Novel Approach for Biomass Synthesis Gas Cleaning for Liquid Fuel Applications

WBS 3.2.5.9

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Thermo-chemical Platform Review

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CERAMATEC TOMORROW'S CERAMIC SYSTEMS

Western Research INSTITUTE

EMERY ENERGY COMPANY

Project Overview

Timeline

- Start Date – 9/30/2008
- Completion Date – Dec 2012
- Construction – 100% complete
- Project – 100% complete

Budget

Total Project Funding
  $1,734,459 DOE
  $1,853,350 Contractor
Funding received in FY11
  $293,161
Funding for FY12
  $137,102.84

Barriers Addressed

1. Tt-C – Gasification of Wood, Biorefinery Residue Streams and Low Sugar Biomass
2. Tt-F – Syngas Cleanup & Conditioning
3. Tt-H – Validation of Syngas Quality

Partners

- Western Research Institute
- Ceramatec
- Idaho National Laboratory (sampling via FWP)

Goals and Objectives

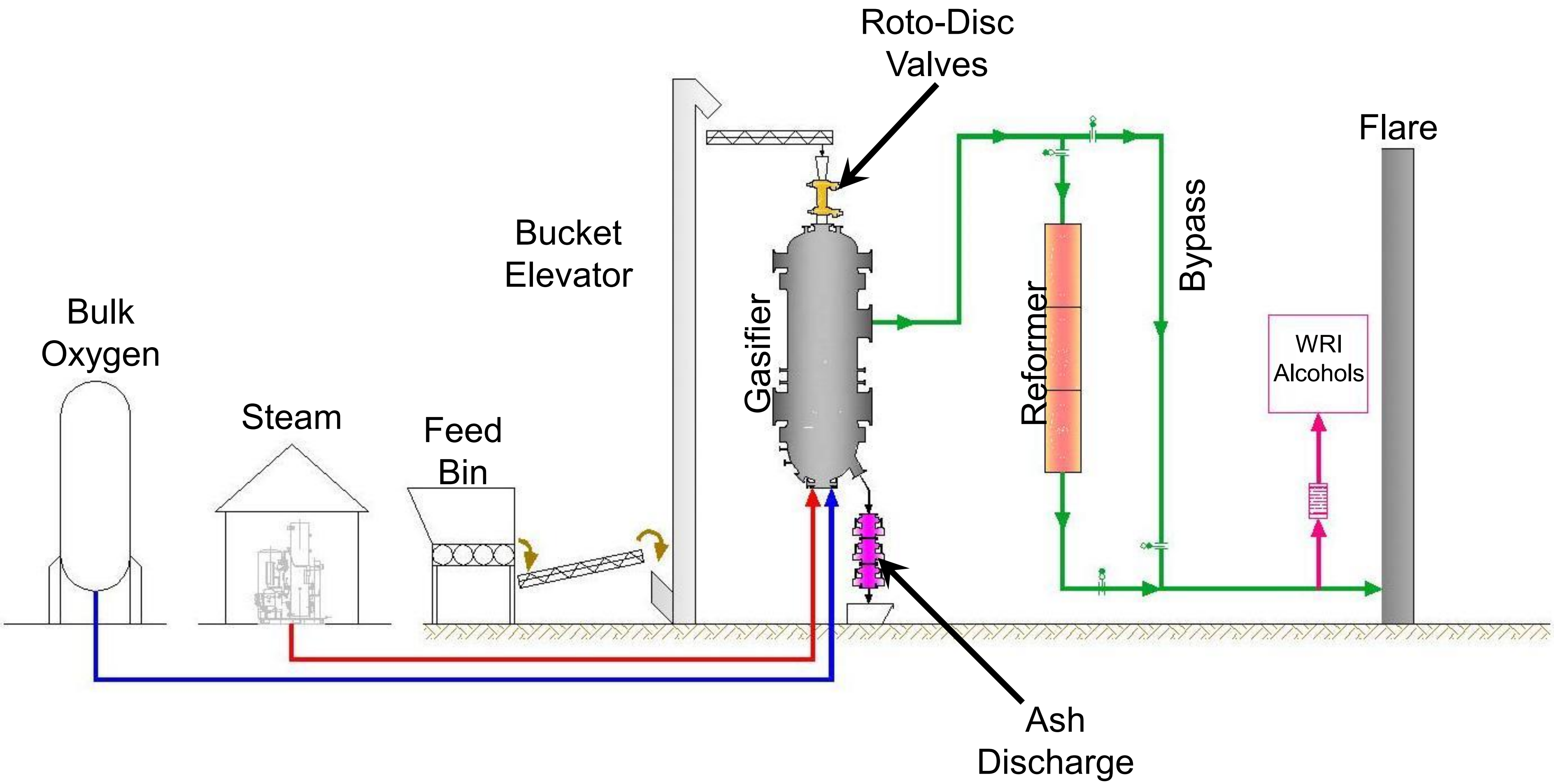
1. Demonstrate the ability of a cold plasma reformer to destroy tars and oils in syngas produced by biomass gasification.
   - Obtain operating data that documents destruction and provides a heat and mass balance. Use these to determine cost benefits relative to alternative processes.
   - Optimize the operation of the cold plasma reformer

