EERC
Energy & Environmental Research Center

UNIVERSITY OF NORTH DAKOTA
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Web Site: www.undeerc.org

December 31, 2009

Ms. Karlene Fine
Executive Director
North Dakota Industrial Commission
ATTN: Renewable Energy Development Program
600 East Boulevard Avenue
State Capitol – Fourteenth Floor
Bismarck, ND 58505

Dear Ms. Fine:

Subject: EERC Proposal No. 2010-0065 Entitled "Development of Advanced Pretreatment Technologies for the Production of Clean Biocoal/Syncoal from Woody Biomass, Agricultural Residues, and Municipal Solid Waste"

Enclosed please find an original and one copy of the proposal entitled "Development of Advanced Pretreatment Technologies for the Production of Clean Biocoal/Syncoal from Woody Biomass, Agricultural Residues, and Municipal Solid Waste." Also enclosed is the $100 application fee.

The Energy & Environmental Research Center (EERC) of the University of North Dakota is pleased to submit this proposal to develop advanced pretreatment technologies for the production of clean biocoal/syncoal from woody biomass, agricultural residues, and municipal solid waste that have the potential to provide a new industry for the state while providing energy security for the country. The proposed cost of the project is estimated at $1,432,047. Of this amount, the EERC is requesting $300,000 from the North Dakota Industrial Commission (NDIC), with $650,000 being secured in the form of cash and noncash cost share from industrial partners. The EERC will seek approval of additional cost share of $482,047 from the EERC–U.S. Department of Energy Joint Program on Research and Development for Fossil Energy-Related Resources. The EERC is committed to completing the project as described in this proposal if the NDIC makes the requested grant.

If you have any questions regarding this proposal, please contact me by phone at (701) 777-5405 or by e-mail at sarvelakis@undeec.org.

Sincerely,

Stelios Arvelakis
Researcher

Approved by:

for Dr. Barry I. Milavetz, Associate VP for Research
Research Development and Compliance

SA/hv
Enclosures

EERC
Energy & Environmental Research Center

DEVELOPMENT OF ADVANCED PRETREATMENT TECHNOLOGIES FOR THE PRODUCTION OF CLEAN BIOCOAL/SYNCOAL FROM WOODY BIOMASS, AGRICULTURAL RESIDUES, AND MUNICIPAL SOLID WASTE

EERC Proposal No. 2010-0065

Submitted to:

Karlene Fine

ATTN: Renewable Energy Development Program
North Dakota Industrial Commission
600 East Boulevard Avenue
State Capitol – Fourteenth Floor
Bismarck, ND 58505

Amount of Request: $300,000
Total Amount of Proposed Project: $1,432,047
Duration of Project: 12 months

Submitted by:

Stelios Arvelakis

Energy & Environmental Research Center
University of North Dakota
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

Stelios Arvelakis, Project Manager

for Dr. Barry I. Milavetz, Associate VP for Research
Research Development and Compliance

December 2009

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ABSTRACT

Carbon mitigation legislation and sustainability issues for energy production are driving the need for new technologies to aid in the adoption of biomass utilization. In order to meet the looming federally imposed limitations regarding the emission of greenhouse gases such as CO_2, North Dakota must reduce its dependence on fossil fuels in the transport and energy sectors. One important way to achieve this is to increase the production and use of fuels and energy produced from renewable energy sources. The use of North Dakota renewable agricultural wastes along with other biomass such as wood and energy crops for the production of green energy and/or liquid fuels and biochemicals can provide significant assistance toward this end. However, biomass utilization in existing power generation systems is hampered by the logistics of transport, the potential for undesirable inorganics in biomass to react unfavorably in existing systems, and the difficulty in handling and feeding the biomass into the system.

The goal of this proposed Energy & Environmental Research Center (EERC) work is to prepare pilot-scale testing equipment and perform testing in the areas of biomass/waste pretreatment for the production of "clean" biocoal/syncoal and subsequent biocoal/syncoal combustion and gasification testing. Various biomass materials such as wood, corn stover, wheat straw, dried distiller's grains and solubles from ethanol production, switchgrass, and refuse-derived fuels will be used for the production of biocoal/syncoal for the testing. The produced "clean" biocoal/syncoal fuel will be tested in pilot-scale combustors and gasifiers to demonstrate the elimination of the ash-related problems, emissions, and milling, mixing, and feeding problems associated with the use of biomass and waste materials. The total cost of the proposed 12-month project is $1,432,047. This includes $482,047 from the EERC–U.S. Department of Energy Joint Program on Research and Development for Fossil Energy-Related Resources, $650,000 from industrial partners, and $300,000 being requested from the North Dakota Industrial Commission Renewable Energy Program.

