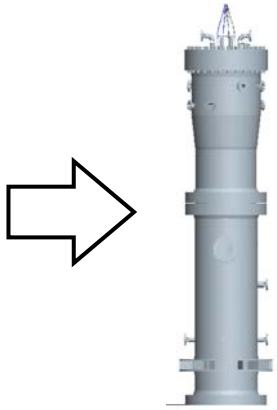
# Compact Gasification Development and Test Status



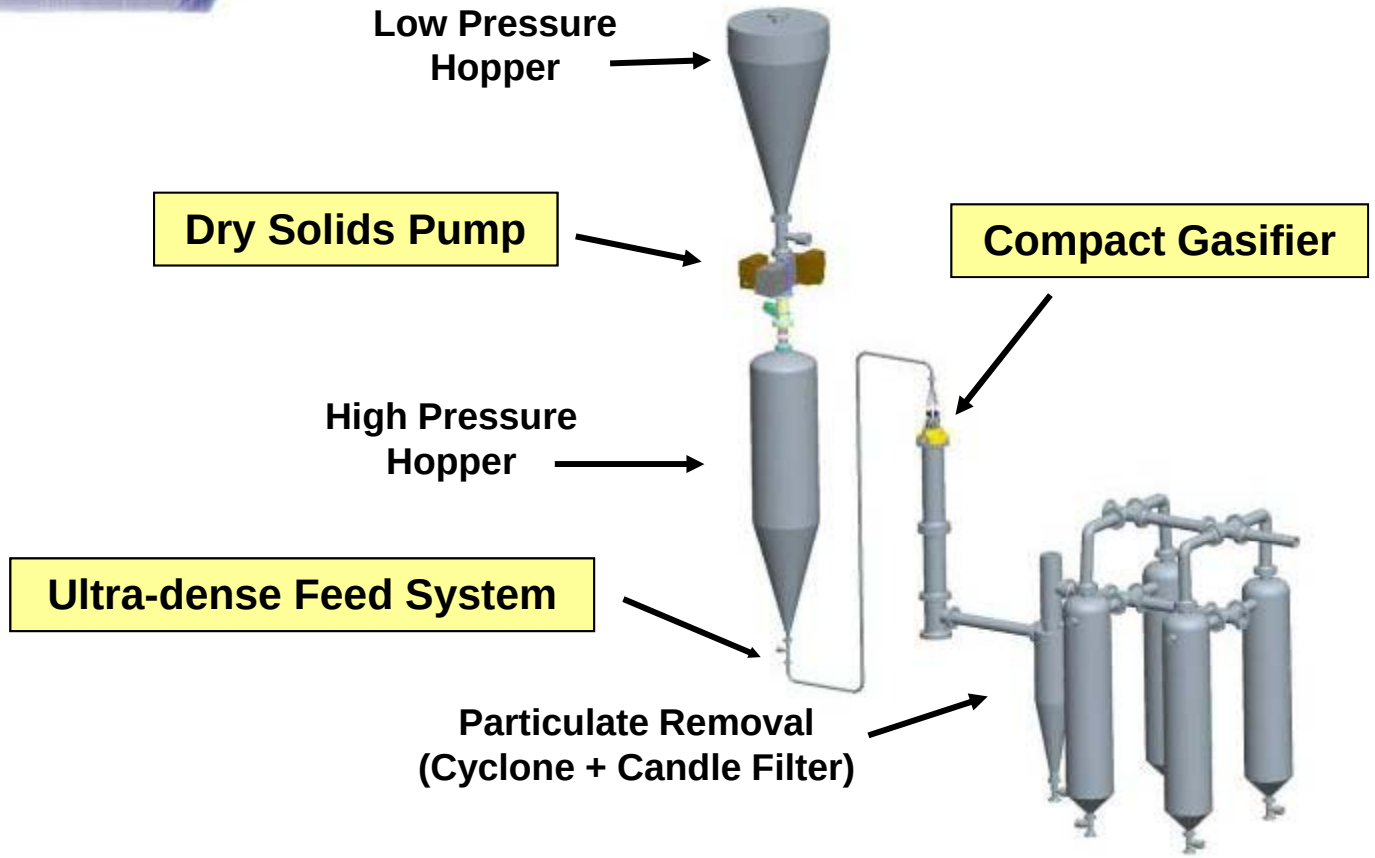
**Alan Darby**
**Program Manager, Gasification**

