

**United States Department of Energy
Federal Energy Technology Center**

A Co-Utilization of Coal with E-Fuel from EnerTech's SlurryCarbTM Process

**Technical Progress Report
Cooperative Agreement
DE-FC26-99FT40296**

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1.0 INTRODUCTION

In August 1999, EnerTech Environmental, LLC (EnerTech) and the Federal Energy Technology Center (FETC) entered into a Cooperative Agreement to develop the first SlurryCarb™ facility for converting Municipal Sewage Sludge (MSS) into a high-density slurry fuel, which could be co-utilized with coal in various industrial applications. Funded primarily by private investors, this program was divided into two major phases, Project Definition (Phase 0) and Design, Construction, and Operation (Phase 1). Project Definition, performed during this reporting period, was designed to define the project from a technical, economic, and scheduling standpoint. Once defined, much of the project risk would be appropriately mitigated thereby providing stakeholders, such as FETC, less risk when investing in the more costly Phase 1, which includes the design, construction, and operation of the first SlurryCarb™ facility.

Since May 1999, EnerTech has made significant progress in the tasks required in Phase 0 for bringing this project to Phase 1. These accomplishments have enhanced the probability for success thereby reducing the risk to the United States Department of Energy's (DOE) for its investment in the project. Phase 0 technical accomplishments include:

- **Locating and securing a project site for the 60 dry ton per day (DTPD) SlurryCarb™ facility;**
- **Locating and securing a project partner who will supply the necessary MSS for the project revenue stream;**
- **Completing the basic engineering of the project, which included value engineering for reducing technical risk and lowering project costs** (*final drawings, detail technical review, test runs on process development unit, fuel production for fuel usage research, and final cost estimate all pending*);
- **Research and a market study necessary for finding a potential fuel user, which included working with General Electric Environmental Research Corporation (EER) with a focus on coal utilization** (*locate actual fuel user and detailed combustion research pending*);
- **Beginning the National Environmental Policy Act (NEPA) process necessary for the DOE involvement** (*final NEPA report pending*);
- **Completing the basic design for the fuel delivery system and developing a research protocol for testing required by the fuel user** (*actual fuel testing pending*); and
- **Locating engineering, procurement, and construction firm (EPC) to provide a fixed price guaranteed schedule for the project** (*EPC contract negotiation pending*).

For this project, a semi-annual technical progress report is required to describe the technical progress made during the duration of the budget period.

2.0 PROJECT SUMMARY

The objectives of the project were to design, construct, and operate a fully integrated Process Design Facility (PDF) incorporating the SlurryCarb[™] technology to generate a carbonized fuel from MSS or other organic wastes and to conduct combustion testing of the product slurry fuel in co-firing applications with coal. Project Definition consisted of six tasks and had an overall objective to provide for project baselining in order to minimize the technical and economic risk associated with the performance of the project. Risk minimization was accomplished by establishing satisfactory management, coordination, and controls essential to the conduct of the project and successfully completing the NEPA review in a timely manner. The six major tasks of Phase 0 included Technical Baselining, Economic Baselining, Schedule Baselining, NEPA Review, Project Management, and Go/No-Go Decision. This phase will culminate in a go/no-go decision for both parties prior to continuance of the project into Phase I – Design, Construction, and Operation. For this reporting period, Phase 0 – Project Definition and its tasks will be described from work performed during the last six months and any problems encountered to work that is planned for the next reporting period.

3.0 WORK PERFORMED DURING REPORTING PERIOD

Site selection and sludge procurements were finalized during this reporting period. The completion of site and sludge agreements was necessary for completion of the remaining tasks of Phase 0. Spectraserv, a large waste hauler in NJ, agreed to lease 1.5 acres of their site to EnerTech and to procure 66.5 DTPD of MSS for 20 years. The site is located in South Kearny, New Jersey.

With the site and sludge supply secured, and based on the Statement of Work in the Cooperative Agreement between EnerTech and FETC, the following goals must be met in the technical baselining phase:

1. Mitigation strategies will be developed and evaluated in order to address the technical issues of the process and the project, which will include re-scoping, re-direction, and/or re-engineering various elements of the project as necessary to reduce the technical risk and economic risk.
2. This work will result in a basic design package, which will form the basis for detailed design.

To accomplish the above objectives, EnerTech needed to add to its team an engineering firm (EPC) and a company capable of addressing technical risk.

