

Thermal Gasification of Biomass United States Update

IEA Bioenergy Task 33

First Semiannual Task Meeting 2014

Ischia, Italy, 13 May 2014

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The University of Utah

Biomass Gasification Research in U.S.

- Universities
 - Iowa State University
 - University of Utah
 - University of California
- National Laboratories
 - NREL (National Renewable Energy Laboratory)
 - INL (Idaho National Laboratory)
- Commercial Research Organisations
 - GTI (Chicago, IL)
 - RTI (Raleigh, NC)
 - SRI (Raleigh, NC)

U.S. Biomass Gasification Technology Providers

- Carbona
- Concord Blue
- Emery Energy
- InEnTec
- Sundrop Fuels
- TRI
- Others...

Update to U.S. Biomass Gasifier Database

- U.S. Dept. of Energy recognized that existing database of U.S. gasifiers was outdated and commissioned BCS Inc. to research and update gasifiers
- Update conducted by Zachary Peterson and Michael Bernstein during Fall 2013 and Spring 2014
- Considered EIA database, GTC/DOE database, plus conducted independent research and contacted plants
- EIA database includes 13 commercial plants
- 32 additional plants identified by BCS
 - 20 confirmed operational
 - 3 confirmed in planning / development
 - 9 still waiting for response from plant operator
- Updating continues

U.S. Gasifier Database Update

Utility Name	Utility ID	Plant Code	Plant Name	Street Address	City	County	Zip	State	Nameplate Capacity (MW)	Operating Year	Energy Source 1
Cox Waste-to-Energy	4413	54850	Cox Waste to Energy	1001 New Columbia Rd	Campbellsville	Taylor	42718	KY	4	1995	Wood/Wood Waste Solids
Cox Waste-to-Energy	4413	54850	Cox Waste to Energy	1001 New Columbia Rd	Campbellsville	Taylor	42718	KY	1	2002	Wood/Wood Waste Solids
Evergreen BioPower LLC	55968	56781	Evergreen BioPower LLC	141 14th St	Lyons	Linn	97358	OR	21	2007	Wood/Wood Waste Solids
Ingredion Inc - Winston Salem	4417	54618	Ingredion Winston Salem	4501 Overdale Road	Winston-Salem	Forsyth	27107	NC	7.5	1985	Wood/Wood Waste Solids
Ingredion Inc - Winston Salem	4417	54618	Ingredion Winston Salem	4501 Overdale Road	Winston-Salem	Forsyth	27107	NC	0.9	1993	Wood/Wood Waste Solids
Riceland Foods Inc.	15597	56079	Riceland Foods Cogeneration Plant	N. Park Ave & HWY 79	Stuttgart	Arkansas	72160	AR	18	1997	Other Biomass Solids
Seneca Sustainable Energy LLC	56776	57457	Seneca Sustainable Energy LLC	29650 E Enid Road	Eugene	Lane	97440	OR	19.8	2011	Wood/Wood Waste Solids
Gettysburg Energy and Nutrient Recovery Facility LLC	58527	58565	Gettysburg Energy & Nutrient Recovery Fa		York Springs	Adams		PA	3.3		Agricultural By-Products
INEOS New Planet BioEnergy	58595	58648	Indian River BioEnergy Center		Vero Beach	Indian River		FL	6.4		Other Biomass Gas
MeadWestvaco Corp	20508	50900	Covington Facility		Covington	Covington City		VA	82.4		Wood/Wood Waste Solids
TBE Montgomery LLC	56789	57472	TBE-Montgomery LLC		Montgomery	Orange		NY	9		Other Biomass Gas
TBE Montgomery LLC	56789	57472	TBE-Montgomery LLC		Montgomery	Orange		NY	12		Other Biomass Gas
Plainfield Renewable Energy, LLC	56067	56847	Plainfield Renewable Energy LLC		Plainfield	Windham		CT	43		Wood/Wood Waste Solids