**Pratt & Whitney Rocketdyne**
**A United Technologies Company**

**GTC Annual Conference**
**October 2010**

## Leveraging 50 Years of Rocket Engine Experience to Reduce Cost and Improve Plant Performance

# Key Design Features of the Compact Gasification System




- Yellow Items are Key Development Items
- Other Items are Commercially Available

# Key Development Partners

- **PWR has teamed with ExxonMobil Research and Engineering (EMRE) to develop and commercialize the technology**
- **Alberta Innovates: Energy and Environment Solutions (EES) is cost-sharing definition of a demo plant for an Alberta location and funding tests with Alberta feedstock**
- **DOE is cost-sharing development of the Dry Solids Pump and Feed System under a Cooperative Agreement**
- **Zero Emission Energy Plants, Inc. (ZEEP) is launch customer with a global license to develop gasification plants**

# Advantages of the Compact Gasification System

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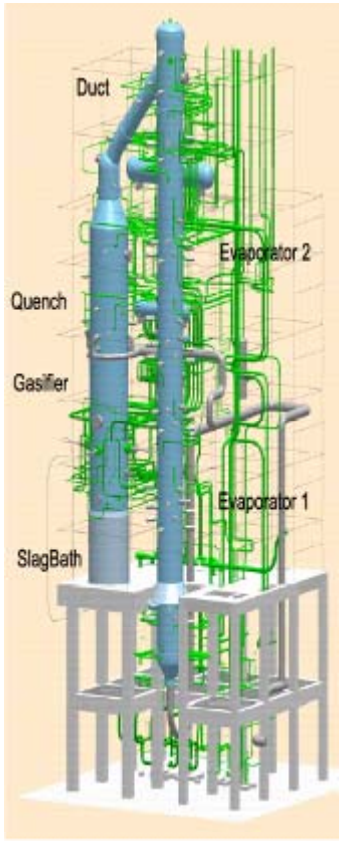
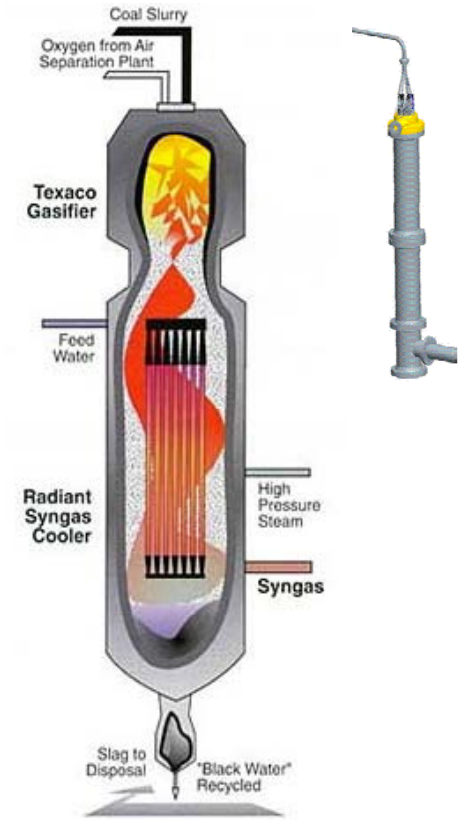
## Current Market Leaders




Source: Shell paper (2004)




Source: DOE paper (2006)

## Compact Gasification System

- 90% size reduction (gasifier)
- 50% lower cost (gasification system)
- 99% availability (gasification system)
- 99% carbon conversion
- 80% to 85% cold gas efficiency
- Dry feed system
  - Low oxygen consumption
  - Gasify all ranks of coal, petcoke, and biomass blends
- High pressure / water spray quench
  - Ideal for $H_2$ production
  - Low cost $CO_2$ sequestration

# Pilot Plant Test Objectives

**Pilot Plant at GTI**

- **Dec 2009 startup**
- **18 TPD**

**Injector**

**Gasifier**

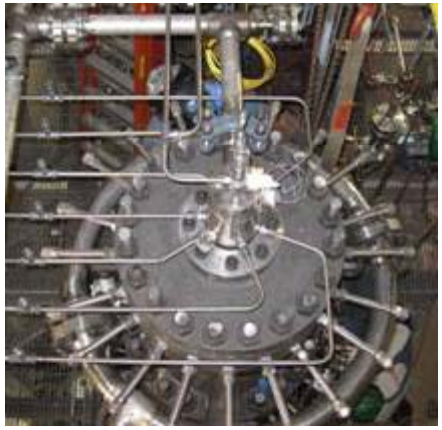
## Test Objectives

- **Demonstrate performance**
  - **Carbon conversion**
  - **Cold gas efficiency**
  - **Protective slag layer**
  - **Particulate removal**
  - **Feedstock flexibility**
- **Verify operating environments**
- **Validate computer models**
- **Obtain preliminary life data**
- **Refine operating procedures**