DEVELOPMENT OF ADVANCED PRETREATMENT TECHNOLOGIES FOR THE PRODUCTION OF CLEAN BIOCOAL/SYNCOAL FROM WOODY BIOMASS, AGRICULTURAL RESIDUES, AND MUNICIPAL SOLID WASTE

PROJECT DESCRIPTION/BACKGROUND

The Energy & Environmental Research Center (EERC) has nearly 60 years of experience in developing energy systems to convert coal, biomass, and natural gas into liquid fuels. The EERC has worked with fuels from throughout the world and with nearly every type of combustion and gasification system in use or under development. The EERC is currently working with a commercial consortium comprising technology providers, utilities, and coal companies to develop and demonstrate technologies for the effective utilization of agricultural residues and municipal solid waste (MSW) for the production of heat and power in cocombustion and cogasification applications using cofiring rates ranging from 30%–100% as well as for the production of hydrogen-rich syngas to be used for the production of Fischer–Tropsch (FT) liquids. One of the challenges for these businesses is the use of cheap agricultural residues and waste biomass streams as well as MSW as feedstock in order to be able to meet the new environmental and energy standards and achieve energy security at a low cost to stay competitive in the market. Woody biomass, agricultural residues, and MSW streams contain large amounts of alkali metals, chlorine, and sometimes sulfur, as well as heavy metals in the case of the MSW. These inorganic elements cause substantial ash-related problems as well as the emission of polychlorinated dibenzodioxins (PCCDs) and polychlorinated dibenzofurans (PCCDFs), making their economical use for the production of energy and fuels impossible.

The application of pretreatment technologies to eliminate alkali metals and chlorine and substantially reduce the amounts of sulfur, phosphorus, and heavy metals will lead to the production of a clean biocoal/syncoal fuel that can be used for energy and fuel production without ash-related problems.

OBJECTIVES

The goal of this proposed work is to prepare pilot-scale test equipment and perform combustion and gasification testing of biomass/waste pretreatment for the production of biocoal/syncoal. Specific objectives include the following:

- Utilizing a leaching reactor and the EERC's pilot-scale fluidized-bed torrefaction system to produce "clean" biocoal/syncoal.

- Performing pilot-scale combustion and gasification testing to demonstrate the benefits associated with the pretreatment technology.
- Evaluating fly ash produced from the combustion and gasification testing to determine its potential for use as an additive in cement production.
- Producing clean biocoal/syncoal pellets to determine the quality and energy costs associated with their production compared to wood pellets.
- Developing an Aspen simulation model to calculate the total energy and mass balance of the integrated pretreatment process.

METHODOLOGY

Activity 1 – Pretreatment System Testing and Integration

The scope of work for Activity 1 involves utilizing a leaching reactor and a pilot-scale fluidized-bed torrefaction system to produce "clean" biocoal/syncoal solid fuels. A laboratory-scale leaching reactor will be built and tested that will pretreat biomass and waste materials to determine the best conditions for the leaching process and to provide liquid samples to treat for effluents and make sure that disposal of liquid streams will not impose any substantial cost on the process. The possibility of using the liquid stream as fertilizer to allow for the recycling of the nutrients removed during the leaching process back to the fields will be essential for the sustainability of the process.

This will allow the evaluation of the process economics, resolving integration problems, and determining the quality and properties of the produced biocoal/syncoal fuels. Several high-alkali and chlorine biomass fuels such as woody biomass, dried distiller's grains and soluble (DDGS), wheat straw, corn stover, switchgrass, and refuse-derived fuel (RDF) material will be used in this stage to produce the biocoal/syncoal solid fuels.

Activity 2 – Pilot-Scale Combustion and Gasification Testing

The produced biocoal/syncoal fuels will be used for pilot-scale combustion and gasification testing using a pressurized bubbling fluidized-bed gasifier as well as a pulverized fuel (pf) combustion test facility available at the EERC. Both reactors are presented in Figures 1 and 2. Those tests will be used to demonstrate the elimination of all the ash-related problems associated with the use of biomass and waste materials as well as the elimination of dioxin and furan production PCCD, and PCCDF and the substantial elimination of emissions such as NO_x, SO_x, H_2S, alkali vapors, and chlorine that can cause corrosion in boilers and substantial problems during the operation of fuel cells, turbines for the production of energy, and FT reactors for the production of liquid fuels.

Activity 3 – Biocoal/Syncoal Pellet Production and Characterization

The produced biocoal/syncoal fuels will be used to produce pellets using a pelletizer to be purchased by the EERC. The produced pellets will be characterized to determine the quality and energy costs associated with their production compared to the quality and energy costs associated with the production of wood pellets.