Success will eliminate the need for catalyst reforming/ tar removal by water quench

2. Use Syngas cleaned by the cold plasma reformer for liquid fuel production
   - Obtain operating data in an existing liquid fuel synthesis pilot plant
   - Identify commercial opportunities
   - Continue reformer data analysis to identify possible process improvements.

1 - Approach

Flowsheet



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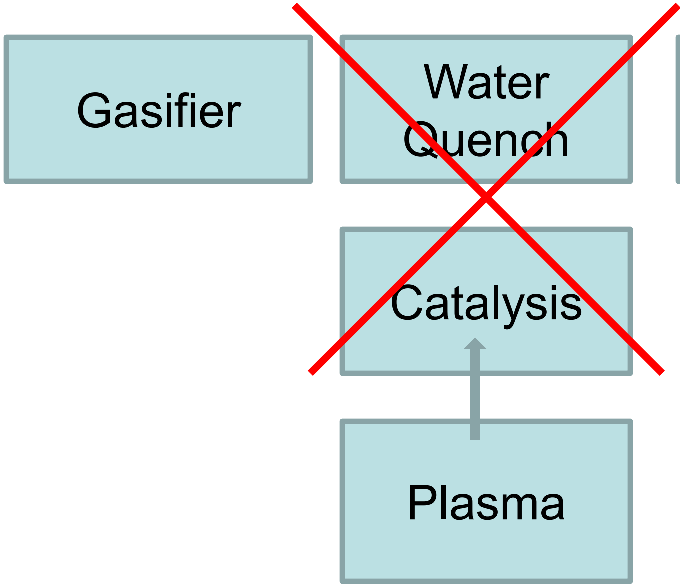
2 - Technical Accomplishments/Results



Completed Tasks

1. Installed pilot plant
2. Modified plasma reformer design
3. Built & installed plasma reformer
4. Startup
5. Ran gasifier and obtained data
6. Submitted Report

2 – Technical Accomplishments (cont'd)

