



# Flex-Fuel Test Facility - Recent and Ongoing Projects and Accomplishments

AIChE - Chicago Symposium 2006  
October 9-10, 2006

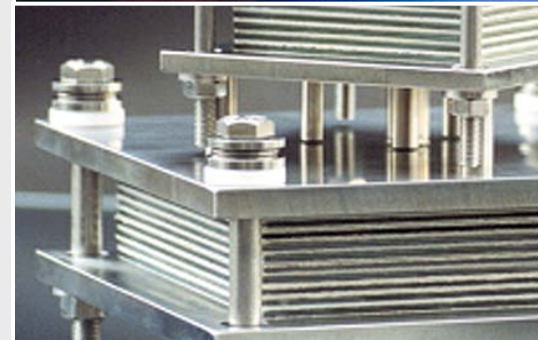
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# >> GTI at a glance

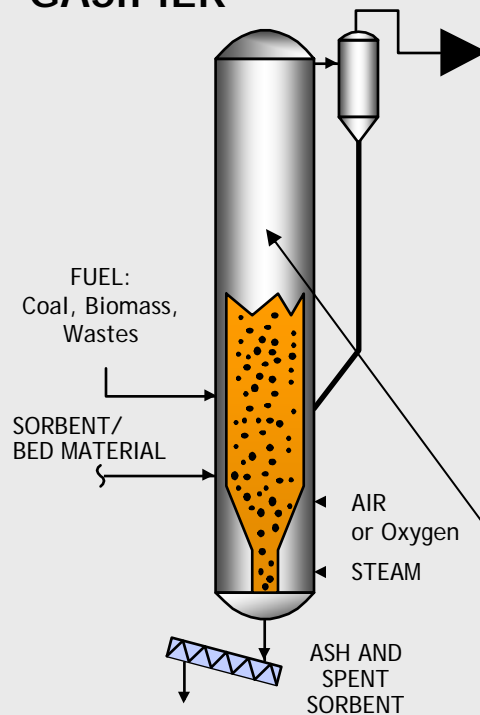


- > Research, deployment and training for the Natural Gas Industry and energy markets
- > 65 years, 1000+ patents, 500 products
- > 18-acre campus, 200,000 ft<sup>2</sup> of labs
- > 40+ years of Gasification R&D



# What is Gasification?

## GASIFIER



### Products (syngas):

CO (carbon monoxide)

H<sub>2</sub> (hydrogen)

(CO/H<sub>2</sub> ratio can be adjusted)

### By-products:

H<sub>2</sub>S (hydrogen sulfide)

CO<sub>2</sub> (carbon dioxide)

Solids (minerals from fuel)

