Biomass Day at ACERC
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Costs

Description	Btu/kWh	$/MMBtu	$/kWe	$/MWh
Biomass:				
stoker, normal efficiency	17,000	2.00	2000	108
stoker, good efficiency	14,000	2.00	2000	102
$1.50 / MMBtu fuel	14,000	1.50	2000	95
heat rate 11,000	11,000	1.50	2000	90.5
$1400 / kW (lower cost)	11,000	1.50	1400	71.3
advanced (adv.) biomass	9000	1.50	1400	68.3
adv., at $1100 / kW	9000	1.50	1100	58.7
“ at $800 / kW	9000	1.50	800	49.1
Fossil:				
new coal-fired plant	9000	1.25	700	43.7
new natural gas CC	6500	4.00	400	43.8

Technologies

- Direct 100% combustion of clean wastes
- Cofiring with coal
- Advanced direct combustion: Whole Tree Energy, slagging combustor, FBC, etc.
- Engines running on biogas
- Gasification: low-pressure IGCC, high pressure IGCC, non-GT approaches (no biomass-gas through gas turbine)
- Biological, fuel-oriented, and other

Key Terminology

- HHV = higher heating value = 16 MMBtu/dt
- dt = dry ton (short ton) [so HHV = 8000 Btu/lb]
- DAF = dry and ash-free
- HHV (if DAF) = 8500 Btu/lb = 17 MMBtu/dt
- Therefore, above assumes ash content dry basis is about 6% (1/17)
- Efficient technology may be ~10,000 Btu/kWh
- Above 10 MMBtu/MWh is 34% eff. (HHV)

History of R&D

- “Earth, air, fire and water” = original R&D
- Pile burners (“teepee” or “wigwam”)
- Modern grates and stokers (still improving)
- Fluidized bed combustion (FBC)
- Advanced steam cycle for direct combustion
- Slagging combustion
- Gasification
- And, engines too

History of R&D (continued)

- Use coal R&D results and fuel properties/consequences (even though “biomass is not coal”)
- Combustion of biogas (biological methane / CO2 etc.) in engines is not coal-based

Successes, Failures, Lessons

- Far beyond the “fire” stage - time, temper-ature and turbulence, plus the right air and attention to moisture, ash, fuel size/shape/etc. ➔ good, clean combustion
- Combustion easier and less expensive than gasification, but less clean / efficient
- Apply coal technology, but remember it is biomass (moisture, alkali, reactivity, density)
- Pay attention to fuel / fuel-handling

One lesson is . . .

. . . many a combustion (or gasification) problem is best solved by paying attention to the fuel input.

Another is . . .

. . . follow the trucks. [or, “Pay attention to transportation.”]

Fuel source and cost and transport is critical to project [and energy policy] success.

Efficiencies and what levels can be expected

- MSW (mass burn and “RDF” or refuse-derived fuel made from MSW) - 20,000 Btu per kWh or 17% efficient (HHV)
- Much of the existing biomass power technology is 17,000 Btu/kWh - 20%
- Best and largest stoker/boiler: 13,000 – 26%
- Cofiring in 10,000 Btu/kWh coal boiler is about 15% less eff.: 11,500 – 30%
- Gasification goal 8500-9000 – 38-40%

Efficiencies and what levels can be expected (continued)

- Do not forget direct combustion by “ad-vanced” technology in steam boilers with higher temperature and pressure steam - 10,000 Btu/kWh - 34 %
- Gasification with fuel cell technology goal could be 7000 Btu/kWh - 49%
- Engines: 11,000 Btu/kWh - 31%
- Gas turbines in small sizes (landfill gas at about 1 MWe, say): 12,000 Btu/kWh – 28%

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Ash Management Components

Item	Wheat Straw	Rice Straw	Waste-wood 1	Waste-wood 2	Shawville Sawdust
Ash (% dry)	8%	20%	11%	6%	0.7%
Ca (% of dry ash)	2.3%	2.0%	?	?	26.8%
Mg (% of dry ash)	3.3%	2.1%	?	?	3.0%
Na (% of dry ash)	1.7%	0.8%	0.1%	0.2%	0.8%
K (% of dry ash)	21.0%	8.1%	4.0%	2.8%	14.7%
(Na+K) / MMBtu	2.40	2.85	0.60	0.21	0.12