Completed Installation

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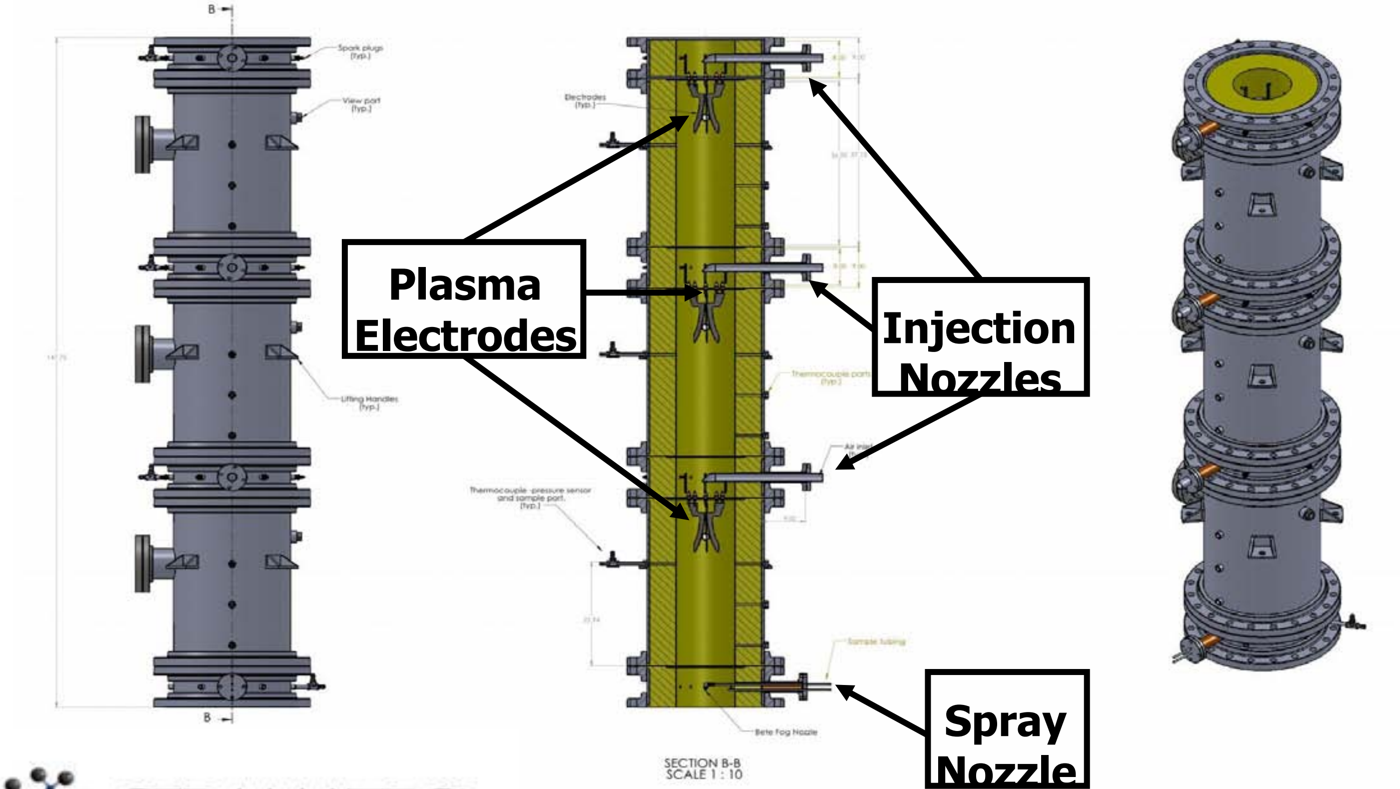
2- Technical Accomplishments (cont'd)

