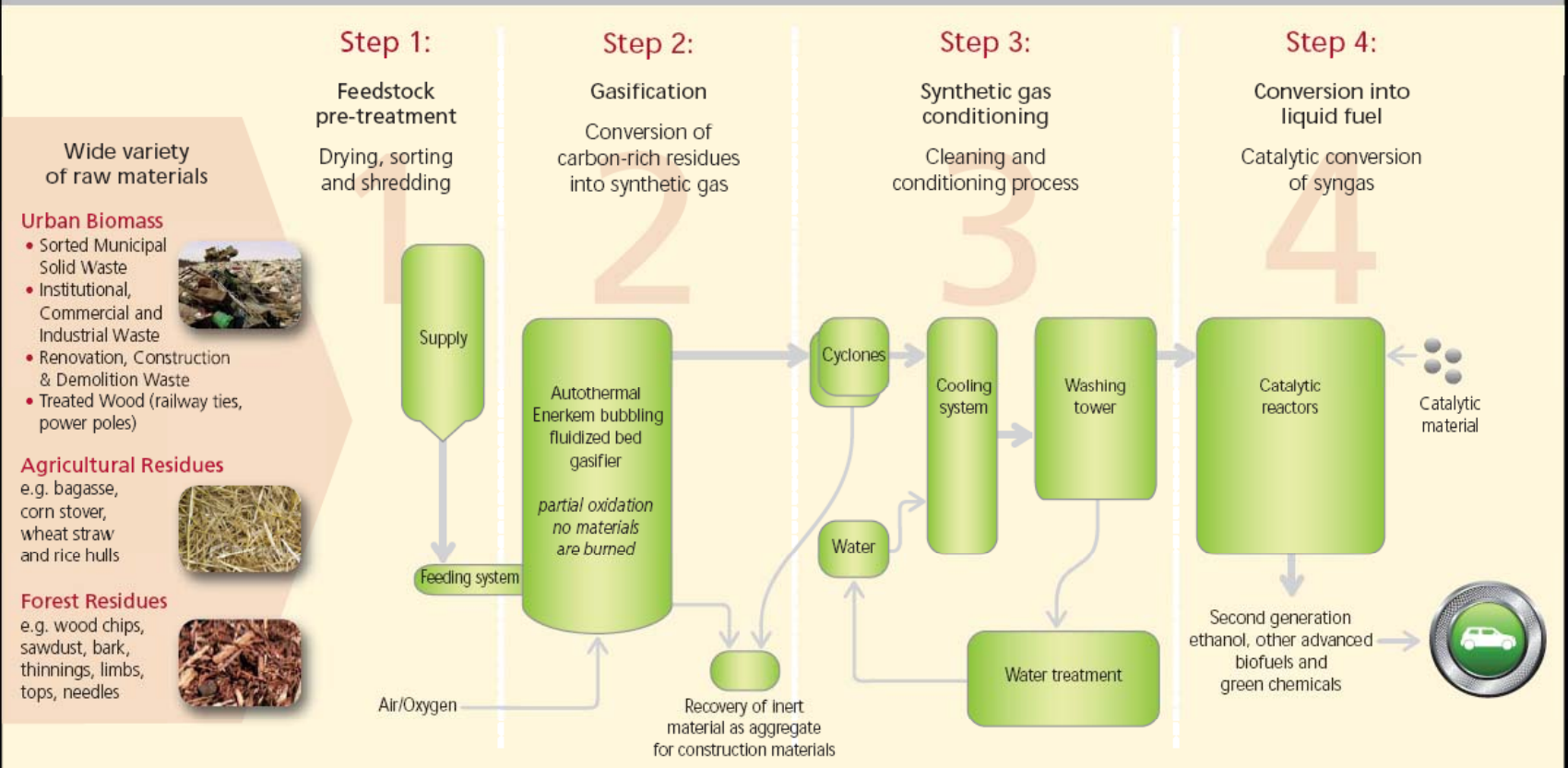
Illustration of Nexterra's gasification system at USC

Credit: <http://www.nexterra.ca/>



# Enerkem converts waste and residuals into advanced biofuels

## A Unique Gasification and Syngas to Biofuels Technology



### Enerkem promotes sustainable development:

- Uses the non-recyclable portion of our waste and creates value from our forest and agricultural residues.
- Produces 360 litres (95 gallons) of ethanol from one tonne of waste (dry base).
- Reduces greenhouse gases by using raw materials that would otherwise produce methane when landfilled and by replacing gasoline produced from petroleum.