Activity 4 – Fly Ash Characterization

The fly ash from the pilot-scale combustion tests will be evaluated as cement additives using ASTM International Method C-618. Biomass ash disposal and utilization constitutes a big issue today for the power companies that want to increase the cofiring rates or switch to 100% biomass firing from coal firing. These results will help to evaluate the possibility of using the clean biocoal/syncoal ash in the cement industry, generating an additional profit for the power companies, instead of treating it as a waste material with additional cost.

Activity 5 – Process Simulation and System Integration

A computer simulation will be developed that will model the entire pretreatment process. The model will be built using Aspen Plus™, developed and distributed by AspenTech. The Aspen simulation will provide insight into the impact of feedstock variation on processing parameters and product yields. The initial model will help to determine the best ratios of liquid to solid needed for the leaching step as well as the temperature and contact time to achieve optimization. It will also model the operation of the fluidized-bed torrefaction unit regarding the optimum particle size and reaction time and temperature to achieve the highest biocoal/syncoal yields. After empirical data are produced from both reactors, the Aspen model will be upgraded to provide more accurate predictions based on the different biomass and/or waste materials used.

Activity 6 – Project Management

The overall success of the project is ensured through strong project management. Day-to-day management is required to ensure that the individual activities meet project goals on time and within budget. Also, the project as a whole is managed with an eye toward effective communication of accomplishments and results to the North Dakota Industrial Commission (NDIC) and North Dakota industry and public institutions.

ANTICIPATED RESULTS

- Demonstration of an integrated-pretreatment (leaching/torrefaction) process utilizing biomass and MSW to produce clean biocoal/syncoal in an economical and environmentally friendly way.

- A computer simulation model to determine the optimum use of liquids, temperatures, reaction time, and moisture content for both the torrefaction and the leaching reactor in order to produce clean biocoal/syncoal fuels economically.
- Demonstration of the combustion and gasification behavior of the clean biocoal/syncoal fuels using pilot-scale pf boilers and pressurized fluidized-bed gasifiers integrated with FT units for the production of energy and liquid fuels.
- Demonstration of the production of clean biocoal/syncoal pellets on a more economical basis compared to standard wood pellets.
- Demonstration of the possibility of utilizing the produced fly ash as cement additive because of its negligible concentration of alkali metals and chlorine.

Facilities, Resources, and Techniques

This project will utilize the EERC's continuous fluidized-bed reactor (CFBR), a schematic of which is shown in Figure 1. The CFBR has a fuel feed rate of approximately 2–5 kg/hr (4.4–11 lb/hr).

The CFBR is integrated with a FT reactor capable of handling the entire syngas output stream of the CFBR or only a portion of it. The CFBR has an online gas chromatograph (GC) for gas analysis, and liquid and gas samples from the FT reactor system will be evaluated in the EERC Fuel Science Laboratory with Agilent GC–mass spectometry and high-performance liquid chromatography systems and an online Fourier transform infrared gas analysis system.

In addition, the project will also utilize the EERC combustion test facility (CTF) furnace, presented in Figure 2. The CTF furnace capacity is approximately 75 lb/hr (550,000 Btu/hr) of pulverized lignite. The combustion chamber is 30 inches in diameter, 8 feet high, and refractory-lined for combustion testing of low-rank coals as well as biomass and waste fuels. Tests are performed using the standard configuration (30-inch inside diameter), with the furnace exit gas temperature maintained at approximately 2000°F for each combustion test with excess air controlled to about 20%.

The pf is charged to a microprocessor-controlled weight loss feeder from a transport hopper. Combustion air is preheated by an electric air heater, with the temperature adjusted based on the moisture content of the fuel. The pulverized feed is screw-fed by the gravimetric feeder into the throat of a venturi section in the primary air line to the burner. Heated secondary air is introduced through an annular section surrounding the primary air line. A typical