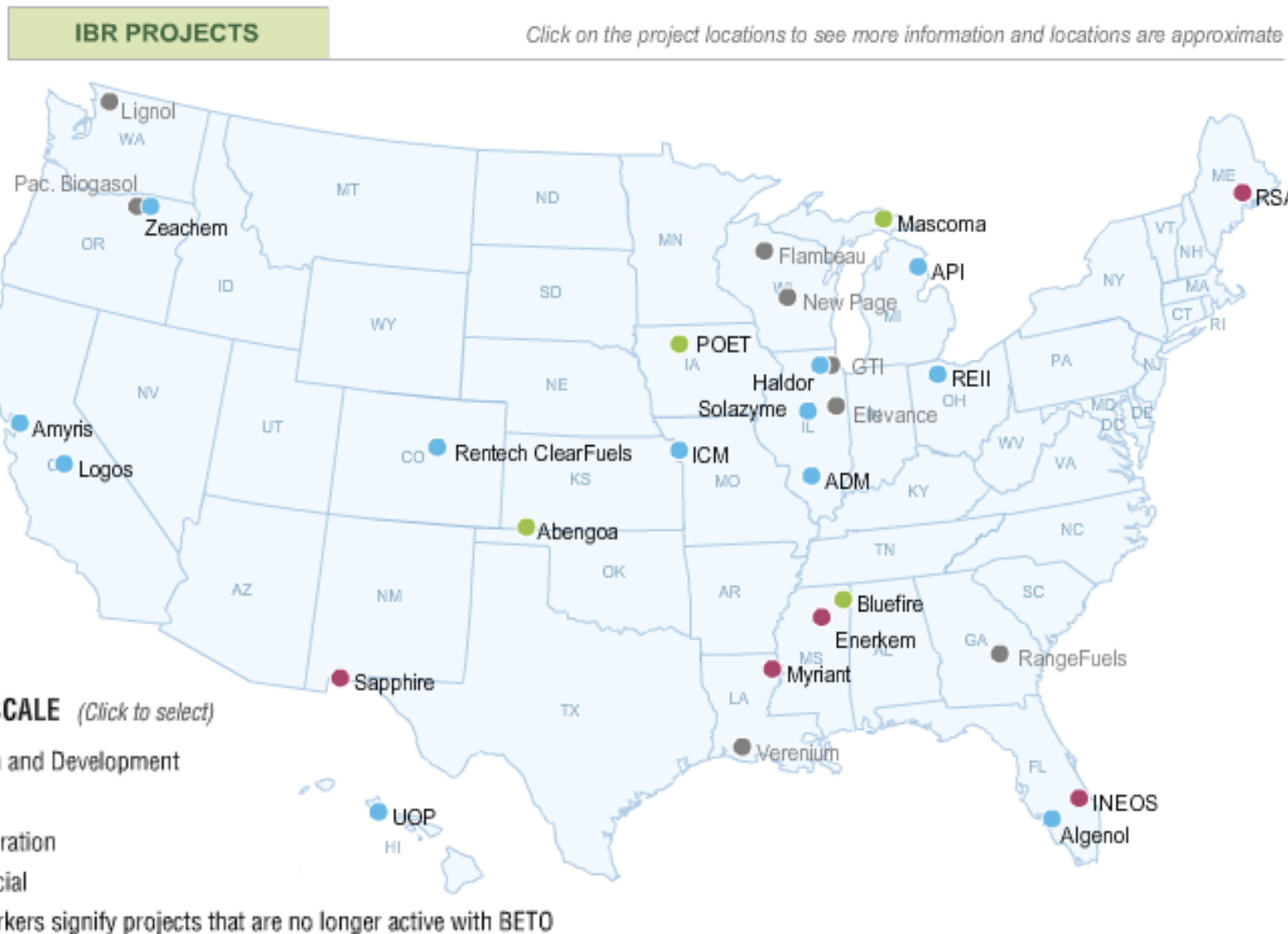
Organization	Gasifier Type	Scale		Status	Contact Information	Comments	Findings	Location	
		kg/hr	Tonnes/d						
Biomass Gas & Electric, LLC	biomass integrated gasification combined cycle			42000	Design	http://www.biggreenergy.com/	Port St. Joe, Florida - biomass fuel	Port St. Joe, Florida	
Catawba Co. - http://www.catawbacountync.gov/	Nexterra - fixed-bed updraft gasification system		44		Under development	Eco Complex - http://www.catawba.com/	*Planned for development	4017 Rocky Ford Rd, Newton, NC 28658	
Emergy Energy Co. (Radis/Bioenergy) http://www.emerenergy.com	Mixed UD/DD	10-1000			Const.	Benjamin D. Phillips, President Emergy Energy Company 157 West P	Coal based gasifier in salt lake city	Salt Lake City, UT	
Gas Technology Institute	fluidized bed biomass gasified			5000	Pilot	GTI Headquarters 1700 S Mount	GTI does currently operate and	51 Wille Road Des Plaines IL 60018	
HTI - Heat Transfer International	UD				?	http://www.heatfer.com/prod	4720 44th Street SE, Kentwood, M	*waiting on follow up (email)	Kentwood, MI
ICM Inc.	Air-blown Auger	136 - 181			Demo	http://www.icminc.com/services	Have gasified over 6,800 tons var	*waiting on follow up (email)	Newton, KS
InEnTec Chemical Midland, LLC			25		2000	OP	InEnTec Inc. 1935 Butler Loop Richland, WA 99354 (509) 946-5700	http://www.inentec.com/pem-fa	8901 S Saginaw Rd, Midland, MI 48640
InEnTec Columbia Ridge LLC						OP	Poble Perez Engineering & Technical Business Development 1935 B	http://www.inentec.com/pem-fa	18177 Cedar Springs Ln, Arlington, OR 97812
Iowa Energy Center	fluidized-bed biomass gasifier			800	pilot	Song-Chang Kong Associate Professor Department of Mechanical	Technology: CHP Raw material:	1521 West F. Ave. Nevada, IA 50201	
Iowa State University	fluidized-bed biomass gasifier			90	Pilot	Song-Chang Kong Associate Professor Department of Mechanical	This fluidized-bed biomass gasifi	Biocentury Research Farm, 1327 U Avenue, Boone, Iowa, IA 50036	
LifeLine Foods	process steam boiler	150			OP	Ron Bailey Sr. rbaileys@primenergy.com 501 276 2101 http://www	LifeLine Foods of St. Joseph, Miss	St. Joseph, Missouri	
Oak Ridge Biomass Gasifier	Nexterra - fixed bed updraft gasification system	120			OP	Nexterra - inquiries@nexterra.co nexterra website - http://www.n	In 2008, JC and ORNL selected N	Oak Ridge, TN	
PHG Energy	Downdraft Gasification	64			OP	phone: 615-471-9299 Mailing Address: PHG Energy 3048 Owen Drive	Nashville, Tennessee 37213 Em	Greenwood, MS	
Phoenix Energy	DD			500	OP		Plant in Merced, CA; pix looks lik	*waiting on follow up (email)	Merced, CA
Primenergy, LLC www.primenergy.com	Mod-UD	27.3			OP	Kevin McGuigg Vice President P	modified updraft with multiple a	*waiting on follow up (email)	Tulsa, OK
