Fixed Bed Downdraft Biomass Gasification

NC STATE UNIVERSITY

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Project Motivation & Goals

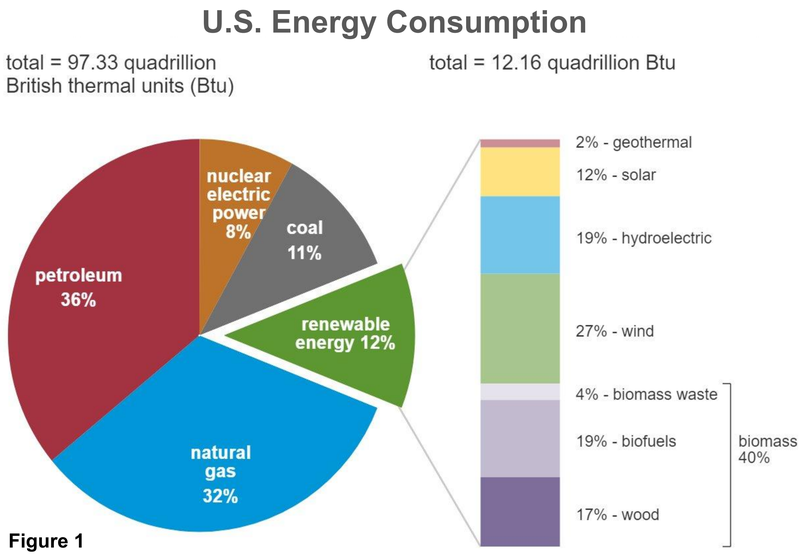

Figure 1

* U.S. Energy Information Administration, Monthly Energy Review, Table 1.3 and 10.1, April 2024, preliminary data.

- Growing need for renewable energy
- Choose reactor, feed type, location
- Design biomass gasification simulation in ASPEN
- Consider environmental impact/regulations
- Economic feasibility

Background

- Downdraft stratified gasifier
- Forestry residue
- Sampson County, NC

Figure 2. Real World Biomass Gasifier

* Zibo Zichai New Energy Co., Ltd., *Biomass Gasifier*, at https://m.made-in-china.com/company-zcxnypower/product-group/BqrnlPzcsgWE/Biomass-Gasifier-1.html, last accessed October 7, 2024.

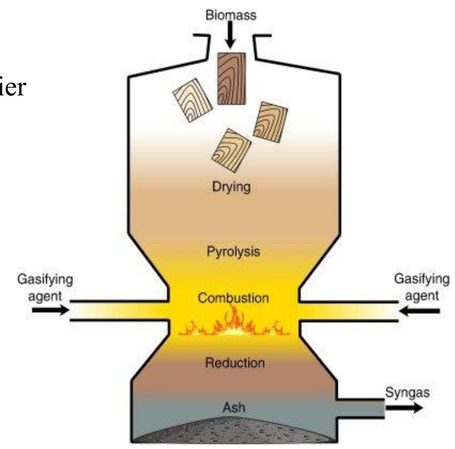

Figure 3. Downdraft Gasifier Schematic

* Science Direct, Downdraft Gasifiers, at https://www.sciencedirect.com/topics/engineering/downdraft-gasifiers, last accessed October 7, 2024.

