CCM

DOE/GO/10224-Q

COMMERCIALIZATION OF THE CONVERSION OF BAGASSE TO ETHANOL

Summary Quarterly Report for the Period January – September 1999

BC INTERNATIONAL CORPORATION

February 2000

PREPARED FOR THE UNITED STATES
DEPARTMENT OF ENERGY
Under Cooperative Agreement
No. DE-FC36-97GO10224

DISCLAIMER

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

Summary Quarterly Report Covering Period 1/99-9/99

Task 1 TVA Bench/Pilot Testing

Scope:

The pilot plant and bench scale work included sugar and ethanol studies in integrated processes, including any vendor tests required.

Background:

These studies were intended to further refine sugar yield parameters which effect sugar yield such as feedstock particle size, debris, acid soak time, temperature, dewatering, and pretreatment conditions (such as temperature, reaction time, percentage solids concentration, acid concentration), liquid-solids separation, and detoxification parameters (such as time temperature and mixing of detoxification ingredients).

Validate and refine parameters, which affect ethanol yield such as detoxification conditions mentioned above, and to fermenter conditions such as temperature, pH adjustment, aeration, nutrients, and charging sequence. Materials of construction will be evaluated also.

Evaluate stillage to determine clarification process and suitability for recycle.

Evaluate lignocellulosic cake for thermal energy recovery to produce heat and electricity for the process.

Support Studies at UF - Toxin Amelioration and Fermentation

TVA work will provide pre-hydroylsates for the evaluation of BCI proprietary methods of toxin amelioration. Pre-hydrolysates from batch studies will allow the determination of the range of allowable hydrolyzer conditions that can be used to produce a fermentable sugar stream.

This information is essential to guide selection of process parameters for refinement and validation in the continuous pretreatment reactor, and for overall process design.

Additional work will be conducted at UFRFI to develop improved strains that are resistant to inhibitors. We are quite optimistic about the long-term prospects for this advancement having recently developed strains with a 25%-50% increase in ethanol production. The biocatalyst platform selected originally, genetically engineered *Escherichia coli B*, has proven to be quite robust and adaptable.

Percent Complete: 100%

Accomplishments:

The objective of Task 1 was to validate the BCI data set. This objective has been achieved, but at a higher than estimated cost.

The higher costs at TVA were due to equipment limitations at the bench scale, requiring the work to be done at the pilot scale which is considerably more expensive. Rotating electrically heated digesters were planned to be used to perform process sensitivity analysis around nominal conditions, and then using this data, perform several pilot scale runs that

validated the bench work. The electric heaters could not provide controlled heat-up and quenching time frames to perform the desired experiments. The bench scale steam guns were also tried, but again, controlled parameters could not be maintained. The bench scale testing was abandoned after the team determined that the pilot plant was probably best suited to perform the required experiments.

The team performed several trial runs in the Sunds digester, but the digester could not achieve the high solids level needed. BCI designed/built a feed tube adapter to allow the use of the Kamyr reactor, which was believed to be capable of handling high solids. Trial runs using the BCI modified feed design proved this capability. The team revised its test plan, and embarked on a test plan that utilized the Kamyr reactor to perform a reduced sensitivity analysis.

During the period of June 1997 through October of 1997, over 25 tons of bagasse and rice hulls were processed under various acid concentrations, temperatures, and residence times. The end result proved that 0.23 grams of sugar could be realized per gram of feedstock using dilute acid hydrolysis.

The higher costs were a result of a longer period to run the pilot plant, plus higher operating costs since 5 people were needed instead of 3 per shift. The extra people were needed to insure feeding of material remained constant.

In order to provide greater confidence in the TVA test results, BCI also utilized Auburn University and LSU for kinetic studies and feedstock testing. These results supported and augmented those performed at TVA.

During the testing performed at TVA, many questions, and small unexpected issues would periodically arise. In order to expedite resolution, BCI stationed a full time Project Manager at TVA through its Joint Venture Partner ICF. This enhanced daily communications and quick resolution of problems, but it raised the cost of the work being done.

UFRFI Scope - 1998:

The original budget submission for Task 1 detailed $200,000 for UFRFI's scope of work which focused on toxin amelioration and fermentability of hydrolysates prepared by TVA under different conditions. The labor portion of this budget ($115,000) was based on one-man year of Dr. Ingram's time, one-man year of Post-doc Associates time, 0.8 man-year of Grad Students time, and about 0.25 man-years of Lab assistant's time (36 man months). The balance of the budget was based on the historical use of supplies at $35,000 per year, and travel of $10,000.

Under Dr. Ingram's direction, his assistants set-up and perform experiments in replicate, record data at six hour intervals (24 hrs/day), analyze results, and draw conclusions. Given the numerous variables in each of the process steps and the need for replicates, this can amount to several thousand specific tests performed in a given year.

