Converting Wood Chips to Electricity: Demo/Research Project on the Kisatchie

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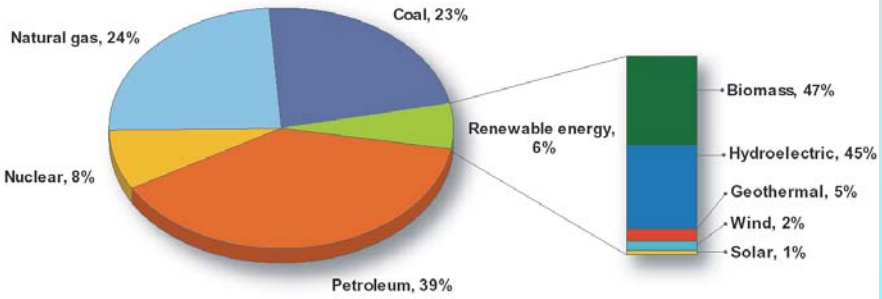
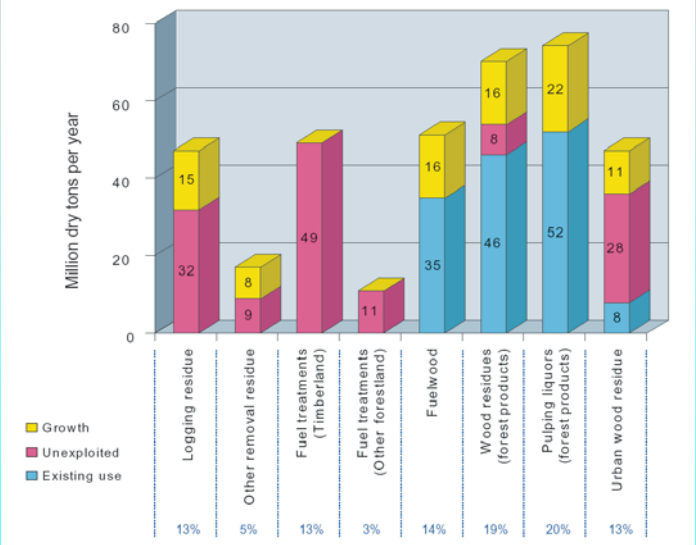
"Where are you guys located???"

From the Billion-Ton Report



Biomass Consumption	Million dry tons/year
Forest products industry	
Wood residues	44
Pulping liquors	52
Urban wood and food & other process residues	35
Fuelwood (residential/commercial & electric utilities)	35
Biofuels	18
Bioproducts	6
Total	**190**

From the Billion-Ton Report

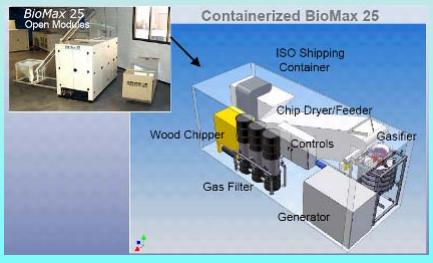


Current Activities

- USDA-FS has been instrumental in the development of an integrated unit for
  - Gasification
  - Combustion
  - Electricity generation
  - Community Power Corporation-Littleton, Colorado

Current Activities

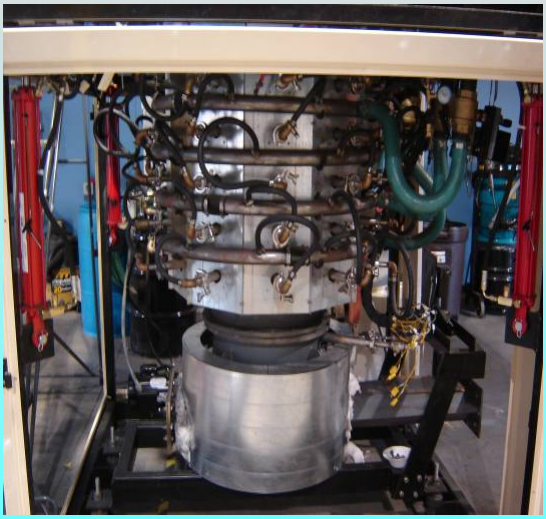
- The Forest Service has acquire a BioMax25
- Wood chips in → Electricity out ←
- This will be used for:
  - Electricity for Winn Ranger District
  - Demo
  - Research



Gasification: "BioMax25"

Gasification: Heart of the Beast

- Gasification Chamber
- Varying levels of oxygen
- Wood chips in →
  - 2 lbs/1 kWhe
  - 400 lbs/day
- Electricity out ←
  - 25 KWh (standard)