### Extreme Conditions:

Pressure = 1 to 30 atm or more

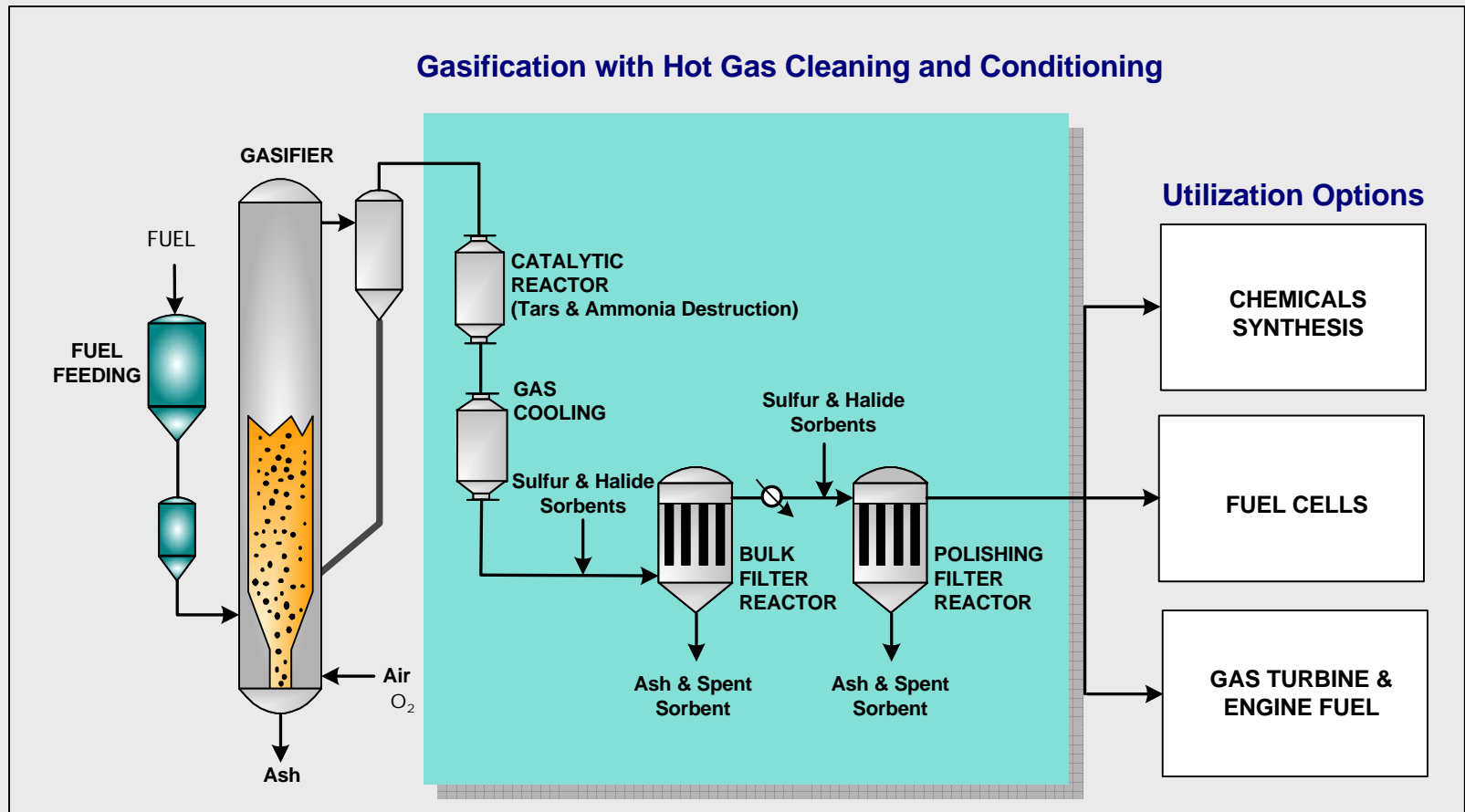
Temperature = 1600 - 2600 °F

Gas  
Cleanup  
Before  
Product  
Use

# Why Gasification?

- > **Fuel flexibility** - to increase fuel diversity
- > **Product flexibility** - fuel gas, chemical feedstocks, power, liquid fuels
- > Highest potential energy **efficiency** among solid-fuel-based technologies
  - Gasification combined cycle ~40-50+% efficient
- > Best **emissions** characteristics among solid-fuel-based technologies
- > Renewable energy option with biomass fuels

# Example Process Configuration to Condition Fuel Gases for Multiple Uses



# GTI's Experience in Gasification

## During the 1950s and 1960s

Concern for natural gas shortage and gas industry commitment to service customers

- Developed gasification technologies to maximize methane production through high pressure gasification, gas purification and methanation.
- Produced Coal Conversion Databook: coal and ash properties, chemistry and conversion kinetics

## From the 1970s

Focus on high efficiency, low emission, and low cost production of synthesis gas from diverse feedstocks for power and chemical production

- Developed simple gasification technologies for a variety of feedstocks to maximize synthesis gas production and minimize emissions.
- Developed demonstration projects for power and chemical productions.
- Commercialized coal gasification technology for the production of fuel gas.
- Performed R&D on advanced and enabling technologies (dense-phase feeders, analytical systems, etc.).

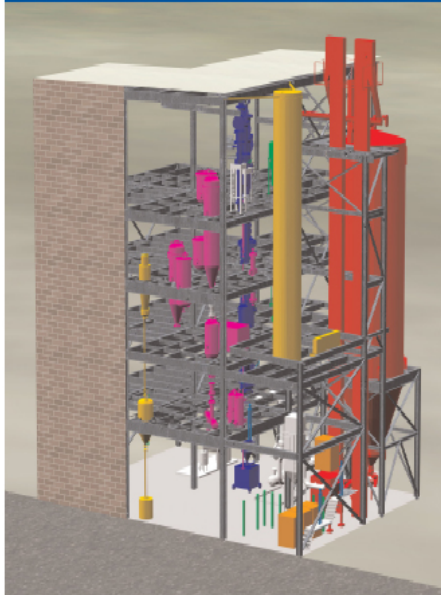
# Discussion Outline

- > Flex-Fuel Facility Overview
  - Purpose
  - Capabilities
- > Current Projects
- > Facility Expansion and Future Directions

# Gasification Pilot Plant Test Platform

Henry R. Linden  
Flex-Fuel Test Facility

for Thermo-Chemical Conversion of Fuels



This clean coal technology project is partially funded with a grant from the Office of Coal Development, Illinois Department of Commerce and Economic Opportunity



Rod R. Blagojevich  
*Governor*

Jack Lavin  
*Director*

Major funding provided by  
Gas Research Institute

*December 2003*


- > Flexible fuel capability
- > Operational flexibility
- > Plug and play systems integration and testing

# Flex-Fuel Facility Overview

## Features

- Coal - 10 tpd w/air; 20 tpd w/oxygen
- Biomass - 24 tpd w/air; 40 tpd w/oxygen
- Gasification Pressure to 400 psig
- Multicontaminant Syngas Cleanup
- On-line Syngas Analysis Systems

