Quarterly Technical Progress Report – Phase I

COOPERATIVE AGREEMENT
DE-FC26-00NT40899

Calla Energy Biomass Cofiring Project

March 2003

CONTRACTOR NAME
Gas Technology Institute
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PERIOD OF PERFORMANCE
From: January 1, 2003
To: March 31, 2003

CONTRACT PERIOD
From: September 25, 2000
To: September 30, 2003

ABSTRACT

The Calla Energy Biomass Project, to be located in Estill County, Kentucky is to be conducted in two phases. The objective of Phase I is to evaluate the technical and economic feasibility of cofiring biomass-based gasification fuel-gas in a power generation boiler. Waste coal fines are to be evaluated as the cofired fuel. The project is based on the use of commercially available technology for feeding and gas cleanup that would be suitable for deployment in municipal, large industrial and utility applications. Define a combustion system for the biomass gasification-based fuel-gas capable of stable, low-NOx combustion over the full range of gaseous fuel mixtures, with low carbon monoxide emissions and turndown capabilities suitable for large-scale power generation applications.

The objective for Phase II is to design, install and demonstrate the combined gasification and combustion system in a large-scale, long-term cofiring operation to promote acceptance and utilization of indirect biomass cofiring technology for large-scale power generation applications.

GTI received supplemental authorization A002 from DOE for additional work to be performed under Phase I that will further extend the performance period until the end of February 2003. The additional scope of work is for GTI to develop the gasification characteristics of selected feedstock for the project. To conduct this work, GTI assembles an existing “mini-bench” unit to perform the gasification tests. The results of the test will be used to confirm or if necessary update the process design completed in Phase Task 1

During this Performance Period work efforts focused on conducting tests of biomass feedstock samples on the 2” mini-bench gasifier. GTI determined that the mini-bench feed system could not handle “raw” biomass samples. These clogged the fuel feed screw. GTI determined that palletized samples would operate well in the mini-bench unit. Two sources of this material were identified that had similar properties to the raw fuel. Testing with these materials is proceeding.

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INTRODUCTION

The Gas Technology Institute, GTI, has assembled a team to perform this project. The team includes Calla Energy Partners, who is providing cost sharing resources. Calla is a developer of energy projects, and plans to generate steam and electricity from the completed facility in an industrial park to be located in Estill County Kentucky. Biomass in the form of saw dust and wood chips shall be acquired from lumber mills located in the region. Coal waste from the impoundment ponds at the site is planned as the cofiring fuel.

GTI shall work with CARBONA and NEXANT to develop a design for a complete gasification facility capable of delivering low-Btu fuel gas, LCV, to a boiler to be provided by Calla. GTI shall also design a dual-fuel natural gas/LCV gas burner to provide clean, high-efficiency combustion to be installed in Calla's boiler.

EXECUTIVE SUMMARY

Contract Objectives

This project is to be conducted in two phases. The objective of Phase I is to evaluate the technical and economic feasibility of cofiring biomass-based gasification fuel-gas in a power generation boiler. Waste coal fines are to be evaluated as the cofired fuel. The project is based on the use of commercially available technology for feeding and gas cleanup that would be suitable for deployment in municipal, large industrial and utility applications. Define a combustion system for the biomass gasification-based fuel-gas capable of stable, low-NOx combustion over the full range of gaseous fuel mixtures, with low carbon monoxide emissions and turndown capabilities suitable for large-scale power generation applications. The design of the gasifier will be confirmed with mini-bench scale testing of the fuels selected for the project.

The objective for Phase II is to design, install and demonstrate the combined gasification and combustion system in a large-scale, long-term cofiring operation to promote acceptance and utilization of indirect biomass cofiring technology for large-scale power generation applications.

Current Activities

During this Performance Period work efforts focused GTI determined that the mini-bench feed system could not handle "raw" biomass samples. These clogged the fuel feed screw. GTI determined that palletized samples would operate well in the mini-bench unit. Two sources of this material were identified that had similar properties to the raw fuel. Testing with these materials is proceeding.