BCI will continue the optimization research under the existing agreement with UFRFI. The 1998 budget for this continued effort is based on the same man loading, supplies, and travel costs as 1997 at a cost of $200,000. Specific elements of the 1998 effort included:

- Optimization of neutralization temperature and pH adjustment profiles to minimize sugar degradation, while maximizing sugar utilization by E. Coli KO11.
- Reduction in nutrient requirements for KO11.

- Investigation of alternative, lower cost nutrients.
- Sensitivity of co-mingling hydrolysates from different feedstocks at different concentrations of each.
- Investigation of fermentation/neutralization sensitivity as a function of hydrolysis conditions such as temperature, acid concentration, and residence time.

BCI Consultants (Katzen/Okonski/Gaylor):-1998:

BCI's consultants played a role in supporting the efforts at TVA and other Labs. Some key highlights of this support were:

- Attendance of several project reviews held at TVA to discuss process refinement, and equipment modifications to achieve desired results
- Design and fabrication of feed system adapters to allow the use of bagasse in the Kamyr
- Installation support of fabricated parts
- On-site and Phone support of Pilot Plant trials
- Assistance in refining measurement and analysis techniques

Task 2 Process Engineering

Scope:

The initial objective of Task 2 was to perform process engineering for a single stage dilute acid hydrolysis facility, followed by detail engineering after a project financial closing.

Background:

In 1998 the scope was amended to included the addition of a second stage dilute hydrolysis, but still included the detail engineering following a closing. A revised budget for this task showed higher costs associated with this effort. The main reasons for the increase:

- Increased scope of work needed to perform the process engineering, and to achieve the knowledge sought by the engineers to provide a process guarantee:
- Longer time frame to perform validation testing.
- Vendor validation testing not in the original scope.
- Vendor Request for Quotation and preliminary equipment negotiations.

Detail Engineering is being removed from the scope of work as part of this scope of work refinement, since it was post-closing activity.

Percent Complete: 100% (see Task 9.1 for continuing refinements- in separate report)

Accomplishments:

Validation Testing at TVA:

- Defined and implemented a test plan to validate design assumptions to a level that supports process guarantees

- Provided project management at TVA to enhance communication and problem resolution
- Compiled, analyzed and summarized all validation testing into a comprehensive technical report that concluded there were no technical barriers preventing commercialization of BCI technology. Report is available at BCI for DOE review.
- Process Engineering: (Single Stage Dilute Acid)

Work Completed in 1997: developed preliminary scoping construction documents

- Defined Design Basis for single stage dilute acid
- Defined Work Scope for the Jennings Project
- Completed Process Flow Diagrams (PFD's)
- Developed Equipment List and Sizings
- Completed Preliminary Piping and Instrumentation Diagrams (P&ID's) for estimating purposes
- Obtained vendor pricing estimates for all major equipment
- Performed several iterations of Value Engineering to reduce capital cost
- Performed detailed Cost Estimates (not factored estimates)
- Provided Overall Project Management

Process Engineering: (Two Stage Dilute Acid)

Process Engineering was performed in 1998 to integrate a second stage dilute acid process into the existing Single Stage Process engineering package

The scope of work included:

- Updated Design Basis to include integration of second stage acid
- Updated Project Work Scope for the Jennings Project
- Updated Process Flow Diagrams (PFD's)
- Updated Equipment List and Sizings
- Updated Preliminary Piping and Instrumentation Diagrams (P&ID's) for estimating purposes
- Updated Vendor pricing estimates for all major equipment
- Several iterations of Value Engineering to reduce capital cost
- Overall Project Management

BCI Consultants (Katzen/Okonski/Gaylor) Support to Process Engineering:

To support the Process Engineering effort, BCI's consultants were responsible for reviewing and providing recommendations on process design, detail engineering, and providing the necessary engineering support to resolve questions that pertain to site specific issues. They provided BCI an independent check on progress, costs, and quality of the work being performed. Specifically, BCI has employed these consultants because of their skills and experience in Hydrolysis, Fermentation, Distillation, Power Generation via Biomass Boilers, and Site/Civil/Structural, which has contributed toward value engineering and capital cost reduction.

Task 3 Jennings Site

Scope:

The scope of this task covered site expenses to keep the Jennings site active, and refurbishment of the pilot plant lab.

Background:

The primary objectives of Task 3 were to:

- Maintain the Jennings Site until project closing
- Refurbish existing equipment
- Refurbish the Lab.

Refurbishing of existing equipment is being removed from the scope of work as part of this scope of work refinement, since it was a post closing activity.

Percent Complete: 100% (see Task 9.4 for ongoing site effort – in separate report)

Accomplishments:

The Jennings site has been significantly cleaned up over the past year. All major equipment is accessible, and the site maintained regularly to prevent overgrowth of vegetation in this fertile climate. This effort has allowed the BCI engineering team to better quantify the existing equipment condition, and has resulted in greater utilization of these assets.