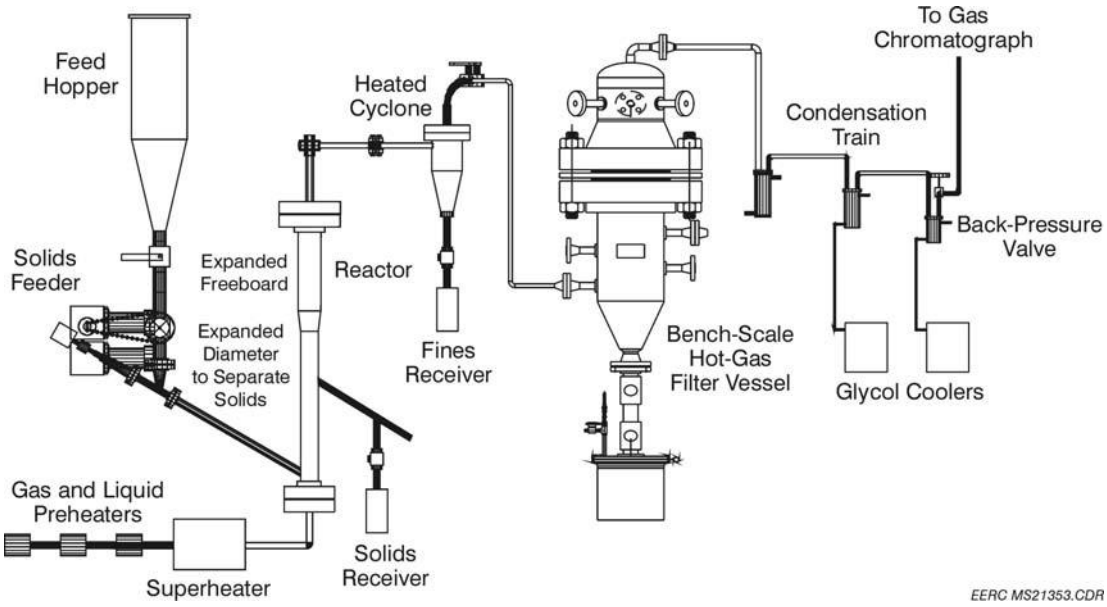

Figure 1. Schematic of the EERC CFBR gasification system.

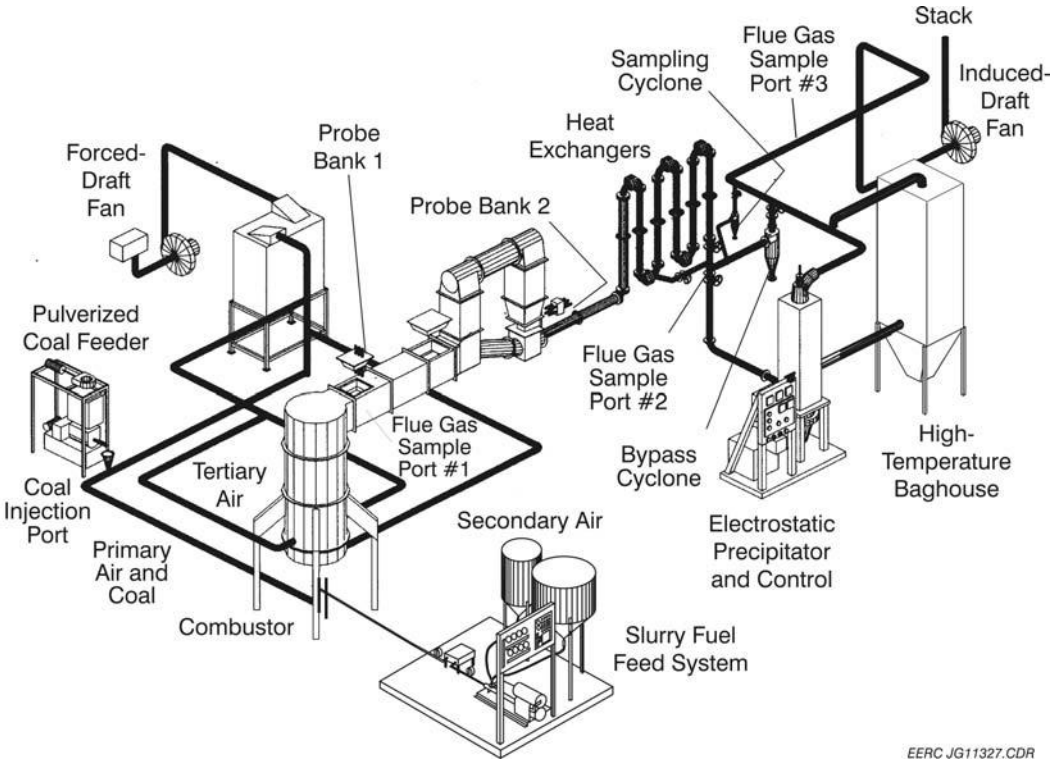

Figure 2. Schematic of the EERC CTF combustion furnace.

operation uses only primary and secondary air, with the percentage adjusted to maintain fuel pipe transport, normally 18% primary air and 82% secondary air. Located in the duct is a vertical probe bank designed to simulate superheater surfaces in a commercial boiler. The three fouling probes are constructed of 1.66-inch-outside-diameter Type 304 stainless steel pipe and are cooled with steam. After leaving the probe duct, the flue gas passes through a water-cooled heat exchanger before being discharged through an electrostatic precipitator (ESP).

