Small-Scale Engineered High Flexibility Gasifier

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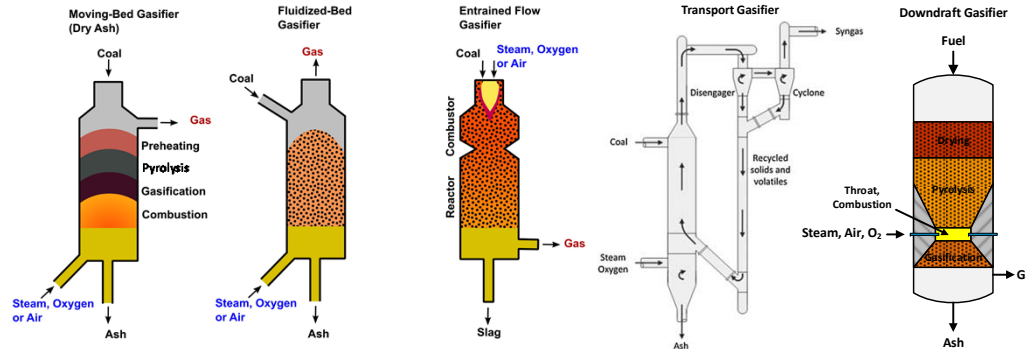
Project Objectives

GOALS
- Develop small-scale coal gasifier featuring
  - High pressure, oxygen-blown operation
  - Standardized modular construction
  - Fuel flexibility for coal, biomass, MSW
- Conduct pilot demonstration of design

IMPACT
- Benefits of final gasifier design
  - Mitigates/reforms tars
  - Can be scaled-down cost-effectively
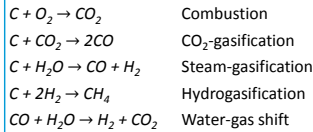- Applicable to 1–5 MW modular, energy conversion system e. g. CHP

Technical Approach

- Computational modeling to optimize design
- Laboratory testing to obtain model inputs
  - Chars produced at relevant conditions
  - Gasification reactivity characterization
- Design & construct 25-50 lb/hr pilot-scale gasifier based on modeling results
- Commission & test pilot gasifier, update CFD model
- Design 1–5 MW energy conversion system

Project Tasks

- 1.0 Project Management
- 2.0 CFD Model Development
  - Select fuels, acquire samples
  - Test plan for fuel/char characterization
  - Computationally optimized design
- 3.0 Gasifier Design, Construction & Testing
  - Engineering design of pilot gasifier skid
  - Construct & commission gasifier skid
- 4.0 Commercial System Modeling & TEA
  - Validate CFD Model
  - Conceptual design of 1–5 MW system

State of the Art Gasifier Technology

Processes & Transformations
- Fuel drying
- Pyrolysis – release of volatile matter, fuel to char conversion
- Combustion – burning of volatiles and some char, releases heat
- Gasification – conversion of char to syngas, absorbs heat

Chemical Reactions

$C + O_2 \rightarrow CO_2$	Combustion
$C + CO_2 \rightarrow 2CO$	CO_2-gasification
$C + H_2O \rightarrow CO + H_2$	Steam-gasification
$C + 2H_2 \rightarrow CH_4$	Hydrogasification
$CO + H_2O \rightarrow H_2 + CO_2$	Water-gas shift

Feedstock Selection
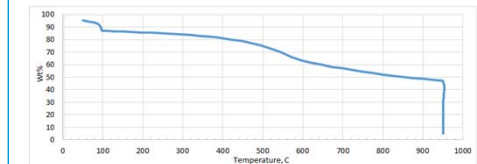- PRB Coal (Preferred)
- Lignite
- Flexibility for biomass, MSW

Challenges to Overcome
- Undesired by-products – tars
- Operational complexity
- Difficulty to cost-effectively scale-down

Project Pathway

Computational Modeling

Two-stage Modeling Approach

Zonal Process Model
- Considers drying, devolatilization, combustion, gasification separately
- To establish initial process parameters

CFD Model
- Porous-media CFD approach
- To explore multi-dimensional mixing effect

Model Inputs and Outputs

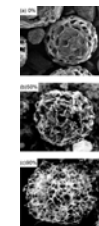| Model Inputs	Model Outputs
- Coal properties - Coal devolatilization behavior - Char reaction kinetics - Geometry - Operating conditions - Boundary conditions	Steady state conditions: - Syngas make and composition - Char/ash make - Bed dimensions - Heat losses - System efficiency

Analytical Methods

Thermal Gravimetric Analysis (TGA)
- Proximate analysis
- Pyrolysis and char gasification kinetics

Char Production Reactor
- Simulated coal pyrolysis
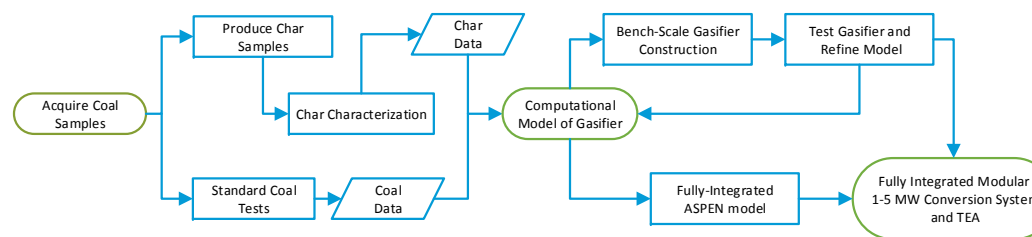- Samples for reactivity tests

TPR/TPD, BET
- Char reactivity testing
- N_2 and CO_2 surface area, pore structure