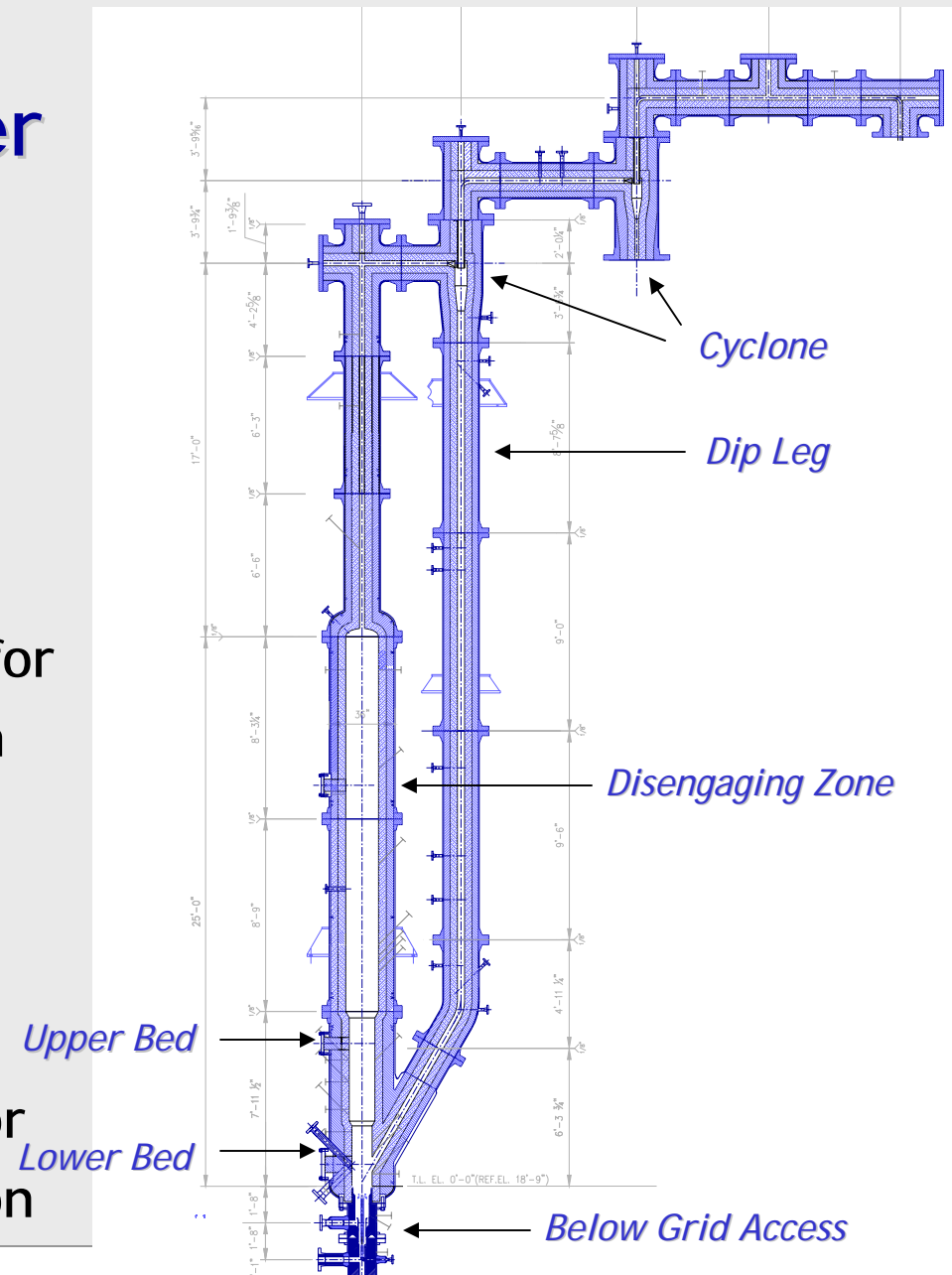
## End-Use Process Evaluations

- Hydrogen Production
- SNG Production
- CO<sub>2</sub> Capture Technologies
- Syngas-to-Liquids Production
- Advanced Power Conversion Systems Tests
- Advanced Oxygen Production Systems
- Industrial End-Use 



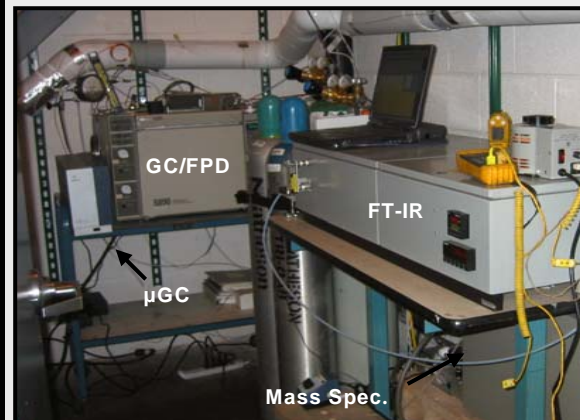
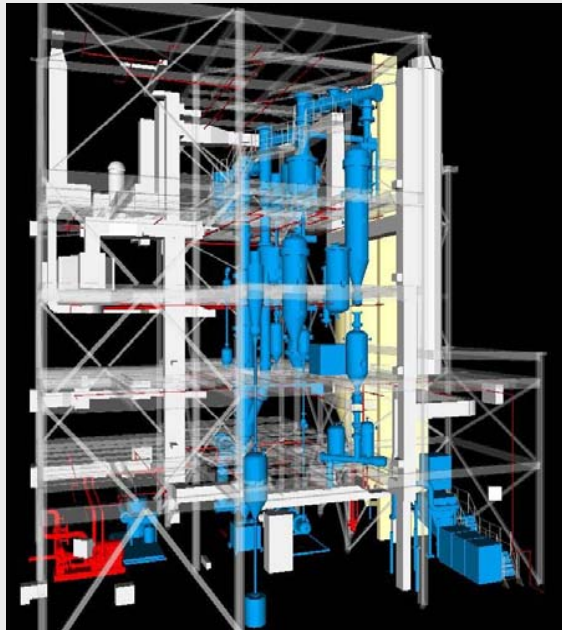
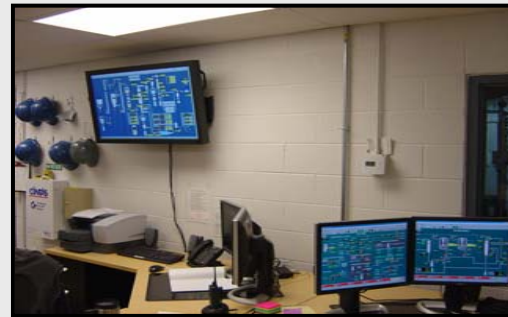
# Flex-Fuel Gasifier