### Enerkem uses an environmentally friendly process:

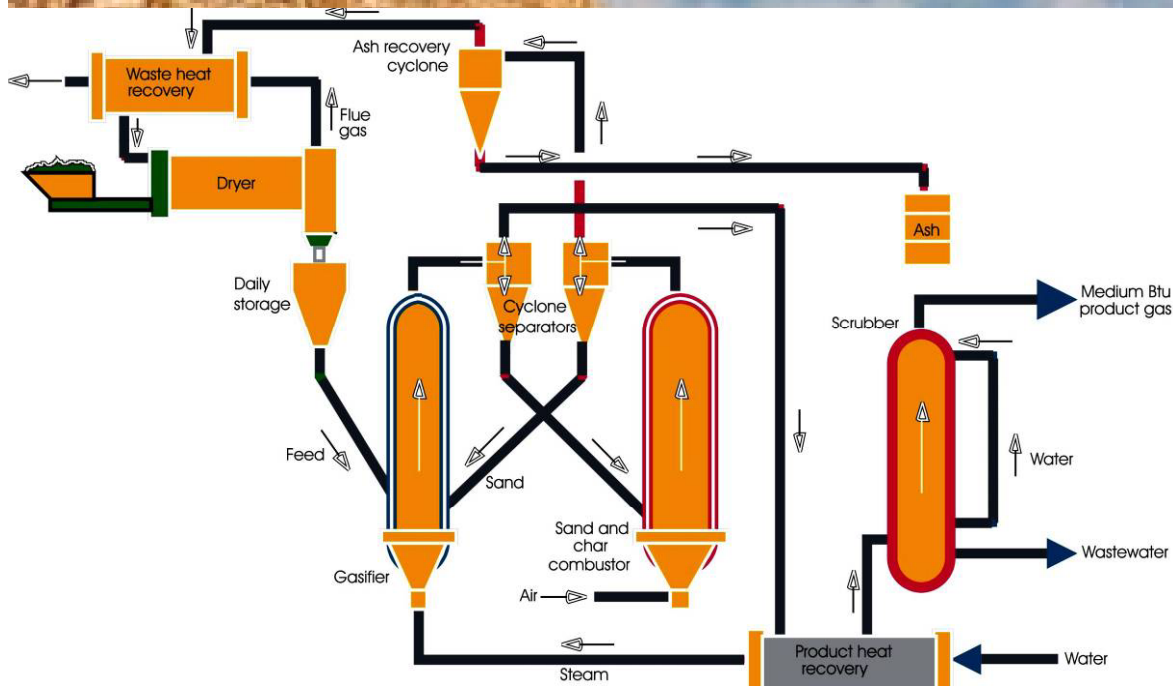
- Energy self-sufficient since the chemical reactions in the gasification process produce most of the energy and heat needed.
- Requires little use of water and allows for its reuse in a closed circuit. With certain feedstocks, the process is a net producer of water.
- Compact and decentralized facilities located near feedstock supply.



