Technical and Economic Evaluation of a 70 MWe Biomass IGCC Using Emery Energy’s Gasification Technology

Gasification Technologies Conference

October 15, 2003
San Francisco, CA
By: Benjamin D. Phillips, President
Project Participants

- INEEL
- Combustion Resources, LLC
- Emery Energy Company
- Saint-Gobain Ceramics
- GE
- Biomass Energy
- SPSA
Discussion Summary

- Brief Background of Emery Technology
- Project Approach / Setting
- Project Activities & Results
- Biomass Project Conclusions
- Current Development Activities at Emery
Technology Background

- 25-ton/day pilot plant in central Utah.
- Fixed bed, Atmospheric, Air-blown
- Unique process characteristics identified at pilot plant
  - extremely low tar and oil carryover for fixed bed gasifiers
  - control of sulfur species in the syngas
- Accumulated over 2100 hours of operational testing
Emery’s 25-tpd Pilot Plant
DOE Solicitation Goals

- Biomass: Ag Residues, Animal Waste, MSW
- Minimum 35% eff. for plants under 100 MW_e
- Potential to improve to 45% efficiency
- Potential for co-production of steam, heat and/or other products
- Benign Solid Wastes
- Biomass Fuel Flexibility
- Emissions ½ of NSPS for coal-fired electric power generation
- COE to be competitive in specific circumstances
- Potential for a large number of regional and/or National commercial installations
Purpose of the Work

• To evaluate the technical and economic use of the Emery Gasification technology for Biomass Power Applications

• To perform preliminary design and engineering work to enable ASPEN modeling and equipment cost estimating

• To determine the technology’s potential to meet the efficiency targets set forth by U.S. DOE

• To determine Capital Costs and COE
Emery Gasifier Configuration

- Prior work led to new design
- Innovative gasifier combines Fixed-bed with Entrained-flow processes
- Novel processes to control gaseous phase pollutants reducing the costs and/or mitigating traditional syngas clean-up
- Non-Slagging ash removal to extend refractory life
Anticipated Gasifier Benefits

- Internal destruction of tars preventing need for downstream tar cracker
- Ability to recover high temp. steam from syngas cooling, improving efficiency
- Greater fuel flexibility (coarse & pulverized fuels)
- Non-slagging version reduces wear on refractory
- Potential for syngas product flexibility with broader H₂:CO control
Refuse Derived Fuel (base case)
~70 MWe (as per GE Comb. Cycle)
2 Gasifier trains with additional spare (50% spare capacity)
Oxygen-blown, pressurized, non-slagging gasifiers
Annual availability of >90%
Setting: Portsmouth, VA
Simplified Block Diagram

Air
Project Organization / Activities

1. Combustion Resources
   Gasifier Mod.

2. Gasifier Des.
   Plant Design

3. Idaho National E&E Laboratory
   Aspen Plus Mod.

4. GE Power Systems
   CC Power Plant

5. Technology Development
   Roadmap

6. Southeastern Public Service Au.
   RDF Cost Info

7. Biomass Energy Foundation
   Ag. Cost Info

8. EMERY
   Economic Analyses

PROJECT CONCLUSIONS
Gasifier Modeling - CR

Finite Difference 1-Dim. Model used to:

1) Investigate the characteristics of flow field
2) Models gas phase and heterogeneous reactions
3) Model devolitalization kinetics for biomass fuels
4) Validate composition of synthetic fuel
Preliminary engineering design of entire IGCC facility
- Fuel Handling / Drying / Densification
- Gasification
- Gas Cooling / Cleaning
- PFD’s / P&ID’s
- ASU Design (by Vendor)
- CC Power Plant Design (by Vendor)
Plant Layout 3D Model
ASPEN Modeling - INEEL

- ASPEN Plus™ modeling used to simulate:
  - feedstock inputs (dRDF, wood, switchgrass)
  - oxygen and steam ratios into gasifier
  - Efficiency of sorbent-based gas cleaning system
  - Incorporated GE’s power plant modeling

- Evaluated 10 Cases (9 CC; 1 Fuel Cell)
## ASPEN Efficiency Results (5 Cases)