In-situ plasma reformer assembly

3-Stage plasma with quench stage



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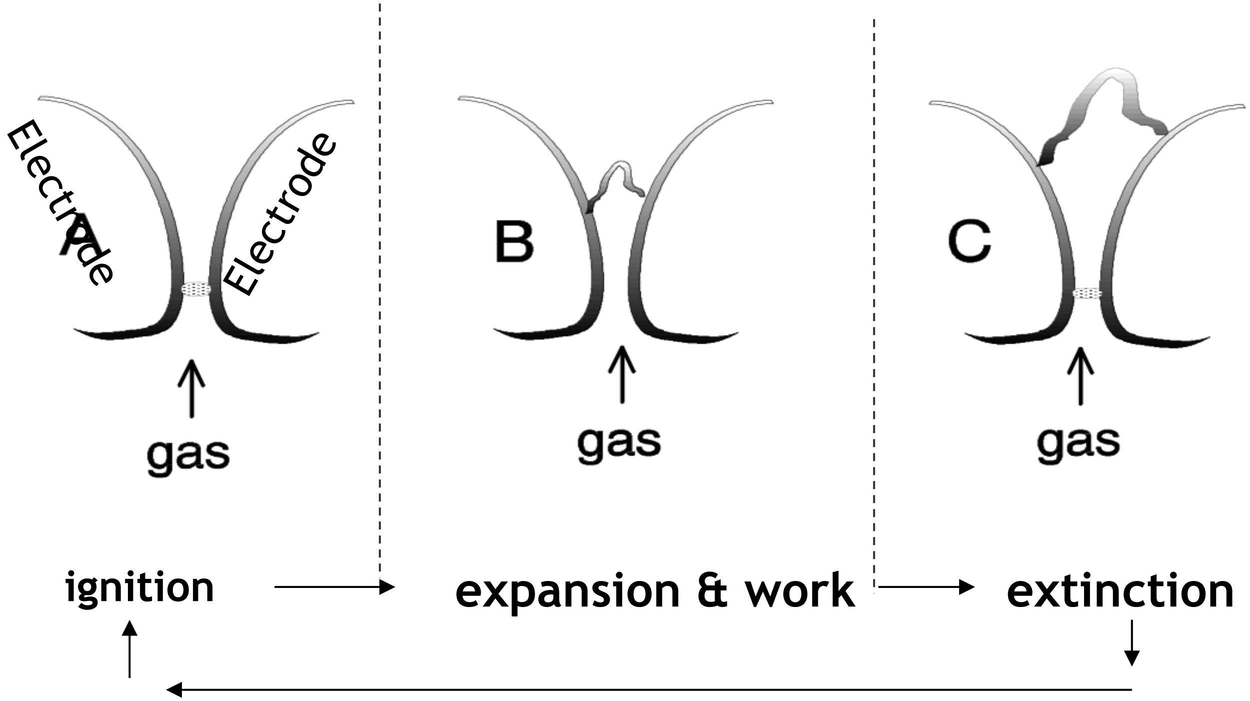
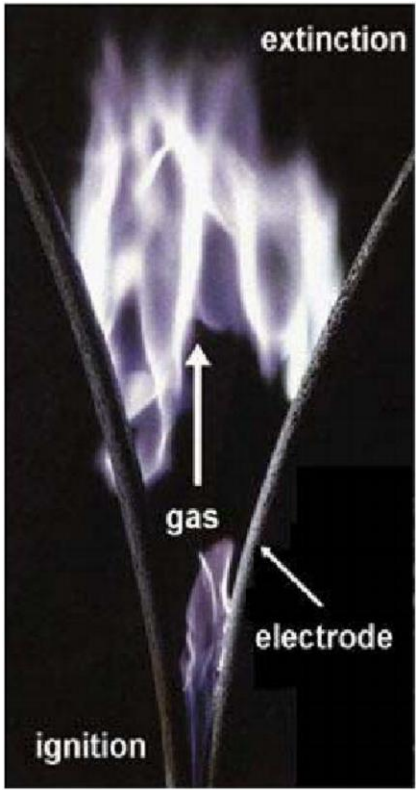
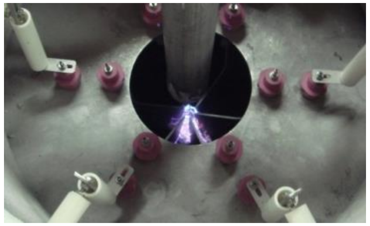
2 - Technical Accomplishments (cont'd)