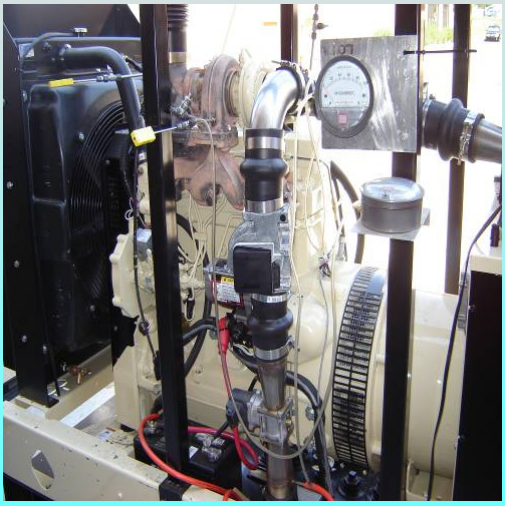


Gasification: Cleaning the Gas

- Combustibles
  - CO (20%)
  - Hydrogen (18%)
  - Methane (2%)
- Non-Combust.
  - H_2O
  - CO_2
  - N_2
- → Scubbers
  - Gas to Engine
  - Ash (0.5 – 8%)

Gasification: Converting to E

- Diesel Engine modified to run on combustible gases
- Turns turbine that generates 25 kW
- Can be throttled down to operate below 25 kW



The Beauty of It All

- "A monkey can run this thing"
- Can be monitored via the internet
- Can be ***controlled*** via the internet
- Wood chips can not be loaded via the internet

Current Activities

- Functional Energy
  - Unit will be installed at the Winn Ranger District (primary power source)
  - Fully portable, so may be transported as needed for emergency power.
- Research
  - Operating conditions will be optimized for feedstocks available in the vicinity of the KNF
    - Hurricane debris
    - Logging debris
    - Fuel load reduction work
  - Unit is instrumented to provide information on gas yield and composition as a function of time

Feedstock Type

- There has been a tendency to treat “biomass” as a uniform substrate that is fed into a conversion process
- Does composition matter?
- If so, what are the important parameters?
  - Density?
  - Carbon, hydrogen, oxygen composition?
  - Cellulose to lignin ratio? (higher lignin levels might be a positive attribute)

City of Alexandria – “Green Waste”

Longleaf Pine Thinnings – Fire/Insects

Kisatchie NF – Fire/RCW/Wildlife/WUI

Hurricane Katrina – Salvage Utilization

Biomass Characterization

			Percentages (Oven-Dry Weight (g))						
ID	Name	MC (%)	Clear wood	Bark	Leaves	Twigs	Pinecones	Needles	Misc.
0	City of Alexandria Utility	49	63	10	4	21	0	1	1
1	Lob Broke Top	35	56	11		14	2	17	
2	Lob Broke Middle	52	95	5				0	
3	Lob Broke Bottom	44	97	3				0	
4	Green Lob Top	125	65	13		10	1	11	
5	Green Lob Middle	97	94	6				0	
6	Green Lob Bottom	76	94	6				0	
7	Longleaf Broke Top	57	61	23		1		15	
8	Longleaf Broke Middle	45	95	5				0	
9	Longleaf Broke Bottom	62	96	4				0	0
10	Longleaf Green Top	115	69	21		1	0	8	
11	Longleaf Green Middle	82	95	5				0	
12	Longleaf Green Bottom	67	94	6					
13	Lob Broke Sample at Break	28	95	5				0	
14	Green Lob Break Height	78	93	7				0	
15	Longleaf Broke 35 ft. Break	30	96	4				0	0
16	Sample Longleaf Green	75	95	5				0	
17	Rummer	69	95	4	0	1		0	0
18	3/10/06 Weyerhaeuser	88	36	9	0	53		1	1
19	3/10/06 Red Oak (borer-damaged)	8	100						
20	Kisatchie - Longleaf thinnings								
21	Kisatchie - Understory removals								

Effect of Raw Material

(From the Biomass to Liquid Fuels EU Report)

	Bituminous Coal	Natural gas	Wood[9]	Bark	Willow	Forest residues[10]	Wood chips	Wood pellets	Cereal straw	Dedicated energy crops
Ash, d%	8.5-10.9	0	0.4-0.5	3.5-8	1.1-4.0	1-3	0.8-1.4	0.4-1.5	3-10	6.2-7.5
Moisture, w%	5-10	0	5-60	45-65	50-60	50-60	20-50	7-12	14-25	15-20
NCV, MJ/kg	26-28.3	48	18.5-20	18.0-23	18.4-19.2	18.5-20	19.2-19.4	16.2-19	16.5-17.4	17.1-17.5
Density, kg/m3	1100-1500	n.a.[11]	390-640	320	120[12]	n.a.[13]	250-350, 320-450[14]	500-780	100-170[15]	200[9]
Volatile matter, w%	25-40	100	>70	69.6-77.2	>70	>70	76-86	>70	70-81	>70
Ash melting point, T?C	1100-1400	-	1400-1700	1300-1700	n.a.	n.a.[16]	1000-1400	>1120	700-1000	700-1200
C, d%	76-87	75	48-52	48-52	47-51	48-52	47-52	48-52	45-48	45.5-46.1
H, d%	3.5-5	24	6.2-6.4	4.6-6.8	5.8-6.7	6.0-6.2	6.1-6.3	6.0-6.4	5.0-6.0	5.7-5.8
N, d%	0.8-1.5	0.9	0.1-0.5	0.3-0.8	0.2-0.8	0.3-0.5	<0.3	0.27-0.9	0.4-0.6	0.50-1.0
O, d%	2.8-11.3	0.9	38-42	24.3-42.4	40-46	40-44	38-45	?40	36-48	41-44
S, d%	0.5-3.1	0	<0.05	<0.05	0.02-0.10	<0.05	<0.05	0.04-0.08	0.05-0.2	0.08-0.13
Cl, d%	<0.1	-	0.01-0.03	0.01-0.03	0.02-0.05	0.01-0.04	0.02	0.02-0.04	0.14-0.97	0.09
K, d%	0.003	-	0.02-0.05	0.1-0.4	0.2-0.5	0.1-0.4	?0.02	n.a.	0.69-1.3	0.3-0.5
Ca, d%	4-12	-	0.1-1.5	0.02-0.08	0.2-0.7	0.2-0.9	?0.04	n.a.	0.1-0.6	9