# FERCO GASIFIER- BURLINGTON, VT

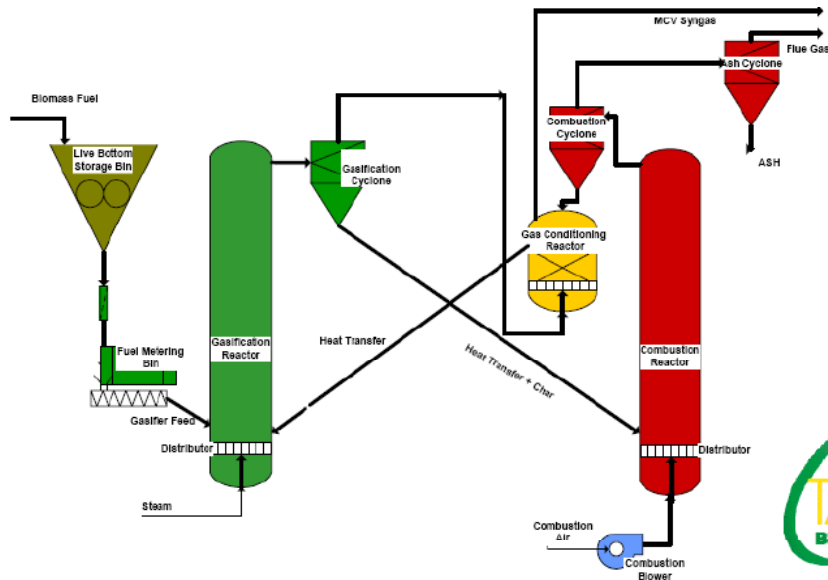
350 TPD

Technology now owned by Rentech





# Taylor Biomass Energy, LLC



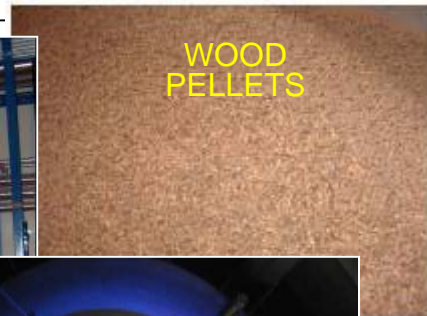
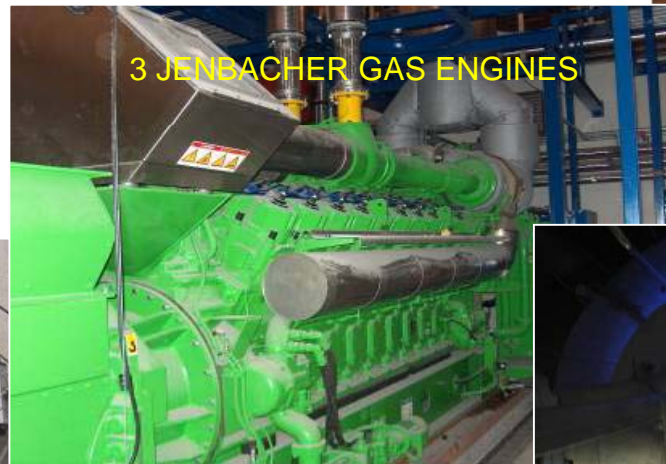
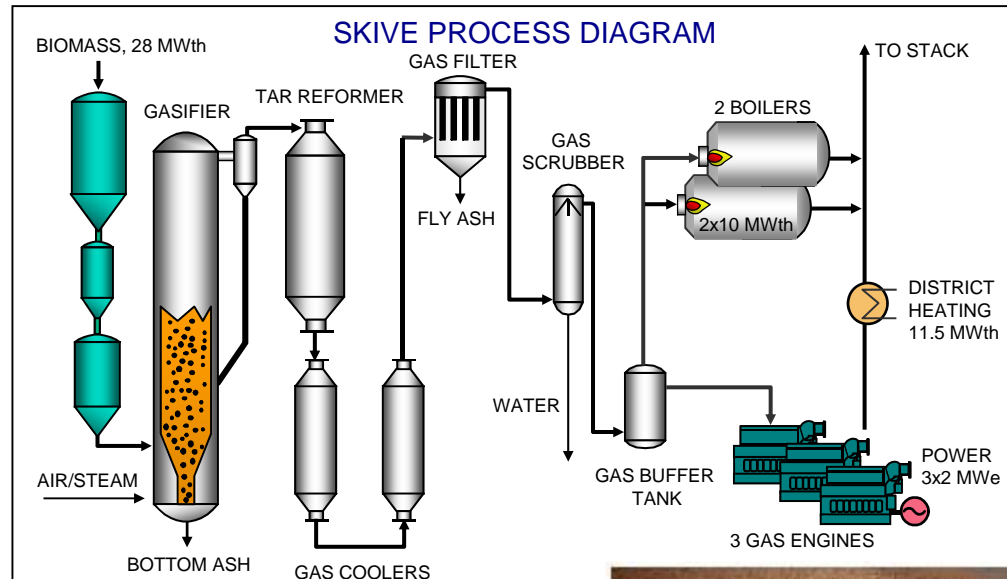
<i>HYDROGEN</i>	<i>45 - 48</i>
<i>CARBON MONOXIDE</i>	<i>15 - 20</i>
<i>METHANE</i>	<i>10 - 13</i>
<i>CARBON DIOXIDE</i>	<i>18 - 20</i>
<i>ETHYLENE</i>	<i>1 - 3</i>
<i>ETHANE</i>	<i>0 - 1</i>
<i>NITROGEN</i>	<i>trace</i>
<i>HHV</i>	<i>14 - 17 MJ/Nm<sup>3</sup></i>