Producers Rice Mill, Inc.	Process heat for drying parboiled rice			75000	OP	Ron Bailey Sr. rbaileys@primenergy.com 501 276 2101 http://www	Producers Rice Mill, Inc. has two	Stuttgart, Arkansas	
Producers Rice Mill, Inc.	Process heat for drying parboiled rice			75001	OP	Ron Bailey Sr. rbaileys@primenergy.com 501 276 2101 http://www	Producers Rice Mill, Inc. has two	Stuttgart, Arkansas	
Riceland Foods, Inc.	Steam for rice parboiling, heat for parboiled rice drying			17000	OP	Mailing Address Riceland Foods Consumer Sales P.O. Box 927 Stutt	Riceland Foods has a PRIME Mod	Jonesboro, Arkansas	
Simken, Inc.	Pyrolysis Recovery Oven	75			test and demonstra	Jim Siparelle 5400 Orange Ave. S	Pyrolysis process. http://simken	*waiting on follow up (email)	Bakersfield, CA
Sundrop Fuels	Solar Heated			1000	Pilot	Sundrop Fuels, Inc 1722 Bowelder Street, Suite 101 Louisville, Color	* Under construction planned to	Broomfield, CO	
Thermo Technologies LLC also SynGasCo & Wiley Consulting	IND	250 TPD			OP	Marcus A. Wiley P.O.Box 4027, E	2 stage indirect gasification; mov	*waiting on follow up (email)	Toledo, OH
Thermochem	IND	1,800-18,900 dry solids			OP	Lee Rockvann Thermochem (MTC)	Steam & chemical extraction Low	*waiting on follow up (email)	New Bern, NC
Thermogenics www.thermogenics.com	Synthesis			100	Demo	Leland T. "Tom" Taylor, President	Air fired non-up or downdraft res	Fuel - Wood, treated, untreated,	511 avenue G Lubbock Texas 79401
University of Utah	pressurized fluidized bed gasifier	32				870 South 500 West Salt Lake Cit	Specifications: Max. throughput: 32 kg/hr [70 lb/hr] Max. temperat	870 South 500 West Salt Lake City, Utah	
University of South Carolina	Nexterra - fixed bed updraft gasification system		22		Unconfirmed	Nexterra - http://www.nexterra.		*waiting on follow up (email)	University of South Carolina - 1220 Cswaba St Columbia, SC 29208
West Biofuels	indirect		6		pilot	Woodland Biomass Research Cen	variation on Kunii gasifier	*waiting on follow up (email)	Woodlands, California
Westinghouse Plasma Center	Plasma		48		OP - test and demon	http://www.westinghouse-plasm	Demonstration facility located ne	*not strictly biomass.	Madison, PA
Enerkem					Under development	1130 Sherbrooke Street West Su	*Planned for development	Type: Commercial Status: Under	Pontotoc, MS
Haider Topsoe, Inc.						Haider Topsoe, Inc. 17629 El Camino Real Houston, TX 77058, USA	Company: Haider Topsoe Inc. De	Des Plaines, Illinois	
Renewable Energy Institute International						Renewable Energy Institute International 5022 Bailey Loop McCle	Company: Renewable Energy Inst	Toledo, Ohio	
Rentech ClearFuels Technology					*inactive	info@rentk.com http://www.ren	Company: Rentech ClearFuels Te	Commerce City, Colorado	
ZeaChem Inc.						ZeaChem Inc. Biorefinery http://www.zeachem.com/contact/infor	Company: ZeaChem Inc. Detailed	71099 Rail Loop Drive Boardman, OR 97818	