The lab was refurbished, and is operational. Refurbishment included:

- Refurbished HPLC
- New Gas Chromatography/Mass Spec
- Lab Benches and hookups
- Vent hoods
- Deep freezer for KO11 storage
- Moisture indicators
- Ovens
- Scales
- Hammer mills
- Lab fermenters

- Lab glassware and reagent grade chemicals

Task 4 Environmental Assessment

Scope:

The scope of this task covered an environmental assessment of the Jennings project, performed under DOE direction by Dames and Moore.

Background:

Dames and Moore was hired by the Golden Field Office to perform an environmental assessment for the Jennings project. Gaylor Engineering assembled a project package which included PFD's, Mass Balances, Design Basis Documents, Local site and permit information, transportation study and responded to various questions that arose by Dames & Moore.

Percent Complete: 100%

Accomplishments:

The EA was completed in 2Q99, and submitted for public and agency comment. The only response came from the Fish, Game, and Wildlife. The issue raised was over the concern that the Jennings project would generate demand for bagasse from farmers. BCI provided a response highlighting that bagasse was a mill waste product, and therefore this was an unlikely scenario. A response to Fish, Game, and Wildlife was issued from the Golden Office, and a finding of no significant issues (FONSI) was issued on August 27, 1999.

Task 5 BCI Project Related Overhead

Scope/Background:

Task 5 was added to reflect the actual project related overhead costs incurred by BCI during 1997. These costs were not included in the original DOE budget submission.

Percent Complete: 100%

Accomplishments:

The updated BCI project related overhead costs were submitted to DOE in the second amendment, and approved.

BCI Overhead expenses for 1998 were prorated in the labor rate for BCI employees assigned to the project. Using 1997 actuals, and adjustments for expected 1998 costs, an overhead rate of 50% was developed. The rate was calculated using the total company payroll costs plus fringes, as the allocation base. Itemized costs in the overhead pool, as indicated, were estimated for a month based on most recent historical costs with modest increases for 1998, and then calculated for the 13-month period covered by this projection.

Task 6 Belle Glade Acquisition:

Scope:

Task 6 reflects the acquisition of the Great Lakes Belle Glade Furfural facility by BCI.

Background:

The Great Lakes Belle Glade Furfural facility was purchased because its equipment could be utilized in the Jennings project at a significantly lower cost. The project schedule was also improved because several pieces of equipment were on the critical path if new equipment were to be purchased.

Percent Complete: 100%

Accomplishments:

The facility was purchased on March 30, 1998 for $2.5 Million Dollars, plus BCI paid a Florida State sales Tax of 6%, or an additional $150,000.

Task 7 Belle Glade Relocation

Scope/Background:

Task 7 defined the effort to dismantle the Belle Glade facility down to the concrete pads, transport equipment that will be re-used at Jennings, disposal of all scrap/waste, and refurbish equipment to specification. This work effort was expected to take a total of 20 weeks to perform.

Percent Complete: 100%

Accomplishments:

The following paragraphs summarize the completion of the work effort associated with the dismantling and relocation of useful equipment from the Belle Glade facility.

The scope of work covered in Task 7 encompassed:

- The dismantling of the Belle Glade facility down to concrete pads
- Inventory and transport of equipment that will be re-used at Jennings or other BCI projects
- Disposal of all scrap and waste.

The projected cost to complete this work was $2,159,800, and estimated to be completed in 20 weeks.

BCI completed the purchase of the Belle Glade facility on March 30, 1998, and began mobilizing a team to begin dismantling the same day. BCI hired the following team to perform the scope of work described above:

ROLE	COMPANY
Project Management	Gaylor Engineering
On Site Project Manager	Louis Shuman (consultant)
Dismantle Contractor	The Industrial Company (TIC)
Transportation Contractor	Venture Trucking

Upon mobilization of the team to the Belle Glade facility, protocols for communication, safety, and roles and responsibilities were established. The first activity performed was to verify the inventory of all equipment per the equipment list, and to designate three disposition categories:

- Primary for Jennings (P)
- Secondary for future projects (S)
- Scrap / salvage

The disposition category was based on discussion with the Jennings engineering team as to whether or not a specific piece of equipment could be used for Jennings or a future project. If equipment could be utilized, then an economic analysis was performed to determine the cost to salvage / transport and refurbish was less than 75% of the cost of new. If so, the equipment was designated for P or S. For equipment designated as scrap / salvage, an economic analysis was performed to determine the best alternative.

In parallel with the equipment classification, BCI and the project team managed the transport of all office, lab, and maintenance equipment and spare parts to Jennings for local storage. Office equipment will be re-used upon completion of the Jennings project; all lab equipment was re-installed to support the pilot plant work effort; the maintenance equipment and spare parts were also put into service to support pilot plant activity.

