Experimental, Economic, and Environmental Assessment of Feedstock Gasification for High-Octane Fuel Production

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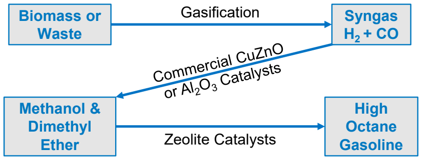
Background

- Biomass gasification and subsequent gas-to- liquid upgrading is a promising route to high-octane gasoline (HOG) for advanced engines and aviation.



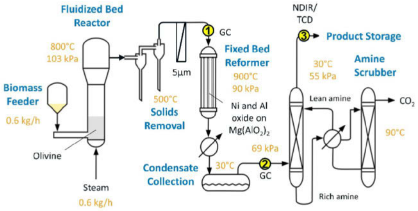
- The US Department of Energy's 2016 Billion Ton Study identified advantaged biomass feedstocks based on price and availability.
- Understanding the relationship between feedstock price and performance and the life-cycle greenhouse gas emissions is critical for biorefineries to select profitable and environmentally benign feedstocks.

Methods

- Obtained and milled five abundant and low-cost feedstocks and mixed two blends:

	2014$/dry tonne
Clean Pine (CP)	96
Hybrid Poplar (HP)	96
Forest Residues (FR)	71
Miscanthus (MI)	68
Switchgrass (SG)	68
50 % FR, 50 % SG	69
60% FR, 30 % CP, 10 % HP	81

- Gasified each feedstock and blend in a four-inch (10 cm) fluidized bed reactor, then reformed hydrocarbons and amine-scrubbed CO_2 in downstream units.



- For the biomass-to-HOG pathway, calculated specific feedstock cost and modeled life-cycle greenhouse gas emissions in GREET[1].

$$Specific\ Feedstock\ Cost = \frac{Feedstock\ Cost}{HOG\ Yield} \qquad (Eq. 1)$$

Biorefineries should gasify **inexpensive** and **low-emissions feedstocks** since **syngas compositions**, **yields,** and heating **values** from abundant feedstocks are **insensitive to price.**

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tcBiomassPlus 2019
Rosemont, IL
Oct 6-9, 2019
NREL/PO-5100-74801

This work was authored in part by the National Renewable Energy Laboratory, operated by Alliance for Sustainable Energy, LLC, for the U.S. Department of Energy (DOE) under Contract No. DE-AC36-08GO28308. Funding provided by the Bioenergy Technologies Office. The views expressed in the work do not necessarily represent the views of the DOE or the U.S. Government. The U.S. Government retains and the publisher, by accepting the work for publication, acknowledges that the U.S. Government retains a nonexclusive, paid-up, irrevocable, worldwide license to publish or reproduce the published form of this work, or allow others to do so, for U.S. Government purposes.

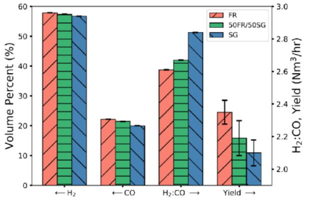
Results

- Syngas compositions, higher heating values, and yields are similar between feedstocks at each process stage and thus, are independent of feedstock cost.

Table 1: Steady-state measurements of reformed syngas composition, yield, and higher heating values.

Feedstock	H_2 (vol%)	CO (vol%)	CO_2 (vol%)	CH_4 (vol%)	H_2:CO	HHV (MJ-kg^{-1})	Yield (Nm$^3_{gas}$-kg$_{feed}^{-1}$)
CP	58	23	19	0.38	2.5	85	2.3
HP	58	23	19	0.22	2.5	84	2.3
MI	58	22	20	0.24	2.7	84	2.2
FR	58	22	20	0.27	2.6	85	2.4
SG	57	20	23	0.33	2.8	83	2.1
50% FR, 50% SG	57	22	21	0.29	2.7	84	2.2
60% FR, 30% CP, 10% HP	58	23	19	0.37	2.5	85	2.3

- Blended feedstocks exhibit near linear behavior with respect to their component feedstock properties, indicating that no synergistic effects exist, so blend properties can be predicted within error.

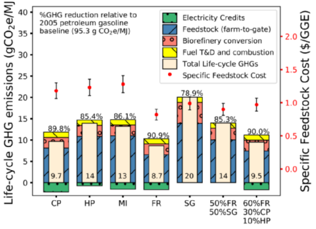


- Specific feedstock costs (Eq. 1) vary as much as 12% of the total HOG production cost, while other contributions vary by less than 3%, so the total delivered cost is the most important feedstock consideration.

Table 2: Techno-economic analysis cost breakdown

Cost Contributions ($/GGE)	CP	HP	MI	SG	FR	50% FR 50% SG	60% FR 30% CP 10% HP
Specific Feedstock Cost	1.45	1.52	1.05	1.17	1.08	1.12	1.23
Ash Removal	0.01	0.01	0.02	0.10	0.05	0.07	0.03
Other Operating Costs & Credits	0.56	0.60	0.58	0.67	0.57	0.62	0.57
Capital Charges & Taxes	1.60	1.63	1.61	1.69	1.60	1.64	1.60

- Life-cycle greenhouse gas emissions for HOG production are not correlated with syngas properties or feedstock cost. FR is the low-cost and low-emissions feedstock.



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[1] Argonne National Laboratory. Greenhouse gases, regulated emissions and energy use in transportation (GREET) Model; 2016. http://greet.es.anl.gov