Operational
 Planned for development or under construction
 Status Unconfirmed/Unverified

U.S. Integrated Biorefinery Projects

U.S. Dept. of Energy Interactive Map

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



INEOS Indian River Bioenergy Center

INEOS Bio, Vero Beach, Florida

- Feedstock: Vegetable and yard waste, MSW
- Products: Ethanol and power
- Scale: 300 tons feed/day
- Gasification technology: Proprietary oxygen-blown
- Cost: More than \$130 million
- Status: First biofuel production July 2013
- Update Dec 2013: “Bringing the facility on-line and up to capacity has taken longer than planned due to several unexpected start-up issues at the Center. These efforts have highlighted some needed modifications and upgrades.”



GTI / Haldor Topsoe Pilot Plant

Chicago, Illinois

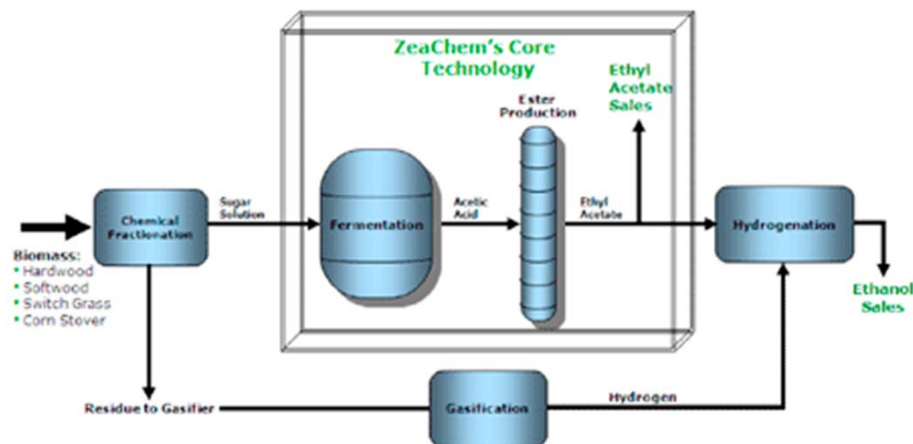
- Feedstock: Wood chips
- Products: Gasoline
- Scale: 20 tons/day feed; 20 bbl/day gasoline
- Gasification technology: Carbona
- Cost: unknown
- Status: First gasoline production June 2013



Zeachem Pilot Plant

Boardman, Oregon

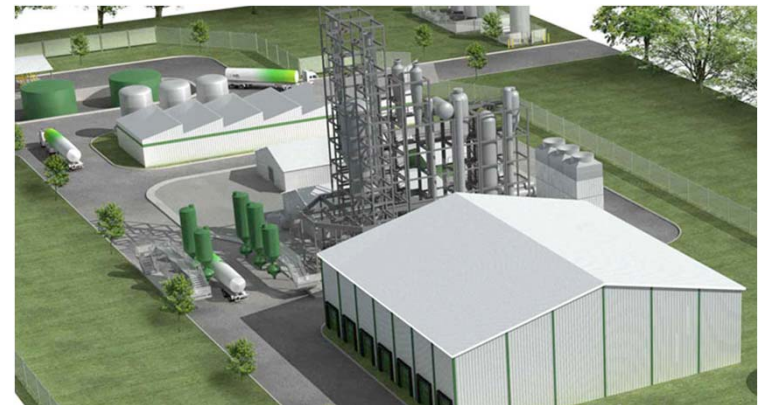
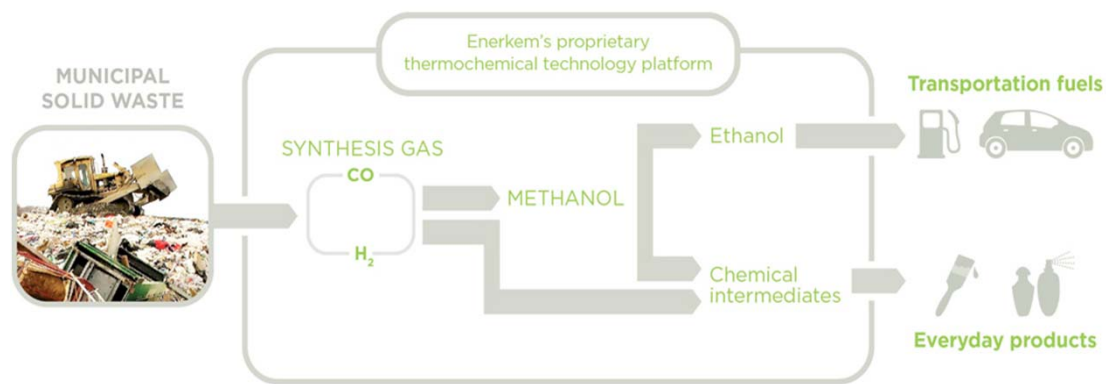
- Feedstock: Poplar + others
- Products: Ethanol + intermediate chemicals
- Scale: 10 tons/day feed; 250,000 gal/yr ethanol
- Gasification technology: Proprietary; gasifies only lignin
- Cost: unknown
- Status: First ethanol production March 2013
- Status May 2014: Continued operation