- Full Refractory Lining
- 4 Vessel Sections for Easy Access & Modification
- Transition Piping Ease for Removal & Modification
- Removable Lower Section for Below Grid Access
- Currently configured for catalytic SNG Production



# Configurable Systems Development Platform

- Solids feed system
- Gasifier
- Cyclones
- Gas conditioning unit
- Analytical systems



# Discussion Outline

- > Flex-Fuel Facility Overview
  
- > Recent and Current Projects
  - Gasifier Assessment for IGCC with high-ash coal
  - Biomass Gasification/ Novel Syngas Analytical Systems Development
  - Syngas Cleaning Process Evaluation
  - *In-Situ* Tar Reduction for Biomass Gasification
  - Catalytic Hydrogasification
  
- > Facility Expansion and Future Directions

# IGCC Gasification Technology Evaluation for High Ash Indian Coal

- > Sponsor: USAID
- > Participants: NEXANT (Prime), GTI
- > GTI Phase B Scope completed
  - Lab evaluation of Indian coal samples
  - Thermogravimetric (TGA) testing
  - Pilot-scale gasification testing
    - > Washed and ROM
  - Preliminary performance, equipment sizing and cost estimations for a 100 MWe IGCC plant
- > Phase C Schedule
  - Phase C Demo Plant Feasibility nearing completion

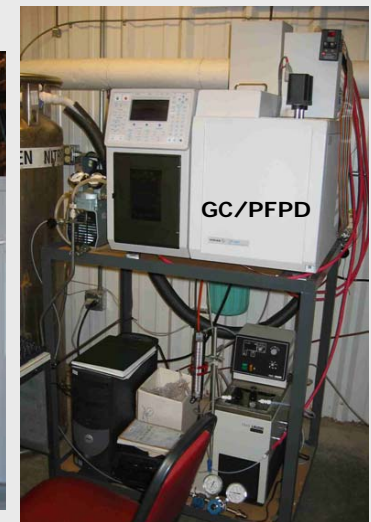
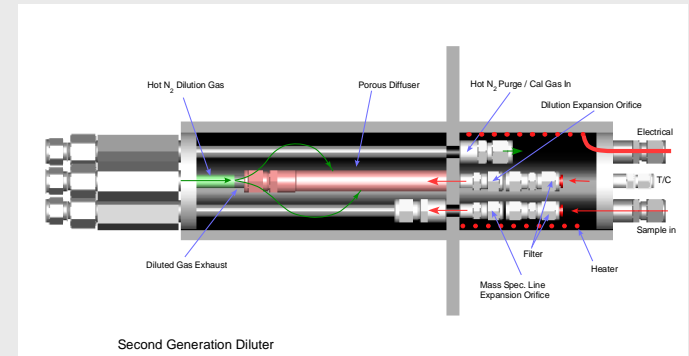
# Biomass Gasification Project

- > Sponsor: DOE-EERE
- > Participants: GTI, UAB, Technical Advisory Panel (VTT, Southern Co, AEP, IPST)
- > Scope
  - Developing, building, field testing novel syngas analytical system for timely, accurate online syngas characterization
  - Testing conducted at Weyerhaeuser BLG at New Bern Mill, Flex-Fuel Test Facility with coals and biomass
  - Flex-Fuel Test Facility operation provides GTI co-funding, other co-funding by Southern Co., VTT, UAB
- > Schedule
  - 36 month program, ending 12/31/06

# Analytical Systems

Comprehensive, continuous, sensitive and accurate measurements at key points in the process are essential to:

- Compare gasification conditions
- Quantify fuel-specific syngas components
- Characterize syngas quality for end uses
- Monitor gas conditioning and cleanup effectiveness