In September 1999, AGRA/Simons Engineering (Simons) was selected as the EPC to determine the facility cost estimate for the Technical Baselining in this project. After careful consideration of bids from four EPC firms, Simons was determined as the most cost competitive and provided the best package for overall project success. Simons contributed to Task 0.1 by performing the basic engineering necessary to prepare the Project Management Plan and to complete the Technology Risk Study. From the basic engineering, Simons provided a fixed price turnkey

estimate. The current budget price for the facility is approximately \$20 million (hard costs only). During the current reporting period EnerTech and Simons will work further to reduce the costs of the plant and to integrate the PDF design with the infrastructure existing on the site. Without the work performed by Simons, the tasks of Economic Baselineing, Schedule Baselineing, and Project Management could not be performed.

During the reporting period, Hartford Steam Boiler Insurance and Inspection Company (HSB) was added to the team. HSB's primary function was engineering insight and risk assessment. HSB has engineering knowledge and industry experience to review technological risks and validate a project's technical merit. HSB also works with project managers and financiers to manage technical risks, enhance efficiencies, avoid design problems and otherwise do everything in their power to increase the project's success. More specifically, and more in line with the goals of the technical baselineing, HSB functions as a strategic engineering consultant to management, contributing ideas to refine designs and project structure, to avoid failures and to enhance a project's overall success and business value.

The EnerTech/Simons/HSB team identified the following technical issues as most critical: materials of construction, pressure let-down, the reactor, sludge handling, and wastewater treatment. Materials of construction work concluded that exotic alloys will be needed for the high pressure section because of chlorine content in MSS. Such alloys are included in the project estimate. Simons surveyed vendors in other industries regarding pressure let-down and found several vendors with solutions for this challenge. The reactor and heat exchanger design were concluded with the heat exchanger pressure drop determined. Simons assigned a sludge expert to the project and along with EnerTech's expertise the design addressed issues unique to sludge. Finally, Simons surveyed various vendors regarding the wastewater issues. Simons is not concerned that the BOD/COD levels will be a problem and a final solution will be determined during the next reporting period.

Regarding the basic engineering mentioned above, the EnerTech/Simons/HSB team developed the basic process flow diagrams, P&IDs, and material and energy balances. The basic process flow diagram and material and energy balances are included in Appendix A.

EnerTech has been working very diligently in located a fuel user. As discussed with FETC during the last technical review meeting, EnerTech would need to raise additional dollars for specific fuel testing. In September 1999, EER won a DOE SBIR program to primarily do specific combustion tests for the slurry fuel. Of the total \$750K award, \$150K was sub-awarded to EnerTech to generate the fuel for testing purposes. EnerTech will generate at least 2000 pounds of slurry fuel produced from Spectraserv sludge, and over two phases, utilize the slurry fuel for combustion testing. The first phase would generate data for general combustion characteristics of the carbonized sludge, and the second phase, if budget allows, is expected to generate specific data dependent upon the needs of the potential fuel users, who would provide the baseline for the combustion work done by EER. Fuel production is scheduled for the next reporting period.

EER performed fuel research and market studies for potential fuel users with the main focus towards coal utilization. The team completed the objectives to perform market definition, to locate potential boilers to utilize fuel in the area, and to perform a very general estimate regarding the fuel delivery system. The results from the studies indicated 25 viable candidates, which utilize coal within a 75-mile radius. The list was compiled with information provided by FETC and other industry sources. The team also produced a “fact” sheet to present to potential users in order to determine interest levels. Currently, EnerTech is developing a business plan for locating a fuel user and awaits a proposal from EER for assistance in this search. The fact sheet is included in Appendix B.

Finally, NEPA work was performed by FETC on the Spectraserv site. With the fuel work to be done with EER, the final combustion side of the NEPA evaluation can be concluded. This will be done during the next reporting period.

In addition to co-utilization with coal and to be investigated under this FETC program, EnerTech has found potential for the integration of the SlurryCarb™ technology with another industrial application, known as gasification. EnerTech has submitted several proposals entitled “Advanced Feed Systems for the Gasification of High-Density Slurry Fuels from Low-Value Feedstocks” (under a DOE SBIR solicitation) and “Co-Feeding Upgraded Sewage Sludge Feedstocks for Gasification” with support to Adelphi University (under a DOE solicitation).