Acknowledgements

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ASPEN Model

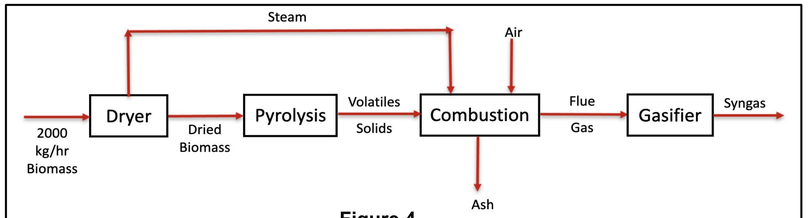

Figure 4

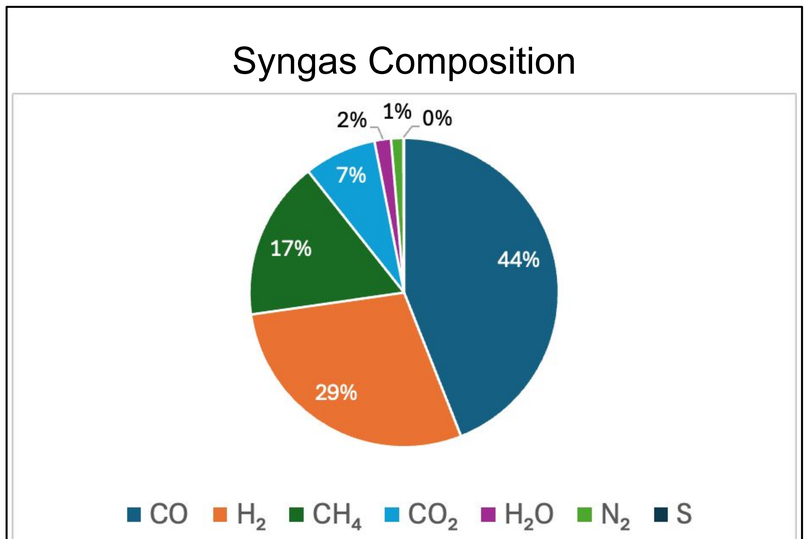

Figure 5

Environmental Analysis

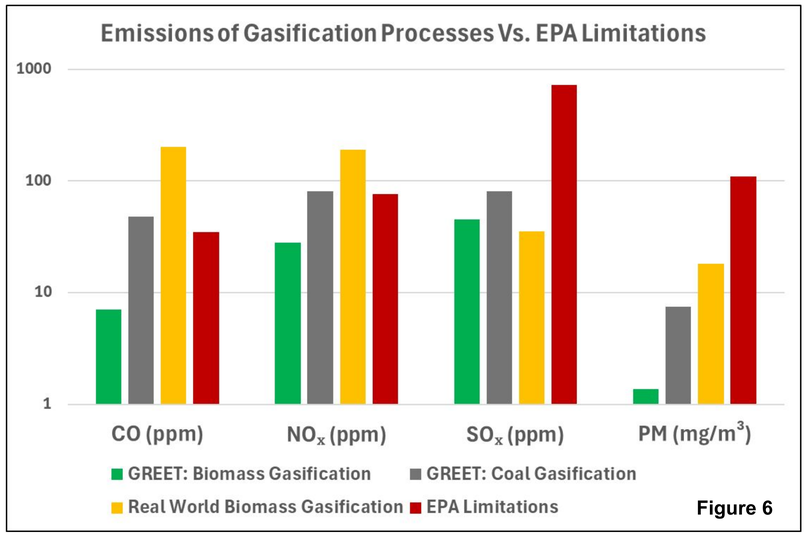

Figure 6

*EPA Limitations: Environmental Protection Agency, *Federal Plan Requirements for Commercial and Industrial Solid Waste Incineration Units*, at https://www.epa.gov/system/files/documents/2024-09/san-5960_ciswi-fp_20240801_finalrule_op.adminmsr_disc.pdf, last accessed December 2, 2024.
*Real World Gasification: M. Carreras-Sospedra, M. MacKinnon, Professor D. Dabdub, *Assessment of the Emissions and Energy Impacts of Biomass and Biogas Use in California*, at https://ww2.arb.ca.gov/sites/default/files/classic/research/apr/past/11-307.pdf, last accessed December 2, 2024.
*GREET: Argonne National Laboratory, *R&D GREET® Model*, https://greet.anl.gov/, last accessed February 6, 2025.

Economic Analysis

	Base Cost for Equipment ($)	Limit	
		-20%	+20%
Total Purchase Cost	655,000	524,000	786,000
Total Module Cost	1,200,000	960,000	1,440,000
Total Grass Roots Cost	1,620,000	1,296,000	1,944,000

Net Present Value	$2,800,000
Present Value Ratio	1.92
Discounted Cash Flow Rate of Return (DCFROR)	21.84%

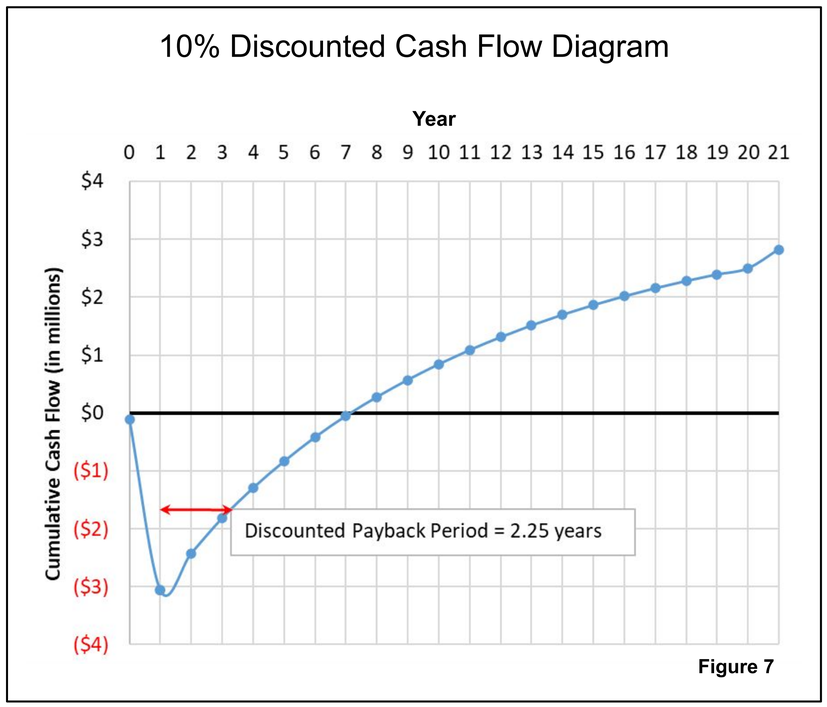

Figure 7

Conclusions

- ➔ ASPEN model produced 2008 kg/hr of syngas from a 2000 kg/hr biomass feed rate
- ➔ ASPEN syngas composition comparable to real world examples
- ➔ Hazardous emissions are in compliance and environmental impact is less severe than comparable existing technologies
- ➔ Economic analysis concludes a 2.25 year payback period and a 21.84% rate of return after project's life