Enerkem Pilot Plant

Ponotoc, Mississippi

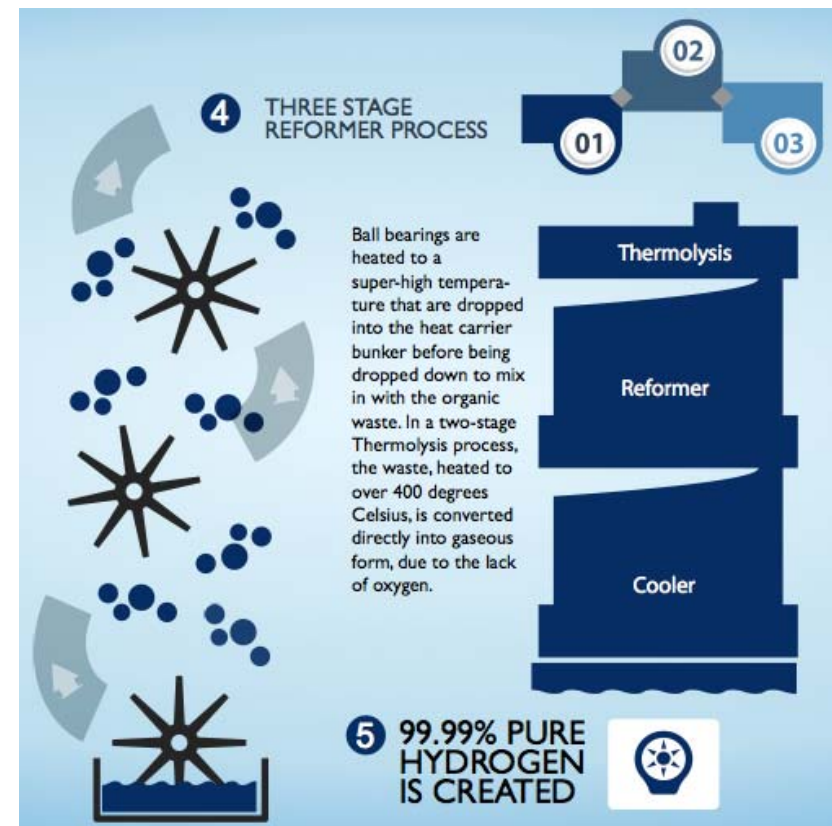
- Feedstock: MSW and wood residues
- Products: Ethanol and methanol
- Scale: 300 tons/day feed; 10 million gallons/year
- Gasification technology: Enerkem proprietary
- Cost: unknown
- Status: Under development
- Update May 2014: Still under development... Construction not yet started



Freedom Pines Biorefinery

Soperton, Georgia

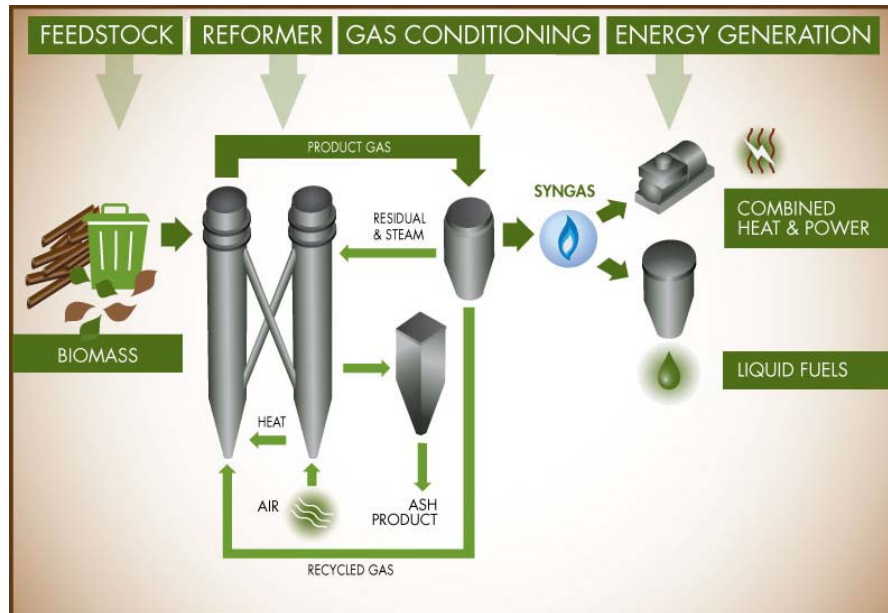
- Targeting biofuel production through LanzaTech's syngas fermentation technology
- Host site is old Range Fuels site in Soperton, Georgia. Acquired for Freedom Pines Biorefinery in January 2012
- Concord Blue chosen as gasification technology provider
- Rebuilding for new configuration still ongoing



West Biofuels

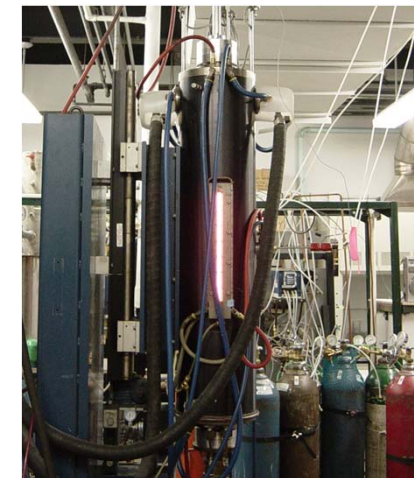
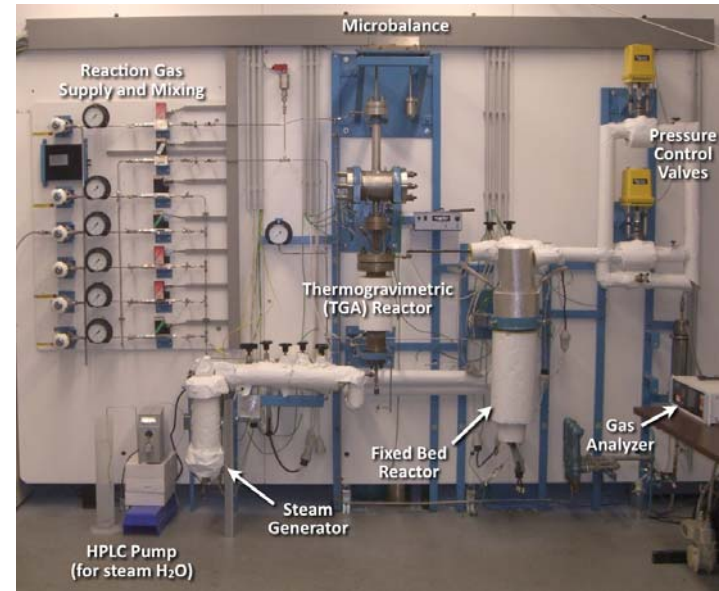
Woodlands, California