Finally, many non-technical accomplishments were made during the reporting period. First, the financial parameters for the project were defined. EnerTech determined the methods for raising the necessary equity and debt to finance the project. All goals pertaining to these activities were accomplished. Also, EnerTech hired Roy F. Weston to perform a market study in New Jersey, which concluded that there was ample MSS in the marketplace at a price to support the project’s economics.

4.0 CURRENT PROBLEMS ENCOUNTERED

Before the completion of the above-mentioned technical accomplishments, decisions and resolutions were carefully orchestrated as to enhance the success of the project, which included special attention to the requirements of the DOE and the financial sources. Problems encountered during this reporting period will be addressed and the solutions will be discussed.

The initial facility cost estimate provided by Simons was in excess of original estimates. This was as a result of several factors: the technical concerns mentioned above, materials of construction, and labor rates in New Jersey. Additional hours were allotted to the value engineering process, which was to re-evaluate certain assumptions made in the basic design in an attempt to reduce costs. To facilitate this effort, a technical review committee meeting was held in Atlanta. Attendees were EnerTech, Simons, HSB, and Spectraserv. The meeting was held on January 27th and the teams are now performing the value engineering tasks assigned to them at the meeting. Indications from this meeting are that the original cost estimate can be significantly reduced.

EnerTech's subcontract with EER is to generate ~2000 pounds of fuel for combustion work by EER. Originally, Hydrocarbon Technologies, Inc. (HTI) was chosen to do the fuel production work for EnerTech. However, initial estimates indicated that the cost of the work would be in excess of \$375K. The sub-award to EnerTech was only \$150K. To resolve these funding issues, EnerTech considered other options such as re-negotiations with EER or HTI to produce less fuel, other facilities similar to HTI, and increasing the capacity of EnerTech's existing Process Development Unit (PDU).

After careful consideration, it was determined that increasing the PDU capacity was the most economical choice with greater long term benefits for the success of the project. With recommendations from Simons and HSB, construction of the new PDU was underway. The operation of the PDU will complete many tasks for this project. First, it will complete EnerTech's fuel production obligations for EER as well as for Task 1.3 in Phase 1. Second, data obtained from the fuel runs will answer several theoretical process questions as well as indicate the slurry carbonization performance of distinct feedstocks and of variable operating parameters. Finally, the PDU will be EnerTech's first modular unit, which can be transported to various locations for further demonstration and testing of this innovative technology.