Sources: Adapted from [29, 30, 42, 59, 120, 131, 148, 170, 200, 201, 209, 218, 249, 266, 272, 273, 304]

Effect of Gasification Method

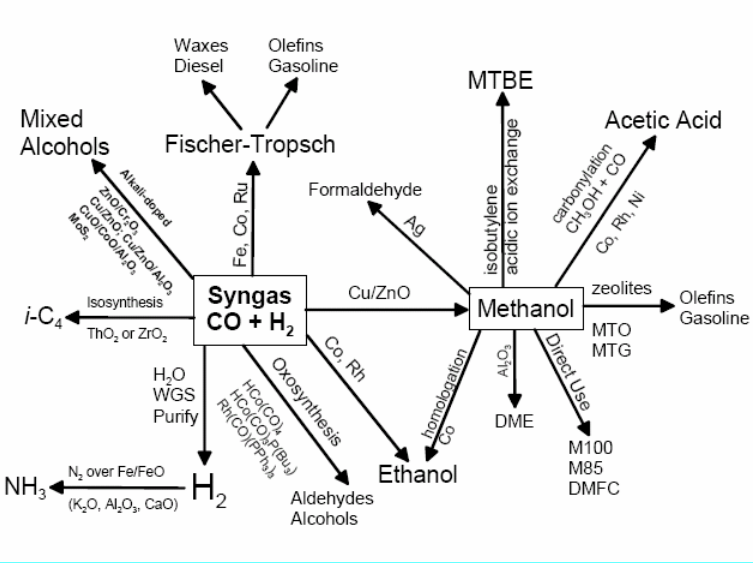
(From the Biomass to Liquid Fuels EU Report)

	A-CFB-air	A-CFB-O_2	P(N_2)-CFB-O_2	P(CO_2)-CFB-O_2	A-indirect-H_2O	P-EFG-O_2
CO, vol.% dry	**19.3**	**26.9**	**16.1**	**16.1**	**42.5**	**46.1**
H_2, vol.% dry	**15.6**	**33.1**	**18.3**	**18.3**	**23.1**	**26.6**
CO_2, vol.% dry	15.0	29.9	35.4	46.9	12.3	26.9
CH_4, vol.% dry	4.2	7.0	13.5	13.5	16.6	0.00
N_2/Ar, vol.% dry	44.5	0.7	12.3	0.8	0.0	0.4
C_2, vol.% dry	1.4	2.4	4.4	4.4	5.5	0.0
NCV, (MJ/m^3)	5.76	8.85	8.44	8.05	13.64	7.43
H_2/CO ratio	0.81	1.23	1.14	1.14	0.54	0.58

Typical Gas, Contaminant Yields

	Hybrid Poplar	Switchgrass	Mixed Woods
H2, vol %	33.99	24.31	31.82
CO	36.67	39.47	31.59
CO2	17.91	14.97	17.96
CH4	12.56	13.77	11.73
C2H4	4.41	5.86	4.50
Benzene	1.35	0.96	1.06
Toluene	0.31	0.20	0.24
H2/CO	0.93	0.62	1.01
H2S, ppmv	64-72	323-396	36-63
Ammonia, ppmv	290 max	760 max	339-369
Cl^- cond, ppm-m/v	0	486 max	4 max
K^+ cond, ppm-m/v	10 max	208 max	7 max
Tot org. C cond ppm-m/v	2060 max	2320 max	2480 max
Cyanide, ppm-m/v	37	1442-1472	ND

“I’m not a chemist… but I did stay at a Holiday Inn Express last night”



Conversion to LT Fuels

- Developing a FT Reactor Module [based on 400#]
  - Syn-Diesel (20 gal./day)
  - Waxes (20 gal./day)
  - Ethanol (50 gal./day)
- Field Demonstration in 2007

Future Activities

- Raw material characterization
  - Physical (moisture, bark, residuals)
  - Chemical (C/H/O, ash)
  - Thermal (BTU's)
- Gasification potential of:
  - Large volume throughput via BioMax25
  - Benchtop analyses via NC State/UT/NREL
- Demonstration projects with S&PF
  - Protocols for SPB control
  - Use for thinnings, low-value, "dirty" chips