**Objective is to obtain data for larger scale gasification plants**

# Gasifier Hardware Assembly

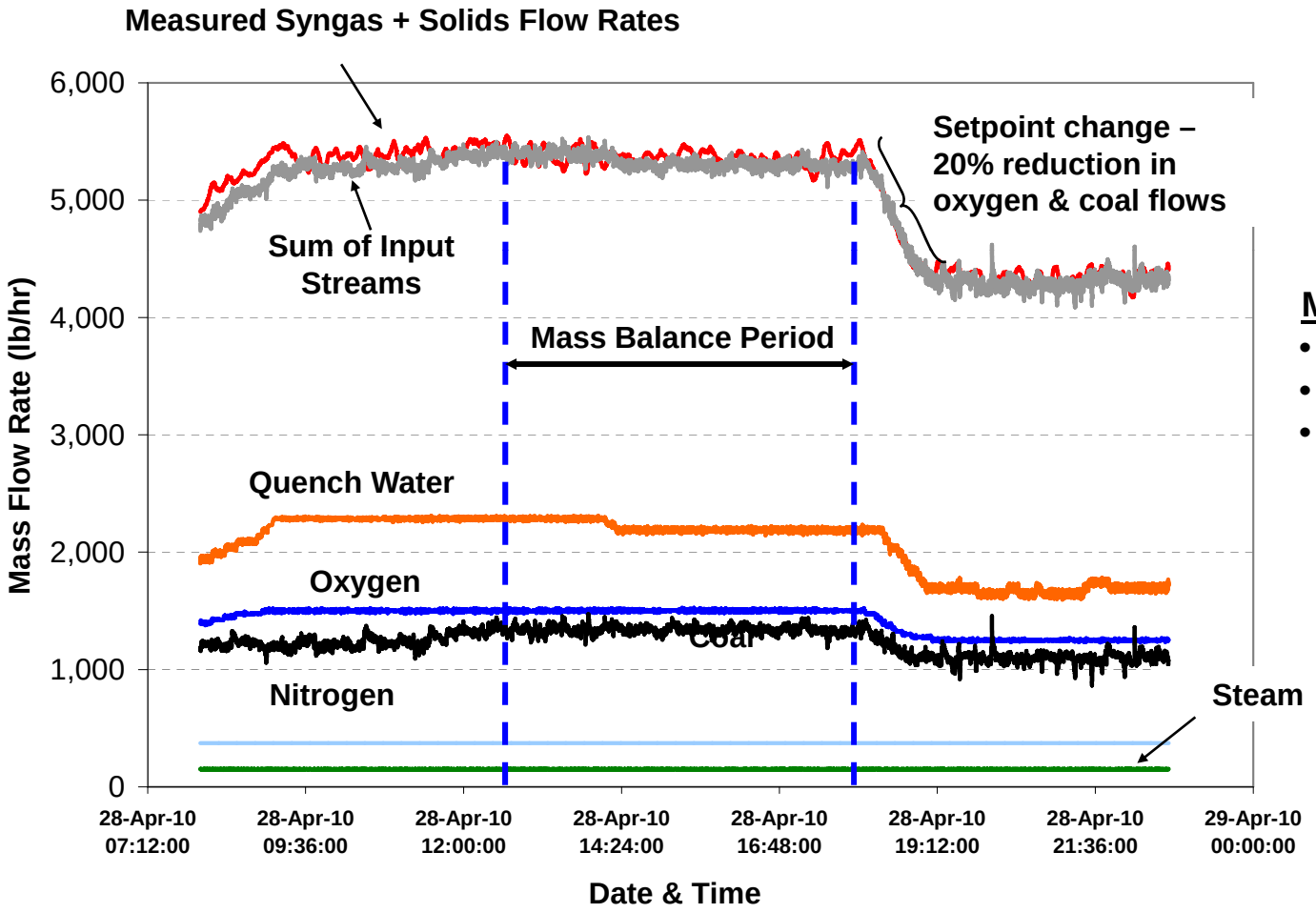
Gasifier installed in process bay at GTI