- **Montgomery, NY**
  - MSW + C&D Material
  - Modular gasification facility
  - Process systems for liquid fuel + hydrogen production
  - 24 MW Combined Cycle system
  - Sell green energy to NY grid
- **Alberta, Canada**
  - 24 MW Combined Cycle system
  - Hog fuel / residuals
- **Maryland**
  - Synthesis to FT liquids

Source: Paisley, M. (2009) Biomass Conf & EXPO, April 28-30, Portland, ORE

# Carbona: SKIVE GASIFICATION CHP-PLANT, DENMARK

## 6 MWe and 12 Mwth



Status: >1000 hours with engines  
April 2009

Source: Carbona

February 2009

# GTI Biomass Gasification Activities



- 2<sup>nd</sup> generation biofuels
  - Laboratory & pilot-scale tests for Andritz/Carbona and UPM F-T project
  - maximum feed rate of biomass (O<sub>2</sub>-blown, 25 bar) is 40 tons/day
- Syngas cleanup
  - Warm-gas cleanup train
  - Engineered catalysts
- H<sub>2</sub> production
  - Membrane reactor system
- Biomass pretreatment
  - Hydrothermal process

Source: GTI

# TRI Technology and Projects



TRI's core technology is deep fluidized bed, indirectly-heated, steam reforming of biomass

- Biomass undergoes evaporation, pyrolysis, and gasification in our system; tars are recovered and gasified

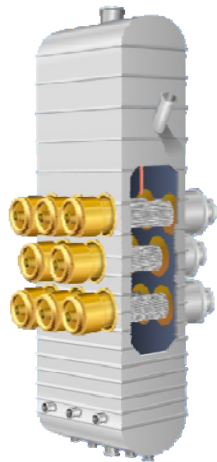
TRI's black liquor gasifier has been commercially operational for six years (Trenton, Ontario)

Two separate DOE "Small-Scale Biorefinery Projects" are employing TRI technology

- NewPage, Wisconsin Rapids, WI; 500 dry tons per day biomass to FT fuels and tail gas. Class 10 study underway (\$30 million award, 2008)
- Flambeau River Biofuels, Park Falls, WI; 1000 dry tons per day biomass to FT fuels. Class 30 completed (\$30 million award, 2008)

State-of-the-art 4 dry ton per day solid biomass pilot plant at Carbon-2-Liquids (C2L) Center, Durham NC

Integrated Fischer Tropsch Synthesis at Durham PDU



Highly-scalable TRI reformer design: number of PulseEnhanced™ heaters is adjusted within same reformer vessel to meet required throughput level