Technical Approach Changes

None

EXPERIMENTAL
Project Tasks

Task 1.0 Phase I - Feasibility Study

The objective of Phase I is to evaluate the major technical and economic factors determining project viability and to define the specific fuel sources, fuel handling requirements, gasification system and combustion system configurations necessary to insure a successful biomass cofiring demonstration. This objective will be accomplished through the following tasks:

Task 0.0. NEPA Information
Calla Energy Partners will provide reports and documentation deemed necessary for DOE to prepare a NEPA review of the project. This information shall describe all anticipated environmental impacts of the proposed project. The NEPA review and approval process shall be completed by DOE before Phase II is initiated.

Task 1.1. Feedstock Evaluation
In this task, GTI and Calla shall identify and fully characterize the available economically viable biomass fuel resources for the plant. Approximately 1000 tons per day of sawdust is know to be available from 3 sawmills within eleven miles of the plant site. Fuel supply and transportation contracts will be negotiated during Phase I to insure adequate primary and backup feedstock supplies for the plant. In negotiating any contracts, realization will be made that the project may end at the completion of the feasibility study and not proceed further. Based on the fuels identified, gasifier sizing, feed handling, feed preparation and gasifier feed system requirements will be defined for the process simulation modeling and the conceptual plant design.

Task 1.2. Process Simulation and Combustion System CFD Modeling
Based on the range of feedstocks identified in Task 1.1, the GTI Team shall perform process modeling to evaluate and optimize plant configuration, reliability and efficiency. GTI will use its proprietary gasification model to develop gasifier heat and material balances, perform gasifier sizing calculations, predict product fuel gas compositions, and define process input and output flow ranges for each feedstock identified and mixtures thereof. NEXANT shall use APEN simulation to model the remaining plant systems and components under consideration using information developed under previous and on-going studies for the US Department of Energy (DOE) to the extent possible, providing a consistent basis of information and methodologies with previous DOE efforts. GTI will use the Fluent Computational Fluid Dynamics software to perform modeling calculations for the FIR low-NOx LCV gas burner design. Fluent modeling has been developed specifically for, and used extensively in, the FIR burner development work by GTI to date.

Task 1.3. Conceptual Plant Design
Based on the feedstock and design configuration modeling results from Tasks 1.1 and 1.2, the GTI team shall develop detailed flow sheets with heat and material balances, performance estimates, and total plant capital cost estimates for the design cases agreed upon. This information will form the basis for the technoeconomic study conducted in Task 1.4.

At the beginning of the conceptual design task, Calla Energy Partners shall prepare a project permitting study identifying all federal, state and local permits required for the entire project through demonstration operations. This study will include a listing of all likely actions necessary to satisfy each permitting requirement, an approximate average time required to obtain the permit based on local experience with similar projects, the likely cost to the project, and the suggested project team member to be responsible for obtaining the permit.

Task 1.4. Technoeconomic Analysis
The capital costs at the total plant cost (IPC) level shall be determined including equipment, materials, labor, indirect construction costs, engineering, and contingencies. Operation and maintenance cost values will be determine on a first-year basis and subsequently levelized on the basis of a 20-year plant book life to form a part of the economic analysis. Quantities for major consumables such s fuels and sorbent will be taken from the technology-specific heat and material balance diagrams developed for each plant application. Other consumables will be evaluated on the basis of the quantity required using reference data. Operation costs are determined on the basis of the number of operators. Maintenance costs are evaluated on the basis of requirements for each major plant section. The capital and operating cost results for each plant case are combined with plant performance in the comprehensive evaluation of the COE. Details of the plant design definition, capital cost estimate, operations and maintenance cost estimate and economic analysis will be reported as follows:

- Plant Design
- Process Flow Sheets (heat and material balances)
- Performance Summary Table
- Overall efficiency and net plant heat rate (HHV basis)
- Summary Capital Estimate including detailed Code of Accounts
- Summary of production costs with details of the following sub-accounts: Fixed O&M, Variable O&M, Consumables, By-product Credit, and Fuel
- COE based on 15-year private sector financing based on 90% capacity factor

Task 1.5. Project Management – Phase I
Project review meetings shall be conducted as required. A topical report shall be prepared at the completion of Phase I that describes the findings of the study. A GO/NO-GO decision on Phase II must be received from DOE before initiation of detailed design and construction.

Task 1.6. Technology Conceptualization
GTI shall prepare a feasibility analysis of the advanced technology, based on their gasification experience. This report shall focus on the potential future opportunities of the proposed technology and other related gasification opportunities for biomass.