- Feedstock: Unspecified biomass
- 6 ton/day pilot
- Repotec dual bed gasifier
- Targeting electricity production

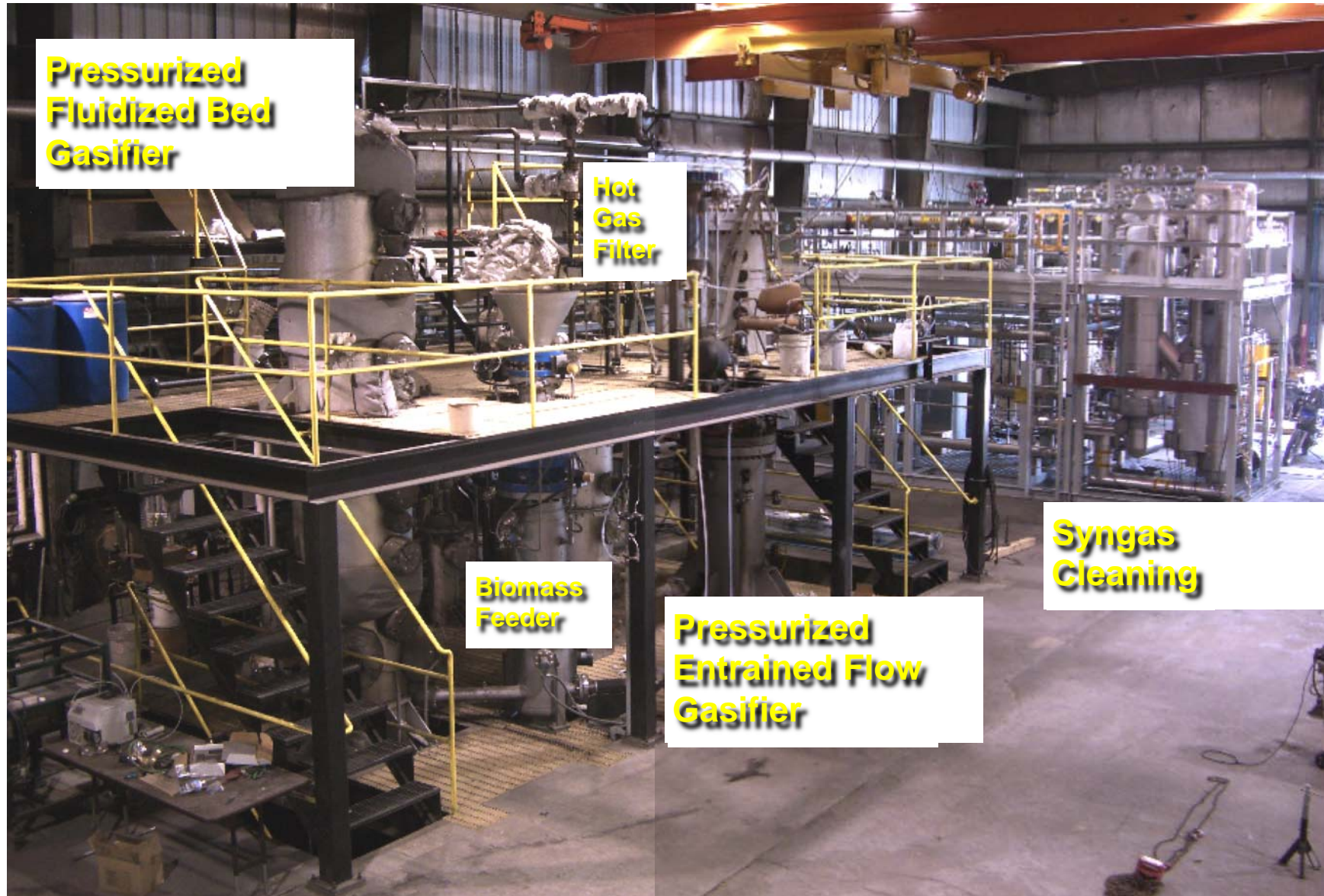


Research at the University of Utah

- Lab-scale characterization
 - High pressure TGAs (2)
 - High pressure wire-mesh heater
 - High temperature drop tube / LEFR reactors
- Lab-scale reactors
 - Indirectly heated 10 kW steam fluidized biomass gasifier
 - New 10 kW dual bed system
- Semi-pilot / PDU-scale systems
 - 200 kW_{th} pressurized bubbling fluidized bed gasifier
 - 500 kW_{th} pressurized O₂-blown entrained-flow gasifier