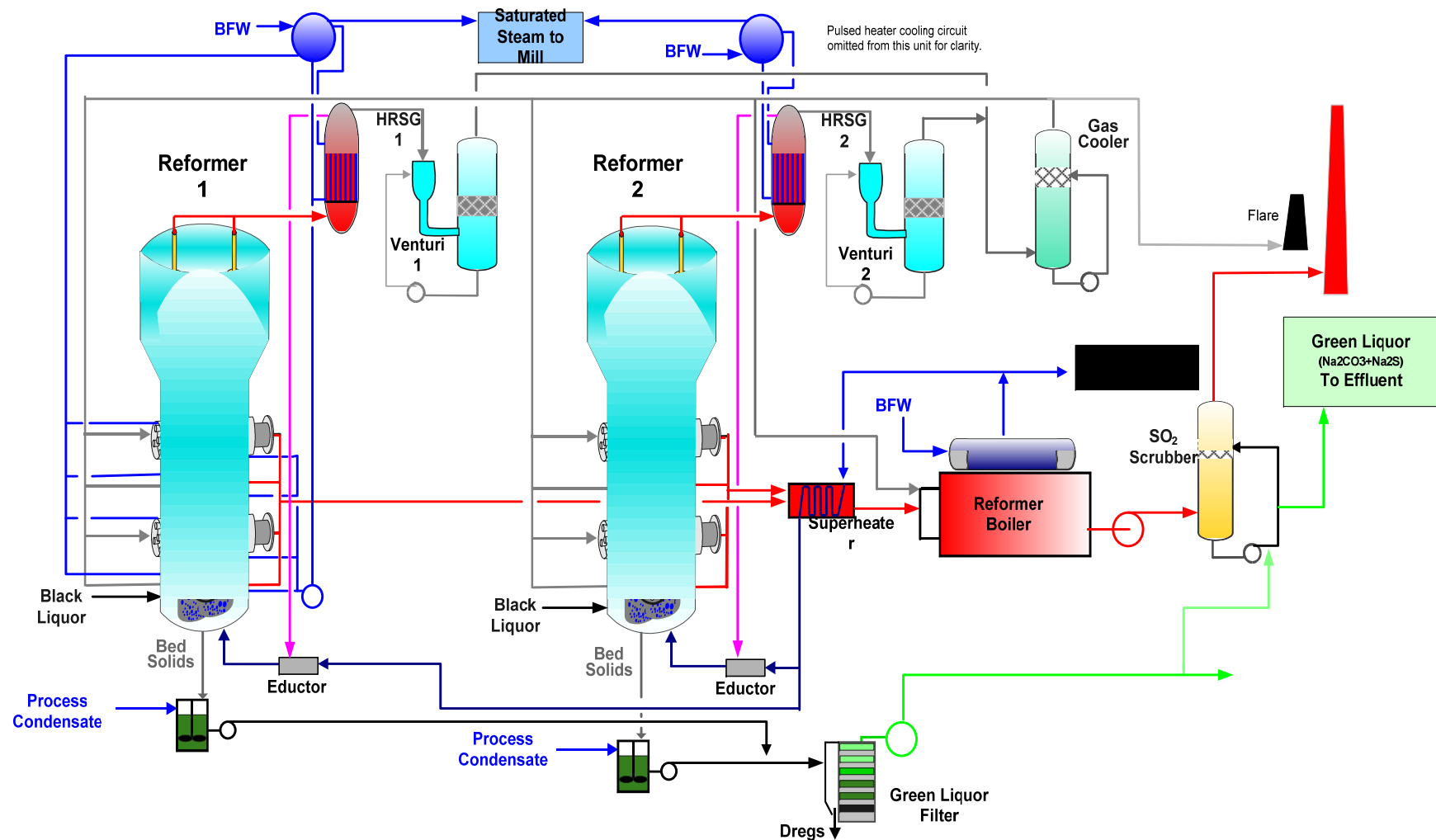


TRI BL gasifier (top left) at Norampac's Trenton, Ontario plant



Newest TRI PDU in Durham, NC

## Black Liquor Steam Gasification



# TRI Technology and Projects

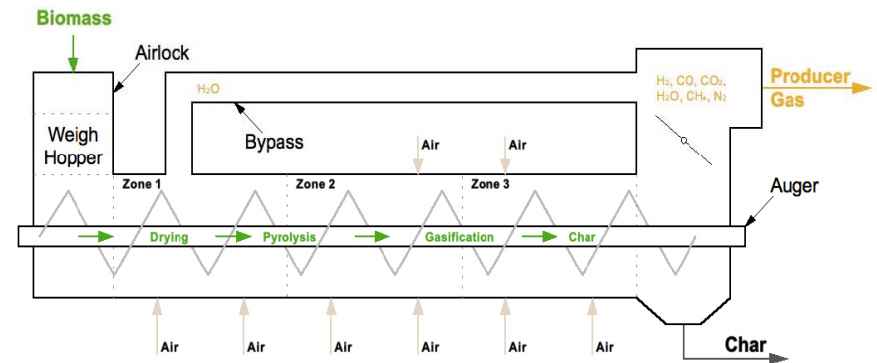


# ICM, Inc.

**Process Description:** ICM Inc.'s gasification technology has been successfully tested and supported at rates up to 250 tons per day by the Department of Energy. ICM currently offers three commercial-scale unit designs with feedstock processing ranges of 150-200 TPD, 300-350 TPD and 450-500 TPD.

**Status:** ICM owns and operates a 200 ton per day commercial demonstration auger gasification unit in Newton, KS that was installed to process municipal solid waste from the Harvey County, KS landfill. Since commencing operations at the facility, ICM has tested more than a dozen feedstocks and amassed more than 2,100 hours of operation on the unit

**Projects:** ReVenture Project, Charlotte, NC: ReVenture Park is a proposed waste-to-energy facility for Charlotte, NC. Forsite Development, the lead developer for the project, selected the biomass gasifier technology by ICM, Inc.