Cold Plasma GlidArc Operation

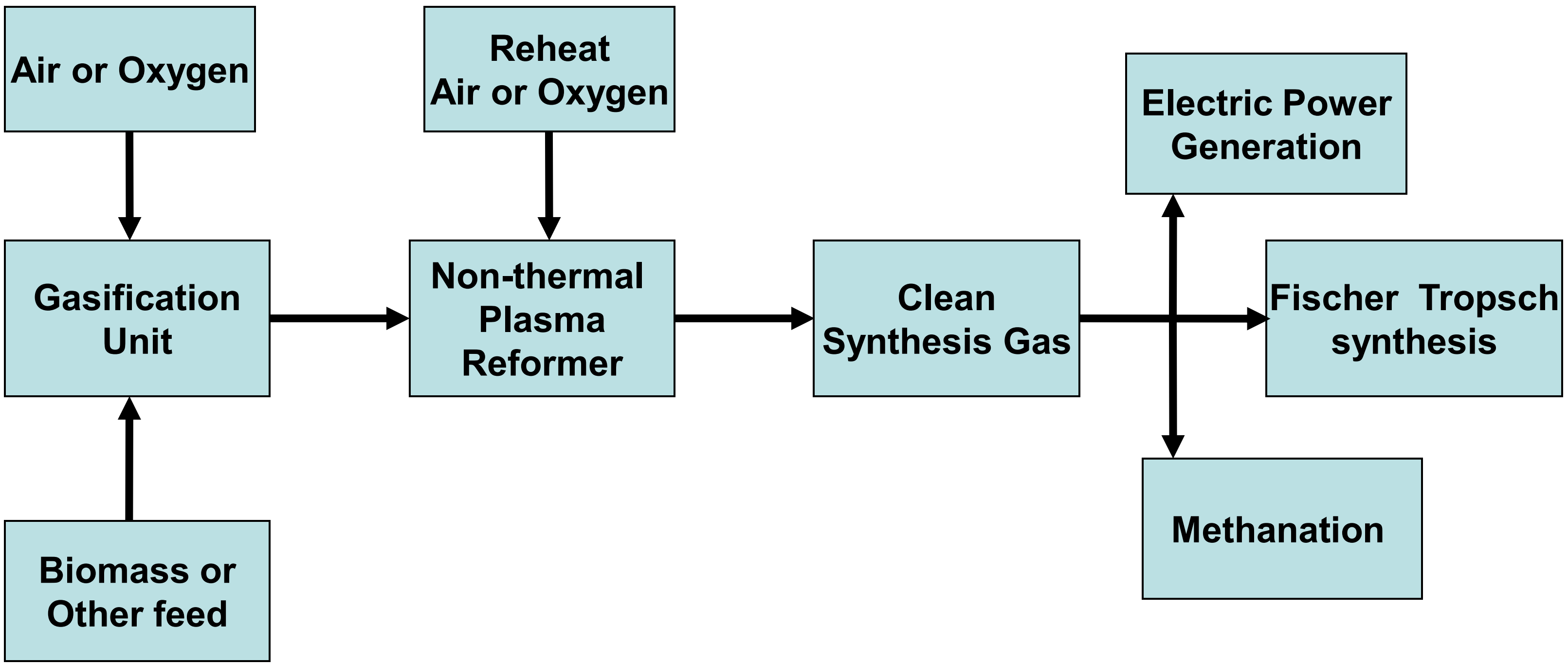






2 - Technical Accomplishments (cont'd)

Directly reform tars & oils



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2 - Technical Accomplishments (cont'd)

Laboratory scale plasma reformer

Simulated gasifier stream

- Bottled synthesis gas
- Toluene injection
- Steam, O_2 ,or air to obtain temperature
- GC analysis of toluene destruction and CGE

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2 - Technical Accomplishments (cont'd)

Best combination

	Dry Gas	Air In	O_2 In	H_2O In	Toluene In
Run	L/min	L/min	L/min	g/min	g/min
4	50	52	0	1.7	5.9