The fluidized-bed torrefaction unit is shown in Figure 3. It operates as a fluidized bed with unique distributor plate and plenum designs that allow a controlled velocity profile across the bed to effectively size-segregate the treated biomass/waste materials. Low-temperature stack gas (300°F) can be used as a source of heat and fluidizing gas so that no external heat source will be required. The larger particles remain in the lower level of the bed until they become reduced in size through drying and the action of the bed. Smaller particles are removed from the top of the bed as the product.

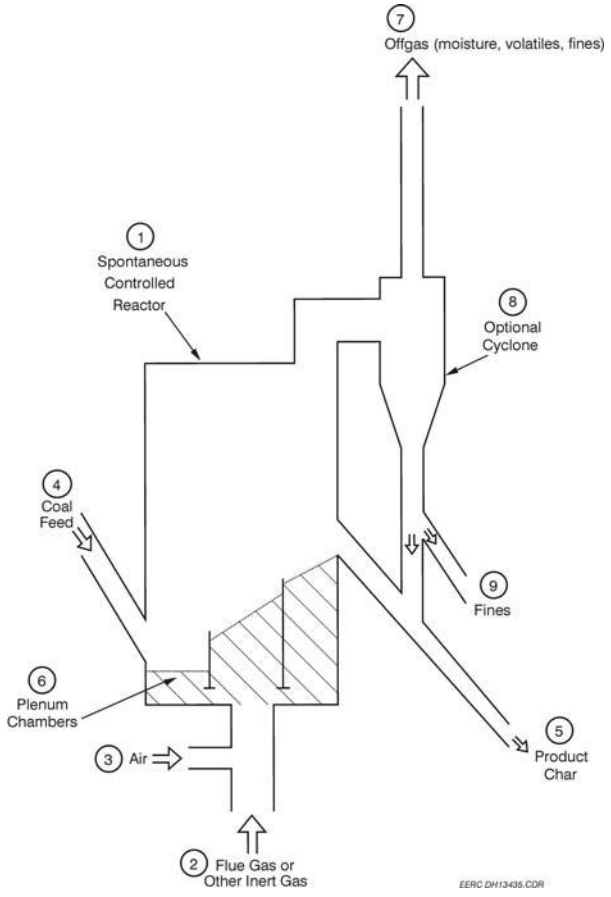

Figure 3. Schematic of the EERC's fluidized-bed torrefaction system.

During the operation of the torrefaction unit, the products would be a dry, high-Btu char along with a combination of low- Btu gas and dry biomass/waste fines suitable for use as a reburn fuel. The leaching process will utilize a leaching reactor that will be constructed at the EERC. This reactor will be able to treat around 500 kg of biomass and waste materials a day to produce clean feedstock to be used in the torrefaction process.

Environmental and Economic Impacts of Under-Way Project

The pretreatment process development efforts will comprise bench- and small pilot-scale experimental activities with minimal environmental impacts. All gases produced during the experimental activity are oxidized and vented to the atmosphere in accordance with the EERC's North Dakota Air Permit. The small amounts of aqueous solutions containing nonhazardous materials will be collected and sent to the city of Grand Forks municipal landfill, Grand Forks County, North Dakota. The economic impact of the project will entail utilizing North Dakota suppliers for materials where possible and the employ of North Dakota residents at the EERC and University of North Dakota students.

Ultimate Project Technologic and Economic Impacts

The ultimate goal of the project is to develop the technological basis for producing a clean biocoal/syncoal solid fuel from North Dakota agricultural residues and MSW that will be able to be used in combustion and gasification processes in an economical and environmentally friendly way. The success of the project will provide the basis for scaling the technology to demonstration-scale activities that can lead to a new industry in the state of North Dakota, which will promote rural economic health and growth while providing power producers with a better alternative for reducing greenhouse gas emissions.

Project Need

The proposed project directly addresses these critical needs:

- North Dakota farmers and farmers throughout the United States need more markets for overabundant, underutilized biomass resources.
- North Dakota needs to develop new industries that will supply much-needed jobs to stem the drain of young people from the state and provide rural economic development.
- The United States, in general, needs to develop technologies to ensure energy security for the future while minimizing the carbon footprint of energy production.

STANDARDS OF SUCCESS

The success of the project will be determined by the following factors:

- Demonstration of the economical and efficient application of the pretreatment process to produce clean biocoal/syncoal fuels in pilot-scale quantities. Achievement of successful integration and operation of the fluidized-bed torrefaction system and the leaching reactor to produce the clean biocoal/syncoal fuels.
- Sufficient technical data to validate the process model which will aid in scaling of the process as well as understanding the effect of feedstock and process variation on the system.
- Demonstration of the efficient combustion and gasification of the produced clean biocoal/syncoal to produce energy and fuels without ash-related and emission problems.

Key project results and potential benefits to North Dakota will be communicated through reports and other communications from the EERC to North Dakota industries and the general public. The EERC will leverage project results to develop North Dakota-based partnerships for process commercialization and the resultant development of a new industry in the state.