Gasifier Type	Auger (screw conveyor) gasifier
Typical Operating Temperature	Feed drying at approximately 316°C (600°F) to syngas outlet temperature of approximately 760°C (1400°F)
Typical Pressure	Vacuum to atmospheric
Feed Preparation and Introduction	Front-end loaders, feed conveyor, metering hopper. Feedstock particle size not identified in research.
Gas Cleanup (refer to image below)	<ul style="list-style-type: none"> <li>Particulate removal</li> <li>Staged injection of air &amp; flue gas recycle</li> <li>NOx control – selective non-catalytic reduction</li> <li>Dry sorbent injection</li> <li>Dual-field wet ESP – strategic alliance with Eisenmann Corp.</li> </ul>



# Coskata – Project Lighthouse

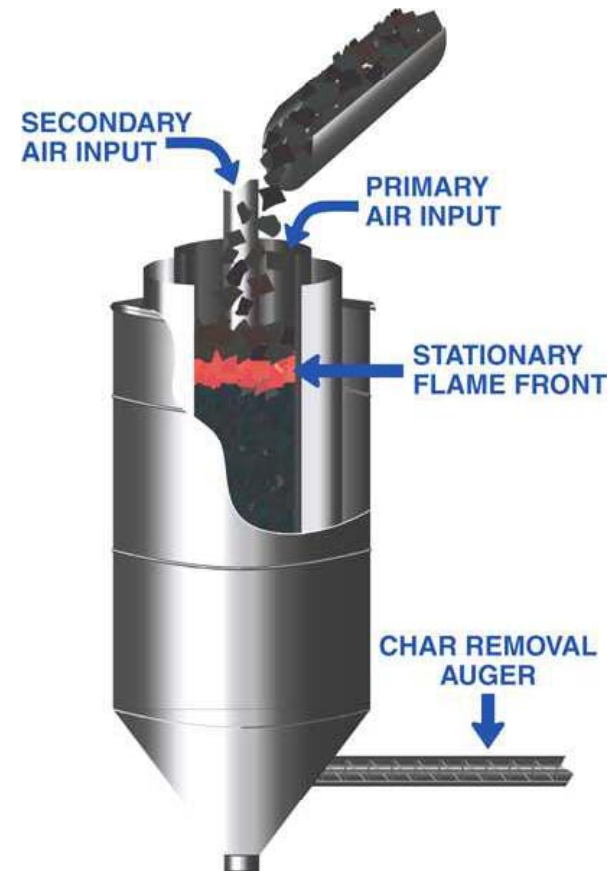
- Semi-commercial demonstration
- Located in Madison, PA
- Partnership between Coskata and Alter NRG
- Technology
  - Gasification Westinghouse Plasma Gasifier
    - Now owned by Alter NRG
  - Coskata – Syngas fermentation to ethanol
- Scale – 50,000 gal/yr ethanol
  - 100 gal/ton
  - Pine chips
- Status – Successful startup announced (Oct 2009)