5.0 WORK PLANNED FOR THE NEXT REPORTING PERIOD

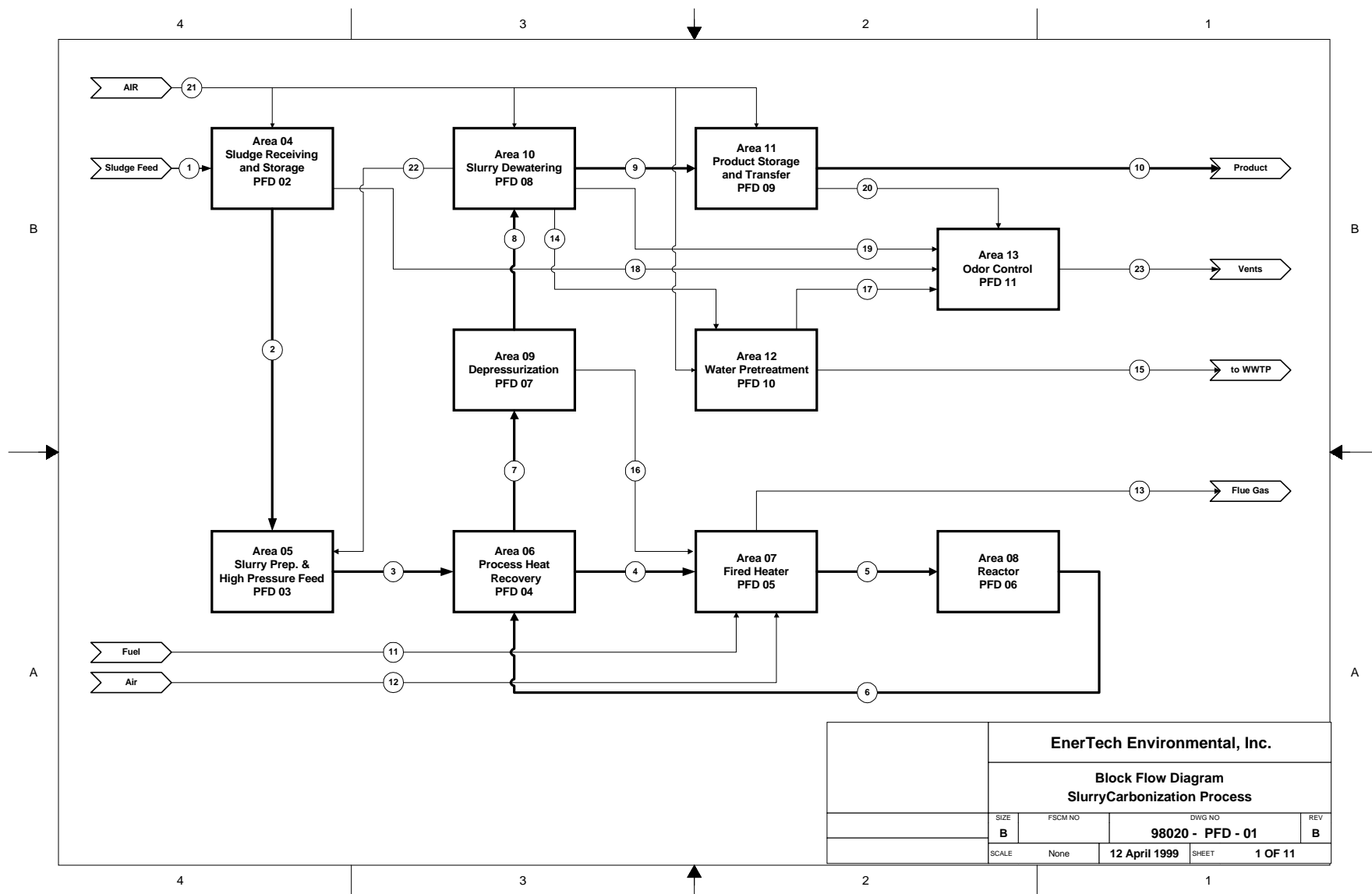
For the next reporting period, EnerTech plans to finalize all value-engineering and estimates in order to complete the basic engineering of the project, and will continue to perform market studies for potential fuel users. PDU construction is scheduled for completion in mid-March with plans for immediate shake-down testing and fuel production by mid-April through July. With the site and sludge agreements complete and fuel production done the NEPA review will be completed. Utilizing the engineering estimate, EnerTech will be able to determine the exact funding necessary to finance the project. The combination of debt and equity will then be raised. EnerTech and EER will continue to seek the fuel user for the NJ project with the goal of finding a user and integrating their boiler characteristics with the fuel testing. EnerTech will also continue feasibility work for gasification. Finally, EnerTech will complete all the necessary reporting for FETC necessary to determine the go/no-go decision.

6.0 ASSESSMENT OF FUTURE PROGRESS

With the successful completion of Project Definition, EnerTech's SlurryCarb[™] facility awaits the next phase, Design, Construction, and Operation, in South Kearny, New Jersey. To date, EnerTech has completed or will complete during the next reporting period, the primary tasks of Phase 0 to bring the project closer to reality. The conclusion of Phase 0 will determine whether or not there is a viable project – indications to date is a resounding “yes.” The current team of EnerTech, AGRA/Simons, Hartford Steam Boiler, and General Electric EER, all committed core competencies, which enhance the project's success. The team continues to be completely focused and committed to delivering a full-scale 66.5 DTPD plant at the end of this project.

APPENDIX A

Project:		New Jersey SlurryCarb Plant		Date:		28-Feb-00	
Project No.		99002		Rev.		C	
				Sheet		1 of 1	
Mass and Energy Balance Summary							
Stream No.	Stream Designation	Input		Output			
		Flow - lb/h	Enthalpy - MM Btu/h	Flow - lb/h	Enthalpy - MM Btu/h		
1	Sludge Feed	27708.3	4.2538E+01				
10	Slurry Product			7246.8	3.4792E+01		
11	Aux Fuel	384.6598	7.5566E+00				
12	Combustion Air	7098.023	9.7953E-02				
13	Flue Gas			9832.2	1.3319E+00		
15	Waste Water			16598.9	9.2242E+00		
23	Vapors, saturated			81348.0	8.4986E-01		
	H2O in Vapors			3894.0			
	Heat of Reaction				5.2684E+00		
21	Ventilation Air	81348.0	8.2320E-01				
	Moisture in Air	1220.0					
Total		117 759.02	5.1016E+01	118 126.93	5.1393E+01		
Enthalpies: based on 60 deg. F, 14.7 psia							