			Mole %	Output			
Run	H_2	N_2	CO	CO_2	Toluene	CH_4	H_20
4	12	54	21	7	0	.3	6

	LHV Gas In	LHV Gas Out	Thermal Eff	Toluene
Run	kW	kW	Percent	% Destroyed
4	5.02	5.87	117	100

- **Run 4 had good destruction and good efficiency**

2 - Technical Accomplishments (cont'd)

- Conversion of BTX and other hydrocarbons very good in laboratory
  - 92% methane (near equilibrium limit)
  - 96% ethane
  - 100% (to detection limit) of other C2-C4
  - 98% benzene
  - 99% toluene
  - 100% (to detection limit) of xylenes

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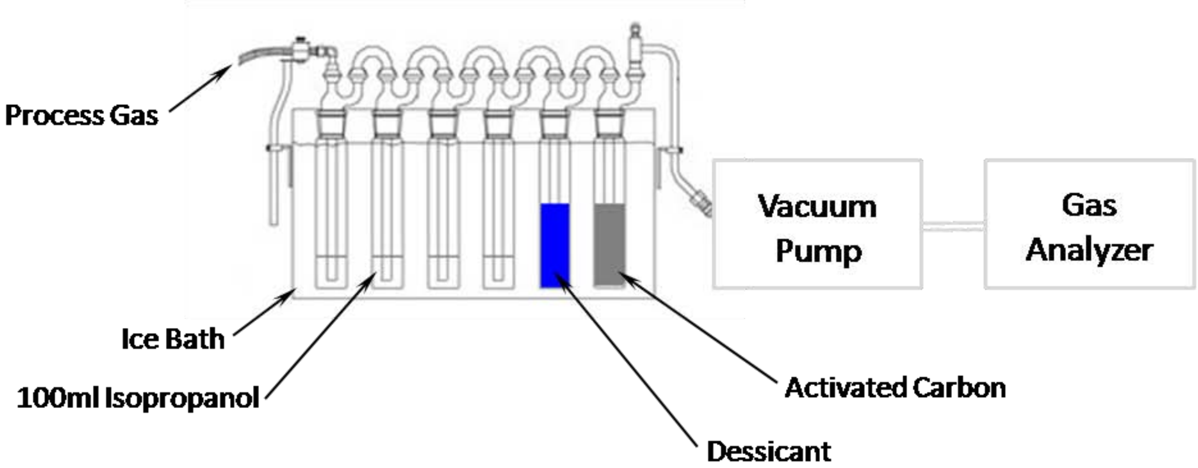
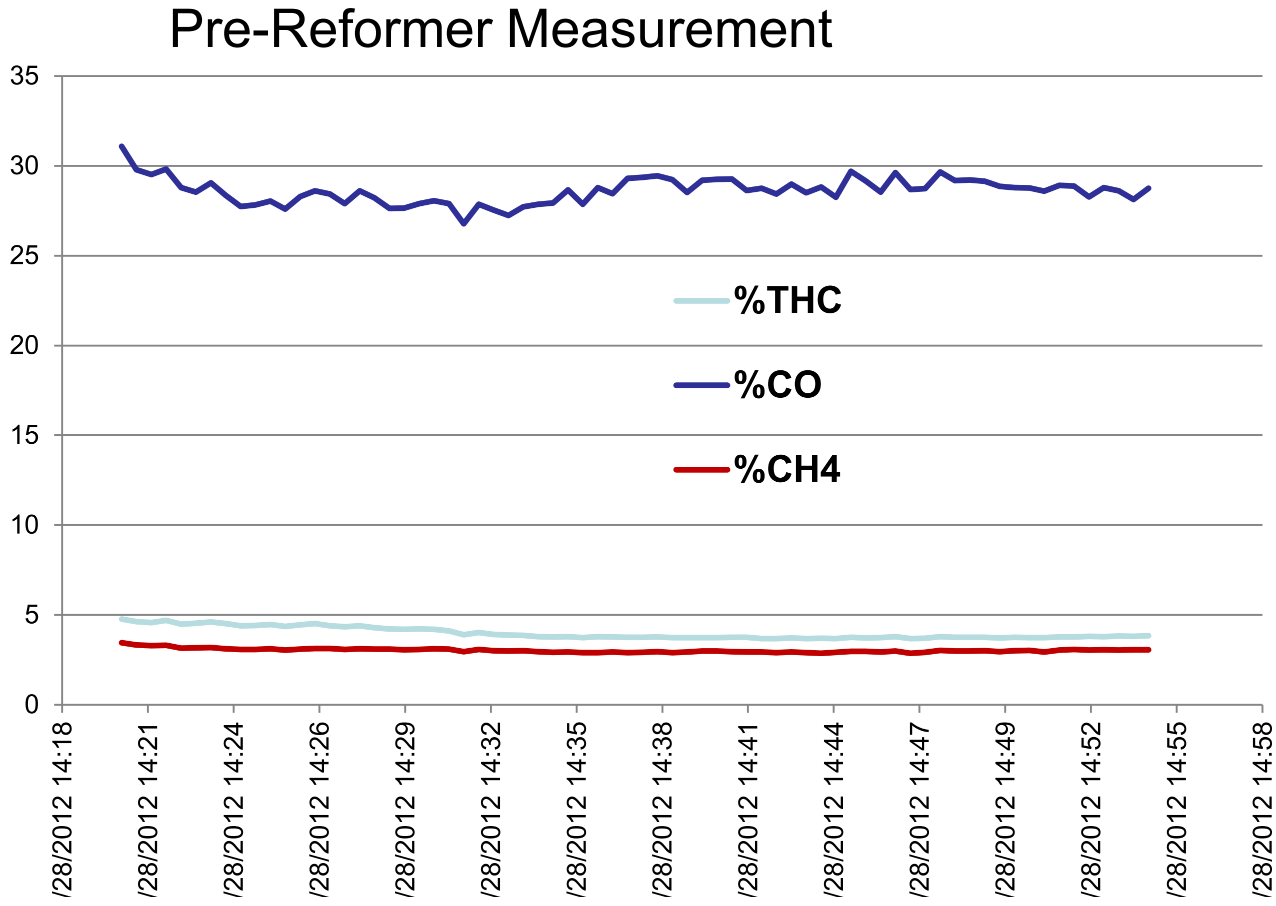
2 - Technical Accomplishments (cont'd)