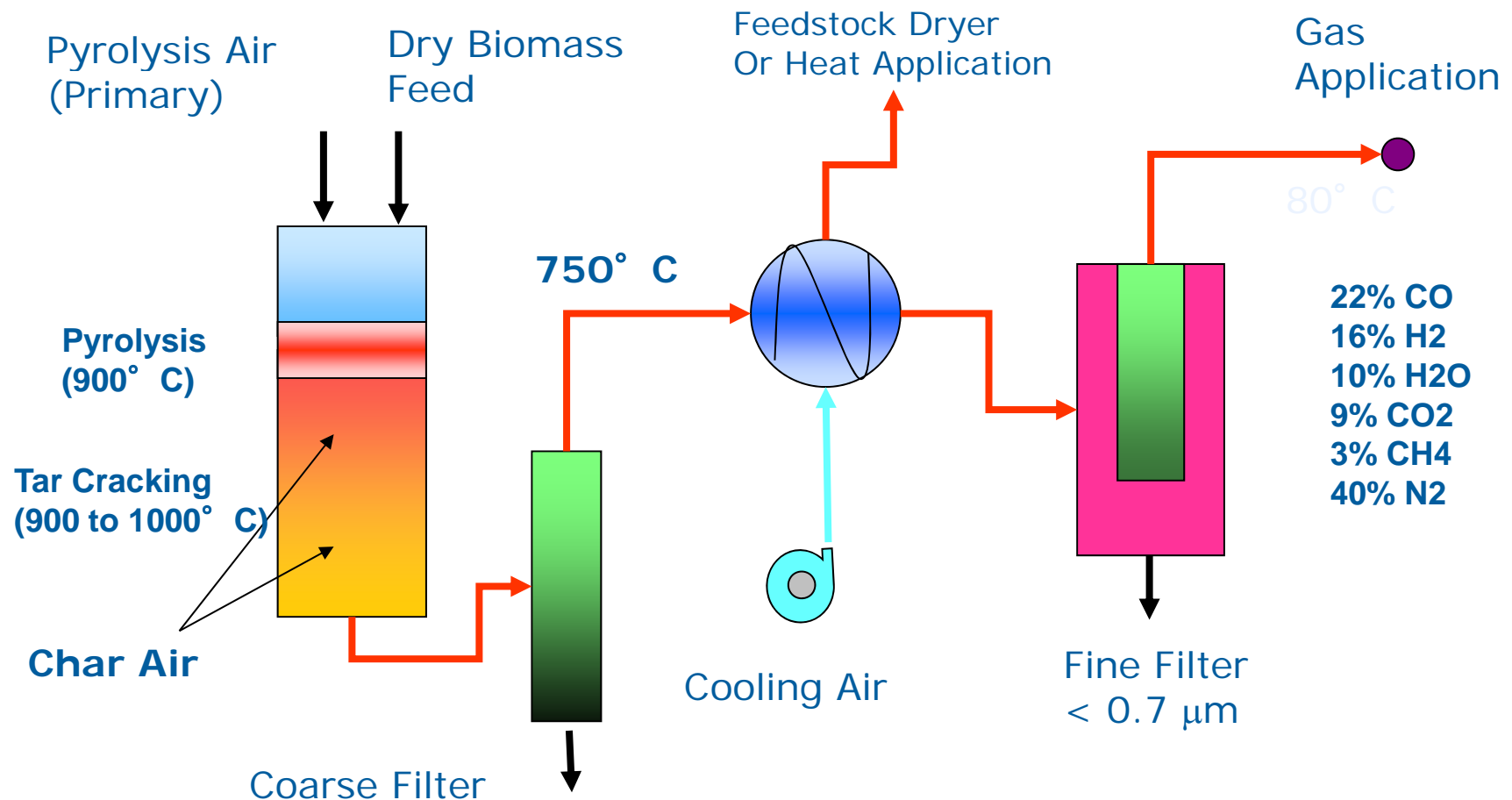
# DOE and the USDA Forest Service have supported development Community Power Corporation's BioMax Modular Biopower System