Injector (left) installed at GTI (right)

Gasifier and Quench Hardware Assembly

# Pilot Plant Mass Balance – Illinois #6 coal



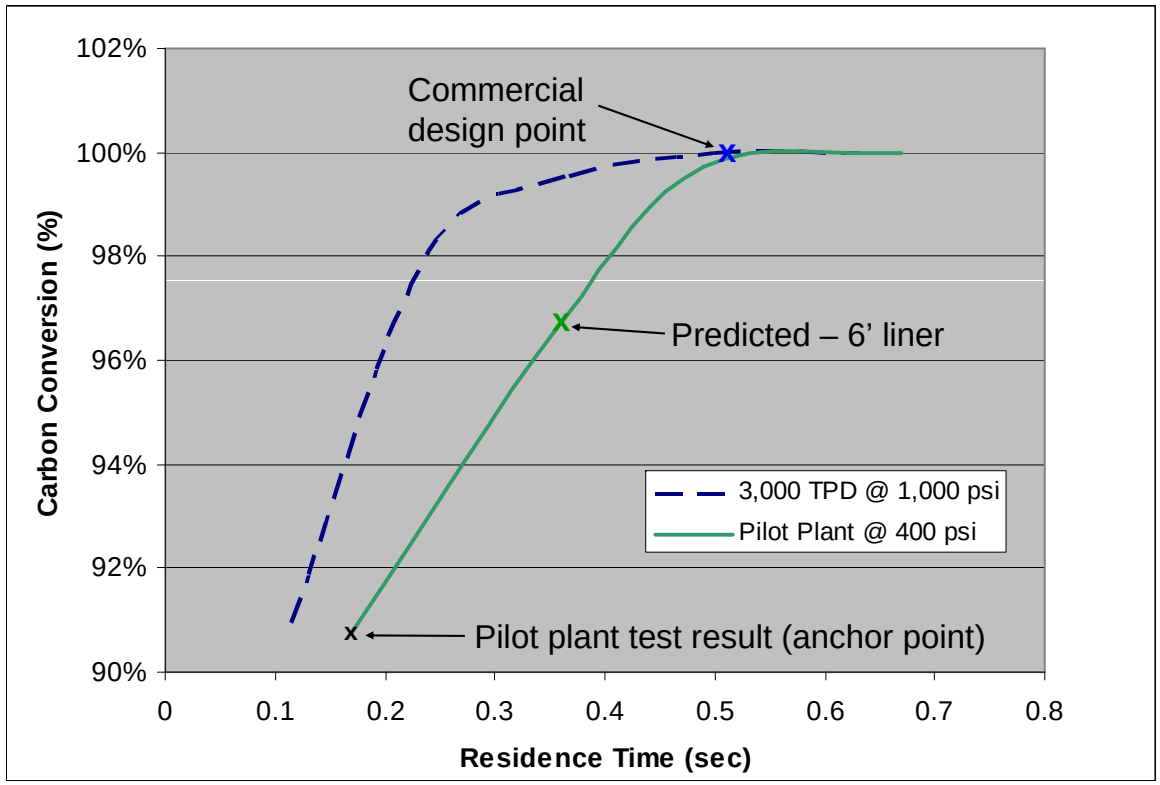

**Mass Balance Period**

- 6 hr duration
- 99% mass balance
- 3 ft gasifier length

# Protective Slag Layer Formation on Liner Surface

**Slag layer deposited throughout gasifier (view looking up from gasifier outlet)**

# Predicted Gasifier Performance – Pilot Plant & Commercial Scale




Carbon Conversion
Test Results
Illinois #6 Coal
Short Liner Configuration

| Condition | Predicted | Actual |
|---|---|---|
| **Nominal** | 90.7% | 90.8% |
| **Low O2** | 85.3% | 84.5% |
| **Low Flow** | 88.7% | 90.4% |
| **High O2** | 93.3% | 93.6% |
| **High Steam** | 90.8% | 91.3% |

- **Short Liner Configuration Tests Confirm Performance Model**
- **Data to Validate CFD Model in the Near Future**