Gasification Research Laboratory



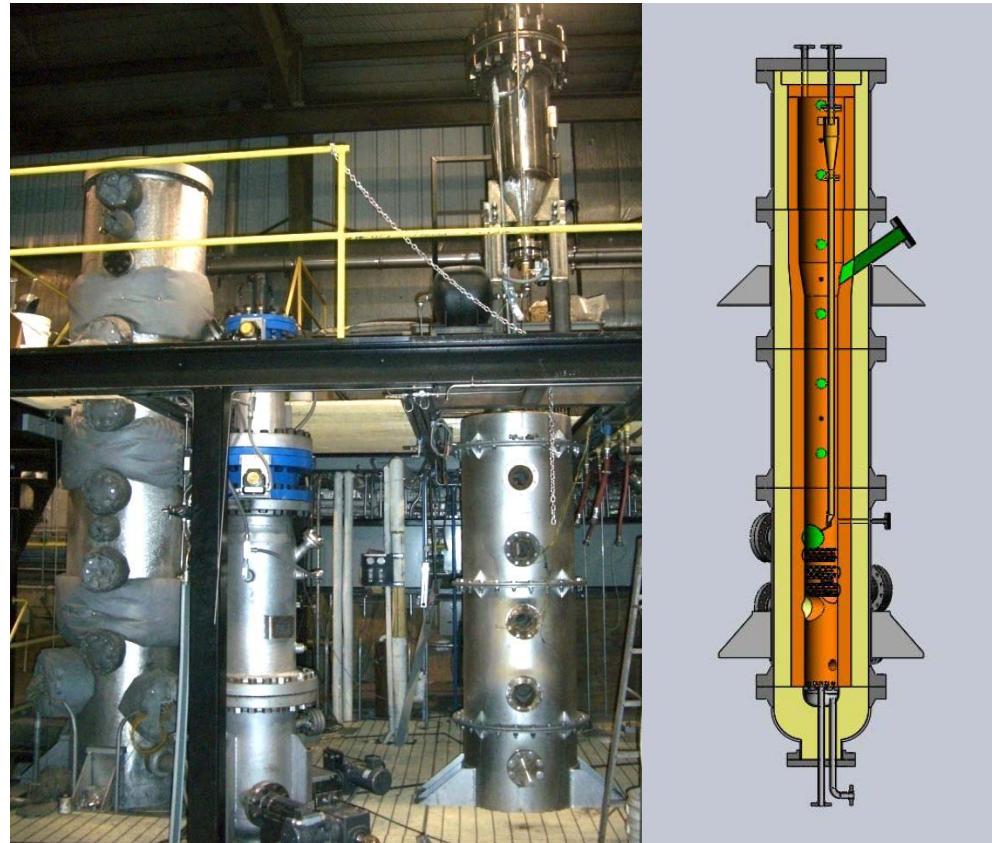
Pressurized Fluidized Bed Gasifier

Gasifier

- Steam, air or O₂-blown
- Bubbling bed system
- Max 35 kg/hr biomass
- Max temp: 860° C
- Max pressure: 20 atm
- 80 in-bed heaters
- 32 kW power input

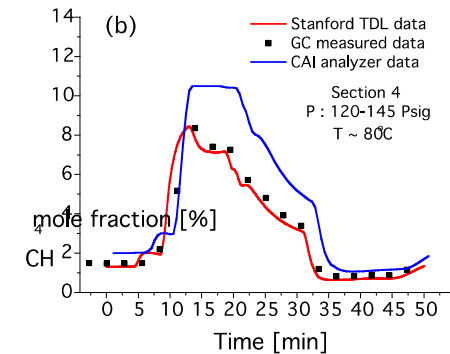
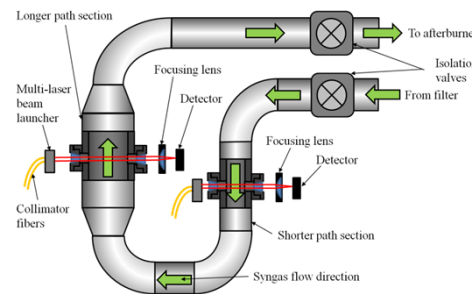
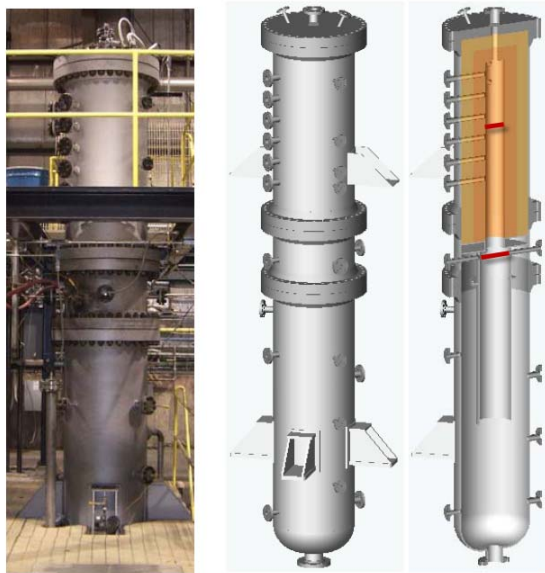
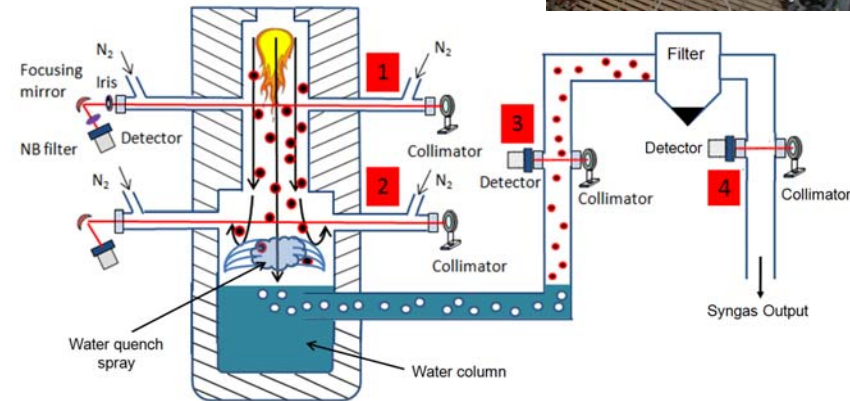
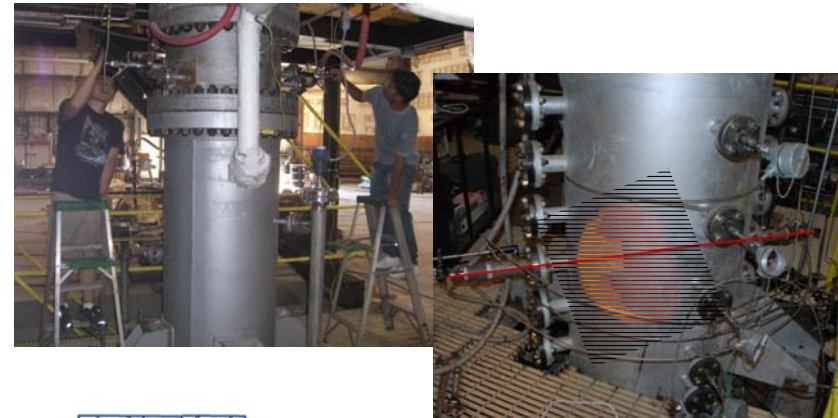
Gas Handling