5, 15, 50 kW systems



Credit: Community Power Corp

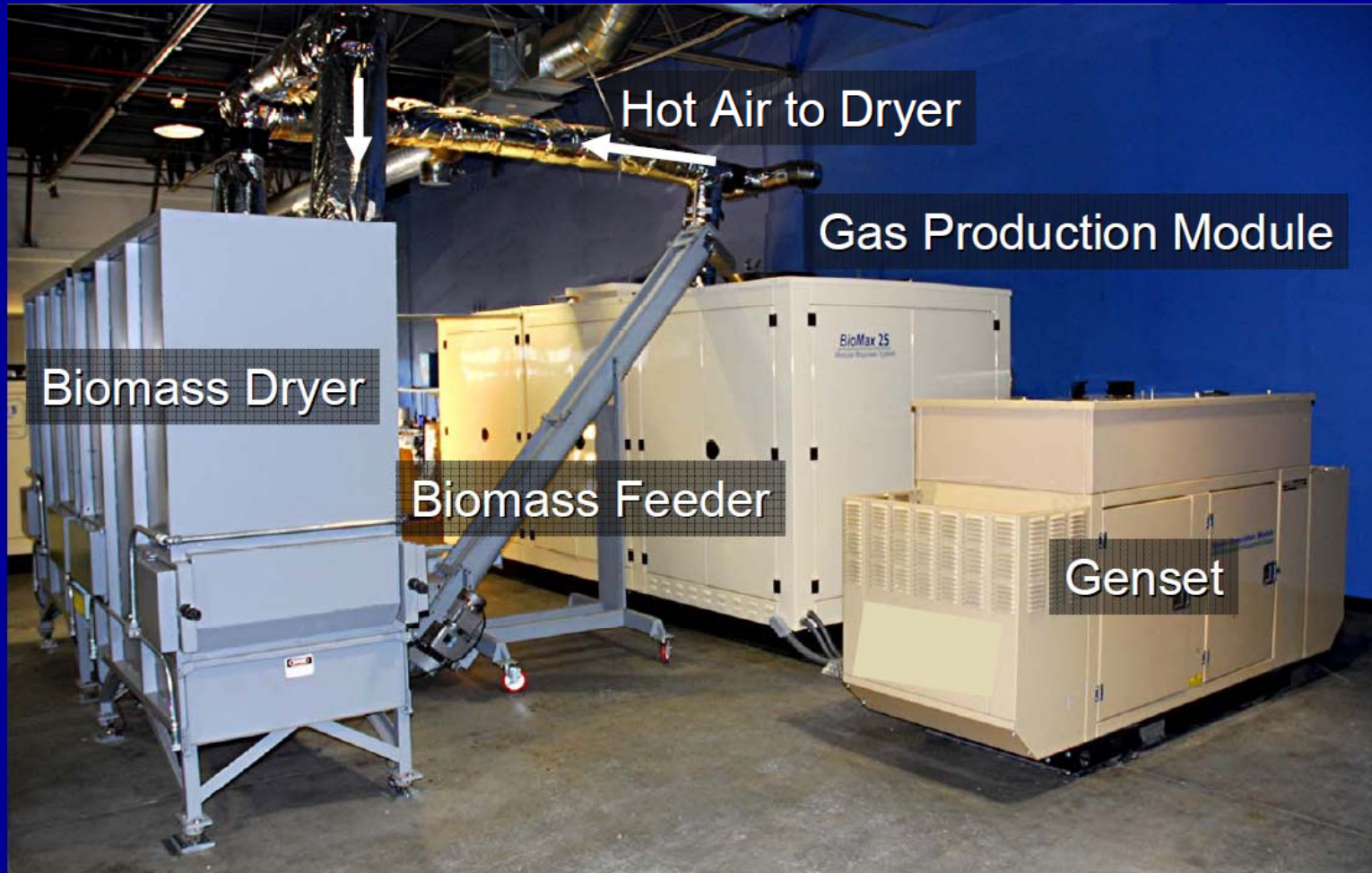
# CPC's Process Schematic



**70% of Biomass Energy = Chemical Fuel**  
**15% of Biomass Energy = Recoverable Heat, Gas Cooling**

# Community Power Corporation, Littleton, Colorado

## Today: BioMax™ – Modular Bioenergy Systems From 25 to 100 (kWe)



# Community Power Corporation, Littleton, Colorado

## CPC's BioMax Has Extensive Field Experience

### 18 BioMax Sites

- Walden, CO
- Reno, NV
- Madison, WI
- Starkville, MS
- Grand Forks, ND
- Mt. Wachusett, MA
- Miami, FL
- El Salvador (#1)
- El Salvador (#2)
- West Lafayette, IN
- Minneapolis, MN\*
- Winters, CA
- Auburn, AL
- Missoula, MT
- Alexander, LA
- Edmonton, Canada\*
- Detroit, MI\*
- US Army\*

\* Installation pending



### Prototype Tactical Biorefinery

Mobile encampment feeding waste to energy (gaseous fuels and ethanol)  
US Army/Baghdad

Contractors: Community Power Corporation, Purdue University, Defense Life Sciences  
May 2008

# University of California & West Biofuels: Thermochemical Conversion of Biomass to Mixed Alcohols

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Research Team: University of California (San Diego, Davis, and Berkeley), West Biofuels LLC.  
Location: Woodland Biomass Research Center, Woodland, CA 95776  
Contact: Professor Robert Cattolica, PI, UCSD, email: rjcat@ucsd.edu



- 5 ton/day dual-fluidized bed gasifier based on “Pyrox Process”
- Producer Gas – 500 BTUs/ft<sup>3</sup>
- Atmospheric Pressure
- Air blown combustor
- Auto-stabilizing: Bed Level Temperature
- Auto-regeneration of catalyst
- Minimizes replenishment of bed material and catalyst
- Extensive Testing on MSW in Japan (MITI) for power production  
3 units each 150 tons/day  
7 year demonstration  
1983 -1989
- Status: In Start-up

Source: University of California, San Diego

# Questions