Task 1.7 Gasification Characterizations of Selected Feedstocks
GTI shall determine experimentally the gasification characteristics of selected feedstock for the project. To conduct this work, GTI will assemble an existing "mini-bench" unit to perform the gasification tests. The results of the test will be used to confirm or if necessary update the process design completed in Phase Task 1.3. GTI will work closely with Calla Energy Partners to identify suitable materials for testing.

Subtask –1
GTI will identify several feedstocks that are available for long term supply to Call Energy. GTI and Calla will confirm the availability of the feedstock and procure sufficient representative samples for biomass gasification tests at GTI. The samples will be analyzed for their physical and chemical properties prior to selection and procurement.

Subtask –2
GTI will assemble, pressure test, the existing mini-bench scale gasification test unit. The instrumentation and data acquisition systems will be calibrated. Test material will be dried and readied for testing.

Subtask – 3
GTI will conduct gasification tests of the selected feed materials. These will characterize the gasification temperatures, steam/feed ratio, air/feed ratio, and other key process parameters. GTI will conduct tests to optimize conversion efficiency and determine conditions that minimize oil/tar formation.

Subtask – 4
The results of Subtask 3 will be used to update GTI's gasification computer model. The results of the testing will be used to compare to the design basis used for Task 1.3 and to update the design basis if necessary.

Phase II Plant Design, Construction and Demonstration

Contingent on a decision to proceed based on the results of the Phase I feasibility study, detailed design, construction and demonstration of the biomass gasification–based fossil fuel cofiring facility will be completed in Phase II. This will be covered under a follow-on contract to this agreement.

RESULTS AND DISCUSSION

Task 0.0. NEPA Review
Completed.

Task 1.1 Feedstock Evaluation
Completed

Task 1.2. Process Simulation and Combustion System CFD Modeling
Combustion System
Completed

Gasification System
Completed

Task 1.3. Conceptual Plant Design
Completed

Task 1.4. Technoeconomic Analysis
The final topical report was completed and submitted to DOE.

Task 1.5. Project Management – Phase I
- GTI has continued to manage the work flow to keep the project on schedule.

Task 1.6. Technology Conceptualization
Task Completed

Task 1.7 Gasification Characterizations of Selected Feedstocks
Testing of the 2" unit has continued through this reporting period and is on-going. Early cold tests were performed with a variety of material to determine the ability of the feed system (originally designed for coal) to handle saw dust and other raw products, Chart 1. These materials could not be fed reliably into the gasifier with the existing feed system. A maximum feed rate of only 0.3 lb per hour was achieved. This is due to the small-scale of the test unit, which poses some restrictions on the types of material that can be tested and the conditions under which the tests can be run. GTI determined that the biomass material must be pelletized for the feed system to operate properly. A feed rate of up to 4.5 lb per hour was demonstrated with pellet feeding.

GTI identified two sources of pelletized biomass feedstocks that had very similar chemical properties as the raw material, but were superior in handling characteristics for feeding the biomass into the small-scale system, Table 1. Testing with these two sources of feed materials has begun, one is strictly a hardwood material scrap from furniture manufacturing; the other is a mixture of woods from a particleboard milling operation.