The dismantling effort began in earnest the second week of April, 1998. The main structure was dismantled from the top down. The equipment was brought to ground level; it was either loaded onto a truck for transport to Jennings, or put in an appropriate salvage pile. Attached with this report is a Bill of Lading Summary by truck load, with the inventory ID for each piece of equipment. By job end, there was 126 truck loads from Belle Glade to Jennings. The last load left Florida on July 10, 1998.

Clean up of the site was performed during the first two weeks of July. All clean up activity was complete by July 16, 1998, and the entire team demobilized from the site. The effort took less than the 20 weeks estimated. In summary, the entire task scope was performed in less time, and for approximately $400,000 less than the $2.1 million budget estimate.

BCI Consultants (Katzen/Okonski/Gaylor):

To support the dismantling effort, BCI's consultants will provided periodic on-site visits to insure the dismantling is performed to contract specifications, and to become familiar with the various pieces of equipment. The dis-assembly experience will be invaluable during the refurbishment and re-assembly at the Jennings site.

Costs Incurred for Tasks 1-7: ***(as of 12/17/98)***

Total $12,726,805 DOE Share: $6,000,000 BCI Share: $6,776,805

Task 8.0 Closing Costs (This task was deleted and funds rolled into task 9.0.)

(It is being provided here for continuity.)

Background:

Task 8 was defined as the expenses associated with closing on the financing of the Jennings Project. Upon closing, activities were to include purchase of product insurance, mobilization of contractor(s) at the plant site, the purchase of "long term delivery" equipment, site preparation for the construction activities and on-going direct labor and plant support costs.

A project closing did not occur as planned in 1Q99 due to several factors involving perceived risk by several financial groups. BCI has continued to pursue alternative financing arrangements in 1999, and expect to close the project in 4Q99. Task 9.0 defines the activities associated with preparation for closing. BCI requests that, consistent with DOE objectives, the funds originally allocated for task 8 be re-directed to task 9.0 to allow for continued efforts to secure financial closing. Task 8 has been deleted from the scope of work for this contract, since it has post closing activity. For reference, the scope of work for Task 8.0 as submitted in January 1999 is detailed below:

Percent Complete: 0%

Scope of Work previously submitted:

In previous cost sharing activities, 7 tasks have been described and executed which relate to the commercialization of biomass to ethanol technology using a patented, genetically engineered microorganism. This commercialization includes a $74 million Engineering, Procurement and Construction (EPC) contract for a facility to be built/retrofitted in Jennings, Louisiana, and the first 7 tasks were specifically associated with that effort.

The commercialization effort has progressed to the point where the funding sources (lending and equity) have been identified, business issues have been developed and are essentially agreed upon, and due diligence/documentation is proceeding towards financial closing, which includes completion of a number of requirements. In the context of this $74 million project, over the next several months (through August 1999) the closing is expected to be imminent. Upon closing, activities will include purchase of product insurance, mobilization of contractor(s) at the plant site, the purchase of "long term delivery" equipment, site preparation for the construction activities and on-going direct labor and plant support costs.

Contractor – Mobilization

At financial closing of the Jennings Project, the contractor will immediately start mobilizing equipment and the engineering and construction teams that will be assigned to the project, including inter alia:

- Assembling and transferring Mobile equipment
- Setting up temporary living quarters and offices
- Setting up various site utilities such as electric, gas, and telephone that are the responsibility of the contractor
- set-up of temporary site trailers, purchase of small tools, expendables, and safety equipment

- Setting up appropriate Insurance
- Setting up appropriate bonding

Purchase of Long Term Delivery Equipment, or Long Lead Items

The Jennings Project will be managed on a fast track schedule basis. Mechanical completion is expected in 17 months from notice to proceed. In order to support this schedule, deposits for long lead items are needed to procure the new equipment, and reserve shop time at these suppliers. This has become necessary due to the strong national economy, which has resulted in longer lead times for equipment and services. The up front deposits (10%) for equipment will minimize schedule risk for the contractor and BCI. Long lead items are estimated to cost $10,000,000, and include

- Biomass boilers/support equipment
- Two natural gas turbines – 4MW/each
- Five distillation columns
- One liquid – solid separation system

Site Preparation:

Site preparation for the Jennings Project encompasses clearing, grading, fencing, security, site drainage, utility relocation, soil stabilization, and structural fill for the main site, plus the clearing, grading, and creation of a bagasse storage area on the new property. This storage area will be built over a gravel base leachate collection pad. The leachate and rainwater run-off will be collected from the pile into a sump for any required treatment. The site preparation is expected to begin within two weeks of a notice to proceed, and be complete by month seven of the project.