BACKGROUND AND QUALIFICATIONS

Much work has been done outside of the EERC in the area of biomass pretreatment over the years and by many organizations, and the limited length of this proposal is insufficient to do the subject justice. The EERC has extensive experience in designing, constructing, and operating pilot-scale gasification systems and in modeling fuel conversion systems, including the development and use of a wide range of computer models for addressing gasification kinetics, slag flow behavior, ash formation, deposit/clinker formation, and trace element behavior. The research project manager (RPM), Dr. Stelios Arvelakis, has extensive experience in developing and leading renewable fuel and chemical projects and teaming with industrial partners to move technologies out of lab and into pilot-scale demonstration.

The project assistant manager, Dr. Bruce Folkedahl, has extensive experience in developing and leading renewable fuel and chemical projects and teaming with industrial partners to move technologies out of lab and into pilot-scale demonstrations.

The principal investigator, Dr. Michael Swanson, is currently involved with the demonstration of advanced power systems such as pressurized fluidized-bed combustors and integrated gasification combined cycle. He will be responsible for the gasification testing in the CFBR.

Mr. Doug Hajicek will be responsible for the operation of the pilot-scale fluidized-bed torrefaction unit and the integration with the leaching reactor. Mr. Hajicek's principal areas of interest and expertise include design, construction, and procurement of bench- and pilot-scale research equipment.

MANAGEMENT

Dr. Arvelakis is the RPM for this project. The RPM is the designated contact person expected to provide leadership in fully coordinating and integrating the activities of the project. During the period of award, the RPM will communicate progress and issues about the research in quarterly reports and on an as-needed basis. Progress of the activities according to the approved plan will be constantly monitored by the RPM. Should EERC personnel determine that a change needs to occur, it will be first discussed internally with EERC senior management. Should the EERC management accept the proposed change(s), the RPM will present, in written form, the proposed change(s) to NDIC, which may require revised cost estimates, schedule activity sequences, schedule dates, and resource requirements. The EERC will not implement changes until it has received formal approval from NDIC.

TIMETABLE

The proposed scope of research will be conducted over a 12-month period extending from May 1, 2010, through April 30, 2011, as summarized in the table on page 14.

EQUIPMENT TO BE FABRICATED OR PURCHASED

Activity 1 – Pretreatment System Testing and Integration

Approximately $30,000 in plant modifications, ductwork, and piping required for integrating the torrefaction reactor to the CTF combustor for burning and recycling the low-Btu gas produced.

Activity 3 – Biocoal/Syncoal Pellet Production and Characterization

Approximately $30,000 will be used for the purchase of a pelletization system which will be used to produce pellets from the biocoal/syncoal materials and evaluate their properties against the properties of standard wood pellets.

Activity 4 – Process Simulation and Product Enhancement

The small pilot-scale leaching test system is expected to cost around $35,000 and will be used to pretreat the different biomass and waste materials to optimize the leaching process as well as the process model to ensure a better operation of the pilot-scale reactors.

ID	Title/Description	Planned Completion Date	Actual Completion Date
Activity 1	Pretreatment System Testing and Integration/Production of Clean Biocoal/Syncoal		
M1	Initial System Testing	07-01-10	
M2	System Optimization and Integration	08-15-10	
M3	System Testing Complete	09-27-10	
M4	Production of Clean Biocoal/Syncoal	12-31-10	
Activity 2	Pilot-Scale Combustion and Gasification Testing		
M1	Combustion Testing	02-10-11	
M2	Gasification Testing	02-09-11	
Activity 3	Biocoal/Syncoal Pellet Production and Characterization		
M1	System Purchase and Preparation	09-25-10	
M2	System Optimization and Testing Complete	11-15-10	
M4	Production and Testing of Biocoal/Syncoal Pellets	02-28-11	
Activity 4	Process Simulation		
M1	Process Simulation Model Complete	03-05-11	
Activity 5	Project Management		
M1	Kickoff Meeting	05-01-10	
M2	Project Completion/Review Meeting	03-24-11	
M3	Draft Final Report	03-24-11	
M4	Final Report	04-30-11	
M5	Quarterly Reporting August 10, October 10, January 11	01-01-10 start	

BUDGET

The total cost of this project is estimated at $1,432,047. At this time, the EERC is requesting $300,000 from the NDIC Renewable Energy Program, with $650,000 provided from industrial sponsors in the form of cash and noncash cost share. Industrial partners include American Crystal Sugar Company, Agni Corporation, Sea to Sky Corporation, Novaspect Inc., and Thermogon International LLC. Supporting cost-share documentation will be provided as it is received. In addition the EERC will propose additional cash cost share of $482,047 from the U.S. Department of Energy (DOE).