# Pilot Plant Test Summary

- Hot fire testing initiated December 2009
- Short duration checkout tests completed
  - 46 tests with Illinois #6, Oil Sands Petcoke, Alberta sub-bituminous coal
  - 36 hours of test time
- 150 hours of long duration testing on Illinois #6 coal completed
  - 144 hours of operation in 181 hour window
  - Eight operating set-points completed
  - Material balances close within ± 2%
- Six additional long duration tests to be completed by Q1 2011
  - Illinois #6, Oil Sand Petcoke, and Alberta Sub-Bituminous coal
  - Three foot liner and six foot liner configurations

**Pilot Plant Gasifier performance is meeting expectations**

# Feed System and Pump Test Facility at EERC

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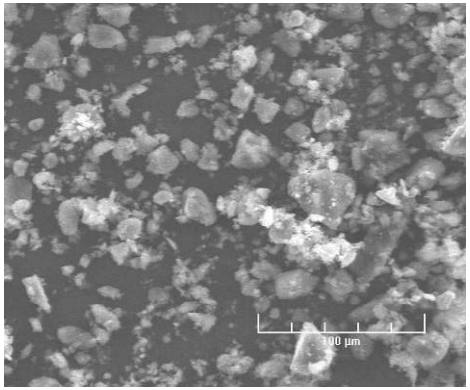
- Initial Capability - 400 TPD (2007)
- Growth - 600 TPD (2010)
- Flow Splitter Tests in 2007-2008
- Pump Tests to Start in 2011

**Objective is to obtain data for the commercial scale demo plant**

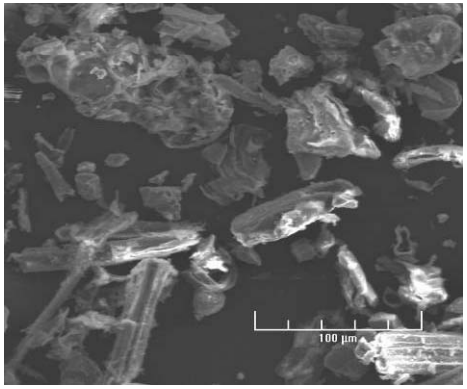
**Test Objectives**

- Feed System
  - Ultra-dense flow (no plugging)
  - Flow splitters (uniform distribution)
- Solids pump
  - Discharge 400 TPD at 1200 psi
  - Twice the efficiency of lock hoppers
  - Obtain life data (erosion rates)
- Multiple feedstocks (standard utility grind)
- Validate computer models
- Refine operating procedures

# Biomass/Coal Blends Study




-200 Mesh Illinois #6 Coal




-200 Mesh Corn Stover

CS: Corn Stover
SWG: Switch Grass
NDL: North Dakota Lignite

**Test Program Study:**

- Matrix of 36 blends selected for lab scale analysis and evaluation
  - Biomass - Corn Stover, Switch Grass, and Wood Waste (Saw Dust)
  - Coals - Illinois #6, PRB, and North Dakota Lignite
- Conducted study of IGCC performance with Biomass/Coal blends
- Key Cost Drivers
  - Biomass Harvesting and Transportation
  - Biomass Preparation (Milling & Drying)
  - Need $75/ton CO2 Off-set to match 100% coal fed

| Feedstock (Blend Ratio) | Ill #6 100 | Ill#6/CS 90/10 | NDL/CS 75/25 | PRB/SWG 50/50 |
|---|---|---|---|---|
| Feedstock Flow Rate (TPD) | 2,890 | 3,010 | 4,140 | 4,250 |
| Net Power Output (MWe) | 381 | 376 | 335 | 342 |
| Net HHV Efficiency (%) | 42.0 | 41.6 | 35.7 | 35.3 |
| Feedstock Cost (%) | 15 | 16 | 24 | 34 |
| Credits & By-Product Sales (%) | (1.3) | (3.5) | (8.7) | (18.5) |
| CO2 Avoided (TPD) | 0 | 505 | 1,420 | 3,570 |
| Levelized Cost of Electricity (%) | 100 | 106 | 128 | 127 |

**Biomass blends offset $CO_2$ emissions ~10% - 40%, but with increased electricity costs**

# Acknowledgement


- **Development of the Dry Solids Pump is supported by the U.S. Department of Energy.**
- **Energy and Environment Solutions is the strategic energy technology arm of the Alberta Government in the Ministry of Advanced Education and Technology. Its mission is to enhance the development of Alberta's energy resources through investment in research, technology and innovation in partnership with industry.**
- **However, the opinions, findings and conclusions expressed herein are those of the authors**


# Questions?