- INL on-site testing of Emery Gasifier Reformer
  - Sample pre- and post-reformer
  - Collect impinger train samples and CEMS
  - Survey relative concentrations before and after reformer
- Test Equipment
  - Continuous Emissions Monitoring (CO, CH4, THC)
  - IPA impinger train samples for semi-volatiles



2 -Technical Accomplishments (cont'd)



- Gasifier generally operating at steady state
- THC represents sum of CH_4 and other hydrocarbons converted to CH_4
- Noncondensible THC gases range from 0.5-1.5% above CH_4 when converted to CH_4-equivalent

2 – Technical Accomplishments (cont'd)

- Gas bag samples (foil bags) collected – results support CEMS results

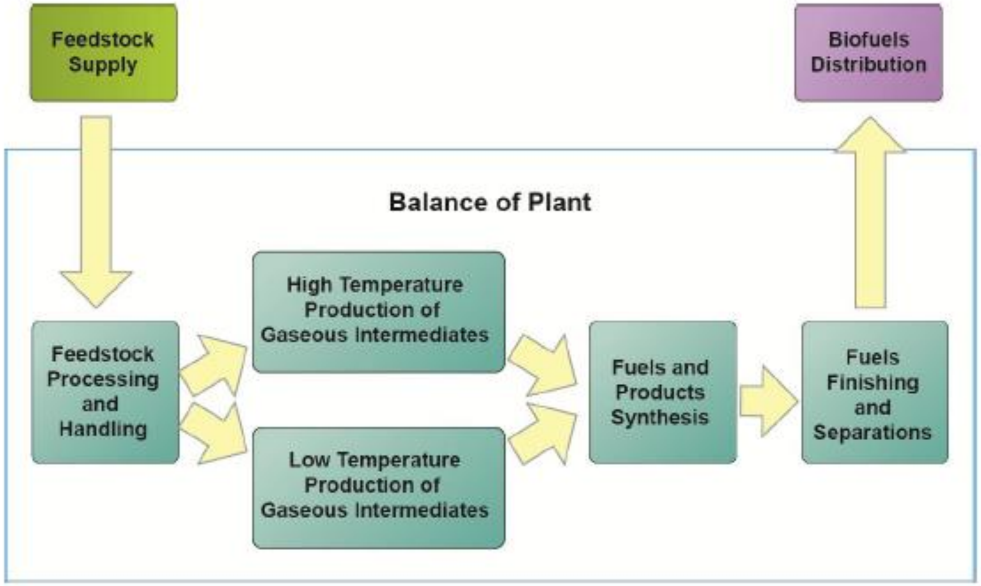
Corrected Samples:	H2	CO	CO_2	Methane	Ethane	Ethene
Mean Pre-reformer	30.03	31.35	29.19	3.44	0.15	0.49
Corrected Post Reformer	28.80	35.57	26.24	3.69	0.13	0.65

- Liquid Impinger Samples
  - Polynuclear aromatic compounds are generally reduced
  - Styrene (intermediate product of naphthalene decomposition) appears to increase as naphthalene decreases

Compound:	Pre-Reformer	Post Reformer
Acetic Acid	34697	53924
Toluene	69729	48902
Styrene	9455	15910
Phenol	24289	23763
Benzene, 1-propynyl-...	53432	39708
Napthalene	130962	76698

3 - Relevance

- The expected output of the project will enable the large-scale production of cleaner syn-gas that is more compatible with down-stream processes for the production of energy or liquid fuels.



From MYPP 2012

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3 – Relevance (cont'd)

- Program Mission:
  - *"Transform our renewable biomass resources into commercially viable, high-performance biofuels… through targeted research, development, demonstration, and deployment supported through public and private partnerships.*
  - *Enable sustainable, nationwide production of advanced biofuels*
- This project focuses on demonstration and deployment of a full-scale biomass conversion platform for production of a high quality gaseous intermediate.
- This addresses specific areas of the MYPP 2012:
  - Gt. C. High-Temperature Gas Production from Biomass
  - Gt. F. Gas Cleanup and Conditioning
  - Gt. H. Validation of Syngas Quality

4 - Critical Success Factors

- Critical success factors include the ability of this process to economically and efficiently eliminate unwanted heavier hydrocarbons from the syngas stream.
- Potential challenges:
  - Biomass feed specifications can affect overall quality of syngas
  - Process parameters must be explored to optimize production and process efficiency.
- This project is continuing to demonstrate viability in the production of biofuels, and continuing work will further demonstrate the importance of this technology for biofuels and bioenergy production.

5 - Future Work

- **No Future Work is Planned**

Summary

- Plasma Reformer:
  - Meets objectives of BETO per MYPP 2012
  - Technology demonstrated on full-size system
  - Work continues with other partners

(Not a template slide – for information purposes only)

- The following slides are to be included in your submission for Peer Evaluation purposes, but will **not** be part of your oral presentation
- You may refer to them during the Q&A period if they are helpful to you in explaining certain points

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Project Delays

- Project was delayed twice due to weather and the need to make additional gasifier modifications.

TASK	PLANNED - LAST PEER REVIEW	TASK ACTUALLY INITIATED
Commissioning	May 2011	December 2011
Initial Runs	June 2011	August 2012
Reformer Runs	September 2011	November 2012

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