Once we have NDIC's firm commitment, we will submit the proposal to DOE, requesting approval of its share of the funding.

Three items are required from NDIC for inclusion in our proposal to DOE:

- A formal commitment to the project. This can be a letter of commitment, a purchase order, or a signed contract.
- A biographical sketch or resume for NDIC's project manager or key technical contributor.
- A short overview of NDIC.

The total project budget is necessary to adequately demonstrate the effectiveness of pretreatment methods to utilize biomass residues and waste without ash-related and emission problems. The level of NDIC funding is important to help demonstrate the common interests of the state of North Dakota and the state's energy and agricultural industry in increasing the use of biomass and waste for energy production. Funding of a lesser amount is inadequate to demonstrate the potential for producing clean biocoal/syncoal from residues and waste.

Project Associated Expense	NDIC's Share	Applicant's Share Cash	Applicant's Share In-Kind	Other Project Sponsor's Share	Project Total
Personnel	87,155	162,414		119,954	369,523
Fringe Benefits	46,012	85,812		61,796	193,620
Travel				4,532	4,532
Equipment				95,000	95,000
Supplies	5,460	24,880		8,660	39,000
Contractual					
Construction					–
Other	48,872	86,269	75,000	63,089	273,230
Indirect Charges	112,501	215,625		129,016	457,142
Total	300,000	575,000	75,000	482,047	1,432,047

A detailed budget and accompanying budget notes are enclosed in Appendix A.

TAX LIABILITY

The EERC does not have an outstanding tax liability owed to the state of North Dakota or any of its political subdivisions.

CONFIDENTIAL INFORMATION

This proposal does not contain confidential information.

PATENTS AND RIGHTS TO TECHNICAL DATA

The EERC Intellectual Property office will protect discoveries that could lead to the evolution of new intellectual property.

APPENDIX A

BUDGET AND BUDGET NOTES

DEVELOPMENT OF ADVANCED PRETREATMENT TECHNOLOGIES FOR THE PRODUCTION OF CLEAN
BIOCOAL/SYNCOAL FROM WOODY BIOMASS, AGRICULTURAL RESIDUES AND MUNICIPAL SOLID WASTE
NORTH DAKOTA RENEWABLE ENERGY COUNCIL
PROPOSED PROJECT START DATE: 4/1/2010
EERC PROPOSAL #2010-0065