APPENDIX B

Seeking User of Fuel Business Considerations

TESTING OF FUEL	\$500,000 testing program sponsored by the DOE/NSF/EnerTech/UCIG (to be proposed) to focus on conditions of client's boiler – <i>ZERO PAID BY USER</i>
CAPITAL MODIFICATION FOR ACCEPTING FUEL	< \$500,000
COST OF FUEL	On a Btu basis, but <i>SIGNIFICANTLY LESS THAN COAL</i> designed only to recoup transportation costs and capital investment.
HEATING VALUE OF FUEL	On an as received basis the fuel will be <i>APPROXIMATELY 4500 BTUS/LB</i>
QUANTITY OF FUEL	Goal: Phase II to provide <i>UP TO 300 DRY TONS PER DAY</i> within five years To begin, Phase I will provide approximately 30 dry tons per day

E-FUEL CHARACTERISTICS

Proximate, Weight % (at 50% moisture)	
Ash	41.6
Volatile	50.0
Fixed C	8.4
Total	100.00
Sulfur	0.95
Btu/lb, HHV (dry)	9,009
MAF Btu/lb	15,425
Ultimate, Weight % (dry)	
Carbon	45.2
Hydrogen	5.5
Nitrogen	3.8
Sulfur	1.0
Ash	41.6
Oxygen	2.9
Total	100.00
C/H mol ratio	0.68
C/O mol ratio	20.92
C/N mol ratio	13.69
Chlorine, ppm	400
Note: Oxygen by Difference	

Note: E-Fuel data above represents a sample from R.L. Sutton Wastewater Treatment Plant in Atlanta, Georgia. Actual characteristics will vary based on the feed material. The Btu/lb, HHV (dry) can range from 6,800 – 12,000 depending on its ash content.

ELEMENTAL ANALYSIS OF THE ASH (%) OF E-FUEL

SiO ₂	37.46
Al ₂ O ₃	20.32
TiO ₂	1.18
Fe ₂ O ₃	9.08
CaO	9.58
MgO	2.38
Na ₂ O	0.92
K ₂ O	1.32
P ₂ O ₅	9.71
SO ₃	3.30
Cl	0.06
CO ₂	0.39
Total	95.70

SAMPLE OF METALS IN E-FUEL

Arsenic, mg/kg	28.9
Beryllium, mg/kg	<10
Cadmium, mg/kg	11
Chromium, mg/kg	580
Lead, mg/kg	920
Mercury, mg/kg	<0.1
Nickel, mg/kg	1,400

SCREEN ANALYSIS OF E-FUEL

Mesh Size Passed-Retained	Wt. %
– 100m	6.2
100m – 150m	3.2
150m – 200m	2.6
200m – 270m	2.4
270m – 400m	2.0
400m – PAN	83.6
Total	100.0

SPECIFIC GRAVITY FOR E-FUEL

As Received Basis, g/cc	1.07
Dry Basis, g/cc	1.63

POTENTIAL CMSS SPECIFICATIONS

Proximate Analysis, weight %	Range	Average
Volatiles	50.0 to 56.0	53.1
Fixed Carbon	6.50 to 15.0	6.9
Ash	29.0 to 42.0	40.0
<i>Total</i>		<i>100.0</i>
Moisture	40 to 55	50.0
Heating Value		
Btu/lb, HHV (dry)	6,500 to 10,500	
Btu/lb, HHV (as received)	3,450 to 4,800	
Ultimate Analysis, weight %		
Carbon	35.0 to 52.5	43.3
Hydrogen	3.5 to 5.2	4.6
Nitrogen	1.7 to 3.5	3.4
Sulfur	0.5 to 1.5	1.1
Ash	29.5 to 54.0	40.5
Oxygen (by difference)	4.5 to 10.0	7.1
<i>Total</i>		<i>100.0</i>
Elemental Analysis of Ash (<i>example to determine reasonable range</i>)		
SiO ₂		37.46
Al ₂ O ₃		20.36
TiO ₂		1.18
Fe ₂ O ₃		9.08
CaO		9.58
MgO		2.38
Na ₂ O		0.92
K ₂ O		1.32
P ₂ O ₅		9.91
SO ₃		3.3
Cl		0.06
CO ₂		0.39
<u>Ash Softening Point,</u> <u>Degree F</u>		
Oxidizing		> 2,275
Reducing		>2,225