<table>
<thead>
<tr>
<th>CASE</th>
<th>dRDF (MW)</th>
<th>S-Grass (MW)</th>
<th>Wood (MW)</th>
<th>dRDF / Bit. Coal</th>
<th>SOFC dRDF</th>
</tr>
</thead>
<tbody>
<tr>
<td>TPD</td>
<td>1140</td>
<td>1080</td>
<td>1000</td>
<td>720 / 211</td>
<td>1140</td>
</tr>
<tr>
<td>GT MWe</td>
<td>48.3</td>
<td>48.7</td>
<td>48.5</td>
<td>47.7</td>
<td>-</td>
</tr>
<tr>
<td>ST MWe</td>
<td>30.2</td>
<td>30.3</td>
<td>30.3</td>
<td>30</td>
<td>-</td>
</tr>
<tr>
<td>Gross MWe</td>
<td>78.5</td>
<td>79</td>
<td>78.8</td>
<td>77.7</td>
<td>-</td>
</tr>
<tr>
<td>Net MWe</td>
<td>71</td>
<td>70.5</td>
<td>68.4</td>
<td>69.4</td>
<td>93</td>
</tr>
<tr>
<td>Effic. (%)</td>
<td>40.8%</td>
<td>38.5%</td>
<td>39.1%</td>
<td>41.1%</td>
<td>53.5%</td>
</tr>
</tbody>
</table>
## ASPEN Emissions Results (Base Case)

<table>
<thead>
<tr>
<th></th>
<th>NOx</th>
<th>SOx</th>
<th>PM</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSPS</td>
<td>1.6 lb/MMbtu</td>
<td>0.6 - 1.2 lb/MMbtu</td>
<td>0.03 lb/MMbtu</td>
</tr>
<tr>
<td>Predicted Removal</td>
<td>0.097 lb/MMbtu</td>
<td>&lt;0.01 lb/MMbtu</td>
<td>0.00 lb/MMbtu</td>
</tr>
<tr>
<td>NSPS Ratio</td>
<td>0.51</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>
Fuel Costs – SPSA, Emery, BEF

- MSW – to – RDF facility not included in capital of Gasification Plant
- Emery & SPSA conducted cost analysis for converting MSW to RDF
- ~ $28 / ton to convert raw MSW to RDF is ‘break-even’ costs at proposed project scale
- Biomass Energy Foundation compiled availability and costs of ag-based biomass feedstocks
  - $30/ton & up is where large quantities became available to support large-scale (70MWe) Biomass IGCC’s
$1,880/kw installed capital (1st Plant)
- $0.048 / kWh
- Competitive with NGCC at similar scales (~70MWe) when paying $3.25/MMBtu for gas

$1,570/kw install capital (Follow-on Plants)
- $0.044 / kWh
- Competitive with NGCC at similar scales (~70MWe) when paying $2.74/MMBtu for gas
Economics / COE w/ 12% Return (2nd Plant)

Reference Case 1140 TPD / 70 MWe

Cost of Fuel, $/ton (~6000 Btu/lb.)

0 5 10 15 20 25 30 35

0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0

Cost of Elect., cents/kwh

Agri-Biomass

dRDF

4.4¢

6.5¢
DOE Project Conclusions

- Emery design able to meet DOE’s technical and economic targets
- Emery technology has potential to reduce Capital and O&M of Biomass Gasification by having fewer unit processes
- COE to be competitive in specific circumstances depending on feedstock and site location
- Biomass Fuel Flexibility
- Emissions ½ of NSPS for coal-fired electric power generation
- Potential for a large number of regional and/or National commercial installations when using dRDF
- Unlike wind or solar Biomass IGCC can provide ‘base-load’ renewable power
- Unlike Coal IGCC, Biomass is considered CO₂ neutral
- If sequestration used, then CO₂ net-reduction possible
Current EMERY Activities

- Secured Additional U.S. DOE monies
- Construction of New Prototype Gasifier System
- 2 – 10 tons/day Solid feed throughput
- ASME pressure system (0 – 125 psi)
- To validate design configuration
- Pursue small-scale DG power opportunities
- Develop design data for scale up to progressively larger Gasifier modules
Emery’s New Gasification Plant
Gasifier and Fuel Hopper
Project & Testing Schedule

- Complete construction and assembly in November
- Initial functional testing – Q1 ‘04 (atm./air-blown)
- Subsequent testing in Q2 ’04 (pres./O₂-blown)
- Testing of a range of biomass and non-biomass fuels
Thank You