Chart 1. Feed System Test

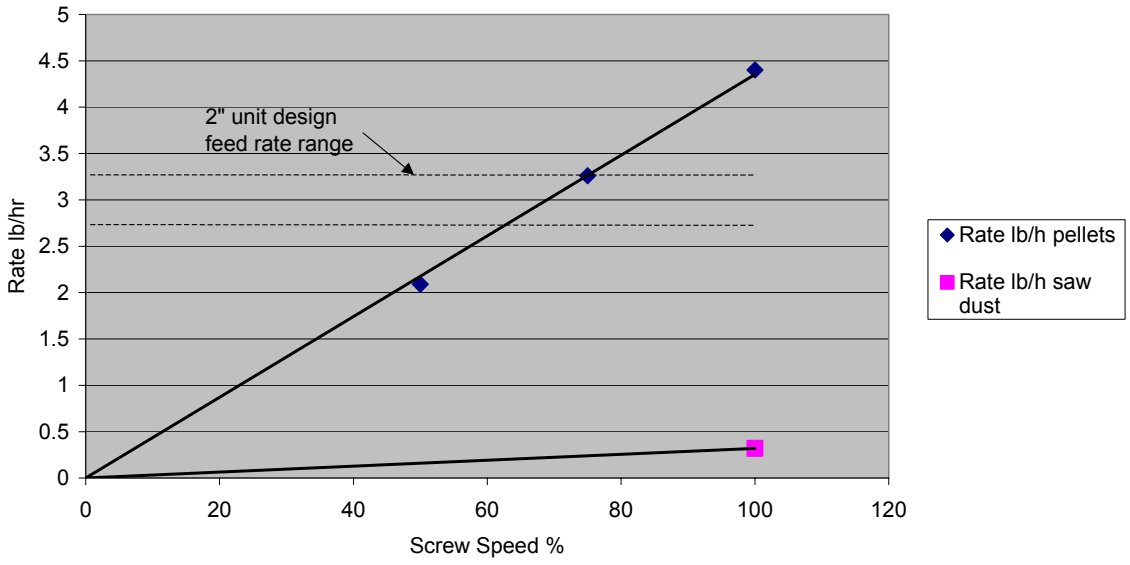

Table 1. Chemical Properties of Feedstock

Component	Mill Saw Dust	Bush Ind. Chip Board Waste	Bush Ind. Wood Pellets	Menard's Wood Pellets
Proximate Analysis				
Moisture %	39.23	35.96	5.53	<0.05
Volatile Matter %	49.35 (81.2 d.b.)	53.21 (83.09 d.b.)	74.85 (79.23 d.b.)	80.61 d.b.
Ash %	0.39	0.27	0.73	0.46
Fixed Carbon %	11.03	10.56	18.89	18.93
Ultimate Analysis				
Ash %	0.63	0.71	0.82	0.44
Carbon %	49.51	48.90	48.65	47.84
Hydrogen %	5.88	6.04	6.03	6.14
Nitrogen %	0.11	3.02	3.75	0.10
Sulfur %	0.02	0.07	0.08	0.01
Oxygen %	43.85	41.27	40.66	45.47
BTU/lb.	8,440	8,480	8,540	8,060

d.b.- dry basis

Preliminary data from two of the 2" unit test runs is contained in the following table (moisture free basis). The test data will be compared to gas compositions predicted using the GTI U-GAS model.

Table 2. Test Run Raw Data

Test No.	WP-041703	WP-020403
Component	Measured Mol% mf basis	Measured Mol% mf basis
Hydrogen	13.7%	13.7%
Carbon Monoxide	11.6%	11.4%
Carbon Dioxide	17.8%	17.3%
Nitrogen	50.4%	52.4%
Methane	4.57%	3.35%
Others (Argon, higher hydrocarbons)	1.93%	1.85%
H2S (other sulfur compounds)	161 ppm	not analyzed

Testing will continue at a pace of one to two tests per week.

The design of the Calla Energy commercial-scale plant GTI is simulating operation at for low-pressure (15 psig). This establishes the testing protocol for pressure and temperature of the test matrix. Current mini-bench testing is at a nominal 15 psig and at the design temperature of 1562 ^{o}F (850 ^{o}C). The test unit will operate at a matrix of test temperatures for model verification. Due to the small size of the unit the reactor temperature will drift ±10 degree Fahrenheit. The air rate is changed to keep the temperature at the design value.

The planned test matrix will test the feedstocks over a variety of conditions outlined in Table 3, below.

Table 3. Planned Test Matrix Overview

Condition	Carbona Design	Minimum	Maximum
Temperature	1562 F	1450	1650
Pressure	15 psig	12 psig	25 psig
Oxygen: Carbon	0.32 mole: mole*	0.25	0.5
Steam: Carbon	0.35 mole: mole*	0.2	0.6

CONCLUSION

Summary Status Assessment And Forecast

The testing of biomass feedstocks is ongoing. The preliminary data will be compared to predicted data from the GTI U-GAS gasification model. Gasification tests will continue at the rate of 1-2 tests per week.

Open Items

None

Future Work Plan Next Quarter:

- Continue gasification testing.
- Analyze results of gasification tests.
- Check U-GAS model prediction versus bench scale plant