- Internal cyclone
- Hot particulate filter
- Pressure control valve
- Thermal oxidizer

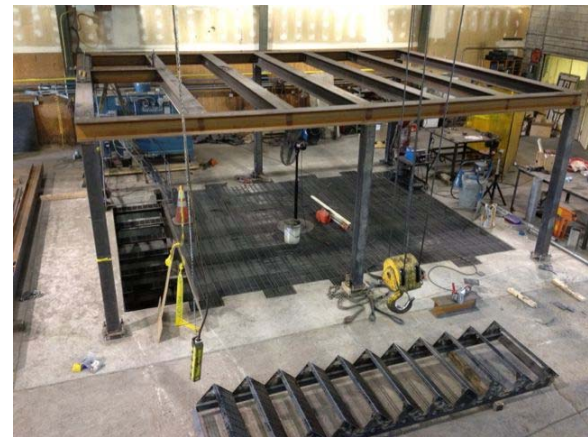
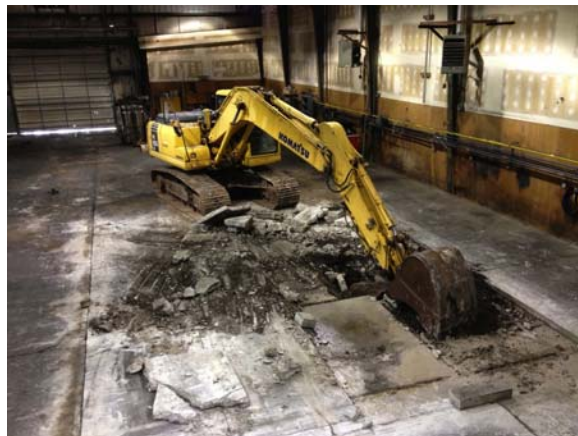
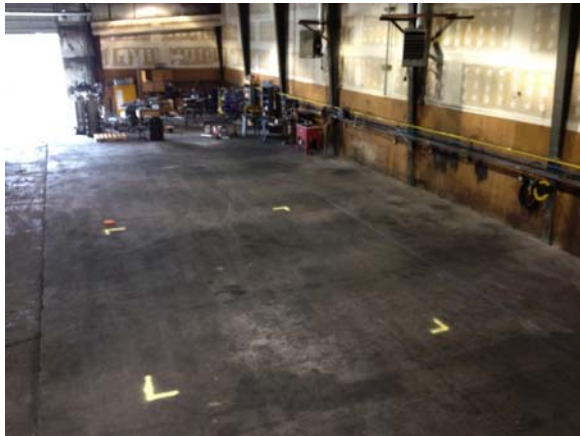


Pressurized O₂-blown Entrained-Flow Gasifier

- Max 1.5 ton/day (~500 kW)
- 30 atm max pressure
- Fuels processed
 - Coal slurry
 - Petcoke slurry
 - Petroleum liquids
 - Some bio-liquids
- Laser-based monitoring



Chemical Looping / Dual Bed Gasifier System



Chemical Looping / Dual Bed Gasifier System