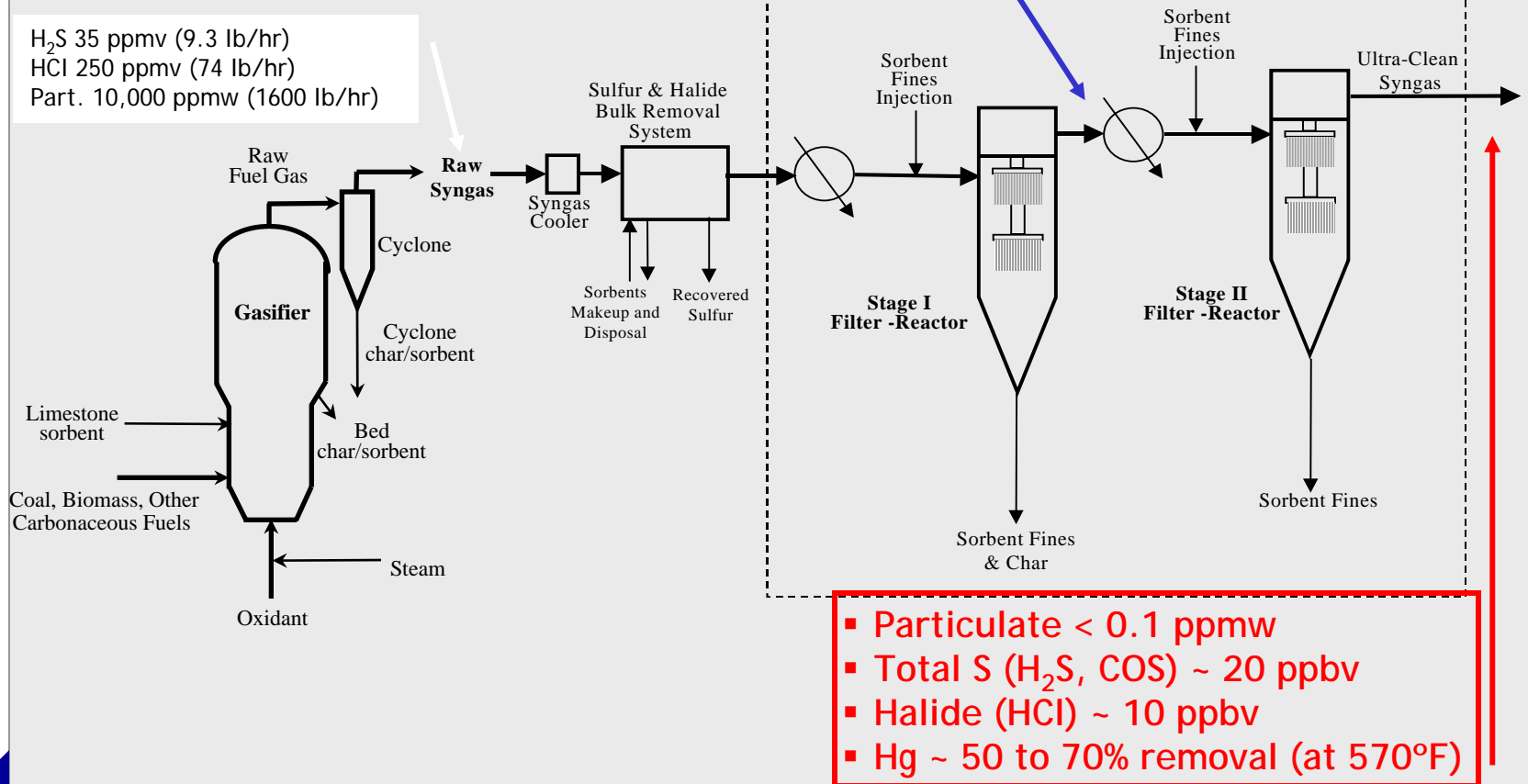


# Novel Syngas Cleaning Process Assessment

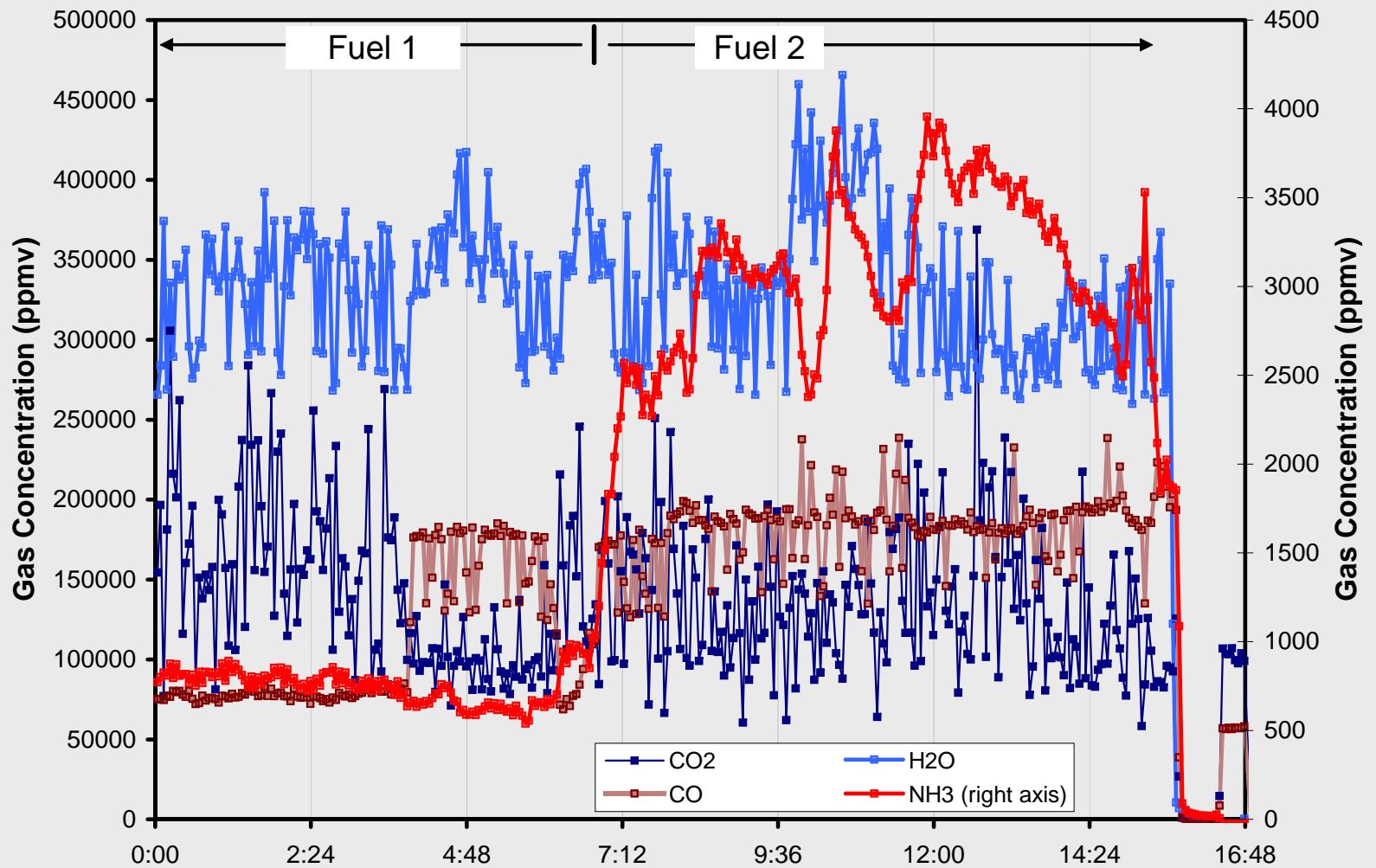
- > Sponsor: DOE-NETL
- > Participants: Siemens (Prime), GTI
- > Scope
  - Concept Development/Evaluation for Warm Gas Removal of particulates, halides, sulfur and mercury to ppbv levels
  - Lab-scale sorbent testing and selection
  - Pilot-scale testing with 3 coals completed for a technical and economic feasibility evaluation
- > Schedule
  - Completed 12/31/05

# Novel Gas Cleaning Process Achieved and Measured Ultra-Clean Syngas

- Particulate < 0.1 ppmw
- Total S ( $H_2S$ , COS) ~ 1 to 5 ppmv
- Halide (HCl) ~ 1 to 5 ppmv



# Analytical Results - FTIR Rapid Process Monitoring



# Engineering New Catalysts For In-Process Elimination Of Tar

- > Sponsor: DOE-EERE
- > Participants: GTI, Ohio State University, Alfred University, Nextech Materials
- > Scope
  - Evaluate catalysts for in-bed tar reduction in Flex-Fuel Test Facility-performance benchmarks based on Alumina and Olivine (Magnesium Iron Silicate) - Testing completed 10/05
  - Engineer new catalyst forms and use GTI submerged combustion melter to economically produce optimized catalysts for tar reduction in biomass gasification
- > Schedule
  - 36 month program, started April 05

# Catalytic Gasification for SNG Production

> Sponsor: GreatPoint Energy



> Scope

- Evaluate catalytic gasification for production of SNG from two potential fuels
- TGA and bench-scale tests underway
- Flex-Fuel Facility Modifications completed
- Pilot-scale testing with two fuels

> Schedule

- 12 month program, started Jan 06

# Discussion Outline

- > Flex-Fuel Facility Overview
  - Capabilities
  - Purpose
- > Recent and Current Projects
- > Facility Expansion and Future Directions
  - Acid Gas Treatment Pilot Plant
  - Advanced Gasifier System Development
  - Fischer-Tropsch Coal-to-Liquids Pilot Plant

# Acid Gas Treatment Pilot Plant

Sulfur and CO<sub>2</sub> capture for low emissions and carbon management.

> Sponsor: State of Illinois DCEO, GTI

> Scope

- Refurbish and Reconfigure the Acid Gas Treatment Pilot Plant for syngas application
- Integrate with FFTF for sulfur and CO<sub>2</sub> removal evaluation on syngas

> Status

- Equipment installation at FFTF and prepared for use by end of October



# Pratt & Whitney Rocketdyne Advanced Gasification Systems Development Pilot Plant

> Sponsors: DOE-FE, Pratt & Whitney Rocketdyne, State of Illinois-DCEO, GTI



## > Scope

- Design and fabricate gasification test facility extension to Flex-Fuel Test Facility
- ~1,000 hours cumulative test time (1500 lb/hr coal feed rate)

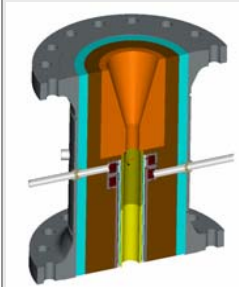
## > Schedule

- 12 month facility integration study completed 12/05
- 36 month pilot-scale program

# Pratt & Whitney Rocketdyne (PWR) Compact Gasification System

Component Development &  
Pilot Plant

2004 - 2009



Component  
Development



Pilot Plant Gasifier &  
Test Facility



Commercial  
Gasification Plant

Commercial  
Demonstrations (1500 &  
3000 TPD Gasifiers)

2007 - 2012



15% to 20% Lower End Product Cost from  
Improved Efficiency, Cost and Availability

# Headwaters Technology Fischer-Tropsch Process Development Unit

**Sponsors:** DOE-FE, Headwaters, State of Illinois-DCEO, GTI

**Participants:** Headwaters, GTI, Nexant, DOD/AF

## Scope:

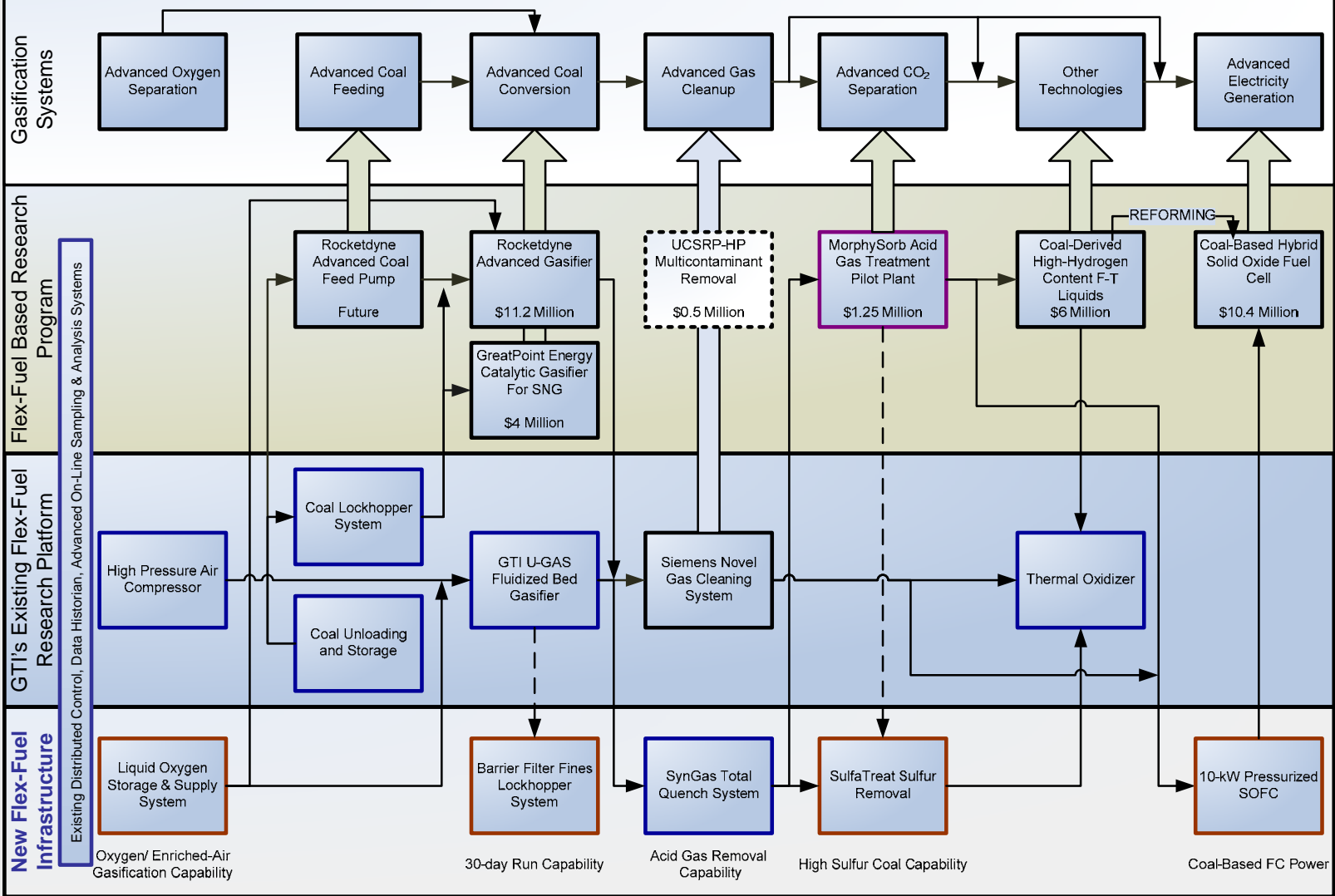
- > Design and build pilot-scale PDU to integrate with Flex-Fuel Test Facility - use existing gasifier, gas cleaning and conditioning systems to pre-treat the syngas
- > Produce F-T liquids and wax for downstream refining and evaluation (5-10 bpd) (DOE and DOD/AF to evaluate)
  - Compare medium- and high-alpha catalysts
  - Compare slurry and fluidized bed operations
  - Test with syngas from various coals
- > Train operating staff

**Schedule:** Prime awarded 6/05, negotiations underway



# GTI Flex-Fuel Test Facility for Gasification Technology and Systems Integration R&D

Oxidant > Coal > Conversion > Gas Cleanup > CO<sub>2</sub> Separation > Co-Products > Power



\$36 MM +

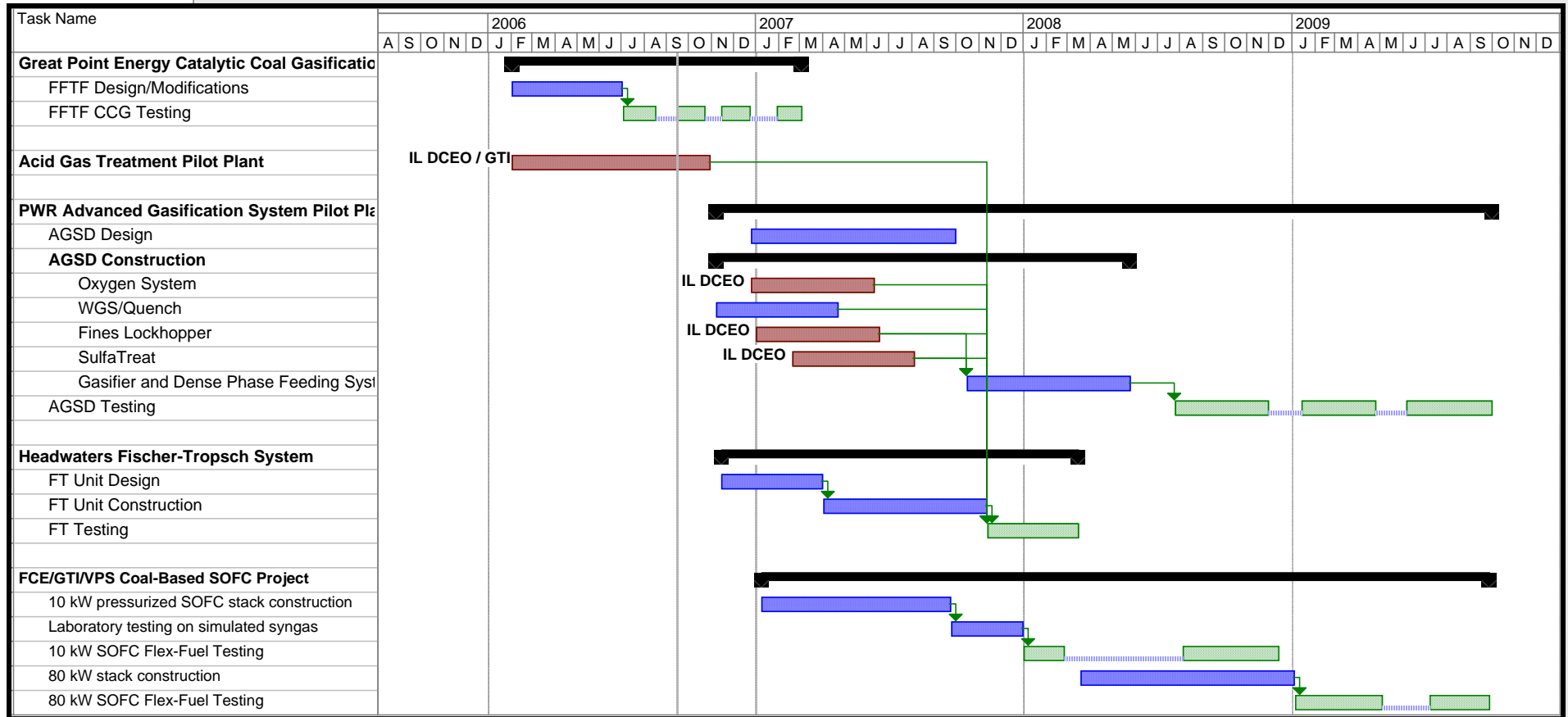
\$16 MM

\$2.3 MM



Proposed ILDCEO Additions
GTI Funded Equipment
USDOE & Privately Funded Equipment
Slipstream
 Dollar values = portions of project funds to be spent at GTI

# Planned Schedule of Major Programs in Flex-Fuel Test Facility



# Gasification and Gas Processing R&D



gti<sup>®</sup>

- > **Advanced gasification systems**
  - GTI fluidized-bed technologies
  - Advanced entrained-flow reactor
  - Catalytic gasification reactor
- > **Gas cleanup systems for sour gas and syngas**
  - Warm gas cleanup with sorbents & membrane systems
  - Tar reduction catalyst development
  - Low temperature solvent & membrane systems
  - Direct sulfur-recovery systems
- > **Integration of syngas production and conversion**
  - Power generation processes - solid oxide fuel cells
  - Fuels generation processes - syngas-to-liquids, substitute natural gas, hydrogen products
- > **Process simulation and techno-economic evaluations**