BUDGET

CATEGORY		TOTAL			NDREC SHARE		CASH COST SHARE		NON-CASH COST SHARE		DOE-JSRP SHARE	
LABOR		Rate	Hrs	Cost	Hrs	Cost	Hrs	Cost	Hrs	Cost	Hrs	Cost
Arvelakis, S.	Project Manager	$ 37.00	1,940	$ 71,780	400	$ 14,800	1,120	$ 41,440	-	$ -	420	$ 15,540
Folkedahl, B.	Principal Investigator	$ 55.79	305	$ 17,016	90	$ 5,021	115	$ 6,417	-	$ -	100	$ 5,578
Gunderson, J.	Principal Investigator	$ 37.06	1,120	$ 41,507	260	$ 9,636	460	$ 17,048	-	$ -	400	$ 14,823
Musich, M.	Research Scientist/Engineer	$ 41.10	860	$ 35,346	160	$ 6,576	300	$ 12,330	-	$ -	400	$ 16,440
Hajicek, D.	Research Scientist/Engineer	$ 52.95	230	$ 12,179	50	$ 2,648	80	$ 4,237	-	$ -	100	$ 5,294
Schulz, R.	Research Scientist/Engineer	$ 54.20	300	$ 16,260	60	$ 3,252	115	$ 6,233	-	$ -	125	$ 6,775
----------	Senior Management	$ 70.17	457	$ 32,068	120	$ 8,420	201	$ 14,105	-	$ -	136	$ 9,543
----------	Research Technicians	$ 25.08	607	$ 15,224	148	$ 3,712	253	$ 6,345	-	$ -	206	$ 5,167
----------	Technology Dev. Mechanics	$ 29.23	3,200	$ 93,536	890	$ 26,015	1,415	$ 41,361	-	$ -	895	$ 26,160
----------	Undergrad-Res.	$ 11.26	780	$ 8,783	128	$ 1,441	228	$ 2,566	-	$ -	424	$ 4,776
----------	Technical Support Services	$ 20.02	580	$ 11,612	114	$ 2,282	204	$ 4,084	-	$ -	262	$ 5,246
				$ 355,311		$ 83,803		$ 156,166		$ -		$ 115,342
Escalation Above Base		4%		$ 14,212		$ 3,352		$ 6,248		$ -		$ 4,612
TOTAL DIRECT HRS/SALARIES			10,379	$ 369,523	2,420	$ 87,155	4,491	$ 162,414	-	$ -	3,468	$ 119,954
TOTAL FRINGE BENEFITS				$ 193,620		$ 46,012		$ 85,812		$ -		$ 61,796
TOTAL LABOR				$ 563,143		$ 133,167		$ 248,226		$ -		$ 181,750
OTHER DIRECT COSTS												
TRAVEL				$ 4,532		$ -		$ -		$ -		$ 4,532
EQUIPMENT > $5000				$ 95,000		$ -		$ -		$ -		$ 95,000
SUPPLIES				$ 39,000		$ 5,460		$ 24,880		$ -		$ 8,660
COMMUNICATION - PHONES & POSTAGE				$ 1,465		$ 276		$ 780		$ -		$ 409
PRINTING & DUPLICATING				$ 1,420		$ 280		$ 780		$ -		$ 360
FOOD				$ 720		$ 150		$ 570		$ -		$ -
OPERATING FEES & SVCS												
Natural Materials Analytical Res. Lab.				$ 52,128		$ 15,680		$ 25,643		$ -		$ 10,805
Fuels & Materials Research Lab.				$ 12,823		$ 2,850		$ 5,699		$ -		$ 4,274
Analytical Research Lab.				$ 4,959		$ 843		$ 2,379		$ -		$ 1,737
Combustion Test Svcs.				$ 26,874		$ 6,126		$ 11,362		$ -		$ 9,386
Particulate Analysis				$ 24,344		$ 6,639		$ 8,853		$ -		$ 8,852
Fuel Prep. and Maintenance				$ 12,659		$ 2,829		$ 5,409		$ -		$ 4,421
Continuous Fluidized-Bed Reactor				$ 32,367		$ 7,287		$ 13,722		$ -		$ 11,358
Graphics Support				$ 10,912		$ 761		$ 1,524		$ -		$ 8,627
Shop & Operations Support				$ 4,859		$ 1,351		$ 2,148		$ -		$ 1,360
Outside Lab.				$ 10,200		$ 2,800		$ 7,400		$ -		$ -
Freight				$ 2,500		$ 1,000		$ -		$ -		$ 1,500
TOTAL DIRECT COST				$ 899,905		$ 187,499		$ 359,375		$ -		$ 353,031
FACILITIES & ADMIN. RATE - % OF MTDC			VAR	$ 457,142	60%	$ 112,501	60%	$ 215,625	60%	$ -	50%	$ 129,016
NON-CASH COST SHARE												
Novaspect - Design Development				$ 75,000		$ -		$ -		$ 75,000		$ -
TOTAL PROJECT COST - US DOLLARS				$ 1,432,047		$ 300,000		$ 575,000		$ 75,000		$ 482,047

Due to limitations within the University's accounting system, bolded budget line items represent how the University proposes, reports and accounts for expenses. Supplementary budget information, if provided, is for proposal evaluation.

DEVELOPMENT OF ADVANCED PRETREATMENT TECHNOLOGIES FOR THE PRODUCTION OF CLEAN BIOCOAL/SYNCOAL FROM WOODY BIOMASS, AGRICULTURAL RESIDUES AND MUNICIPAL SOLID WASTE
EERC PROPOSAL #2010-0065

BUDGET - TRAVEL

RATES USED TO CALCULATE ESTIMATED TRAVEL EXPENSES

DESTINATION	AIRFARE	LODGING	PER DIEM	CAR RENTAL	REGIST.
Unspecified Destination (USA)	$ 950	$ 175	$ 71	$ 75	$ 525
Pittsburgh, PA	$ 900	$ 250	$ 71	$ 65	$ -

PURPOSE/DESTINATION	NUMBER OF TRIPS	NUMBER OF PEOPLE	NUMBER OF DAYS	AIRFARE	LODGING	PER DIEM	CAR RENTAL	MISC.	REGIST.	TOTAL
Nat'l Bio-Coal Conference/Unspecified Dest. (USA)	1	1	4	$ 950	$ 525	$ 284	$ 300	$ 80	$ 525	$ 2,664
Contractor Rvw Mtg/Pittsburgh, PA	1	1	3	$ 900	$ 500	$ 213	$ 195	$ 60	$ -	$ 1,868
TOTAL ESTIMATED TRAVEL										$ 4,532

DEVELOPMENT OF ADVANCED PRETREATMENT TECHNOLOGIES FOR THE PRODUCTION OF CLEAN BIOCOAL/SYNCOAL FROM WOODY BIOMASS, AGRICULTURAL RESIDUES, AND MUNICIPAL SOLID WASTE
EERC PROPOSAL #2010-0065

DETAILED BUDGET - EQUIPMENT

Other Equipment

Pilot-Scale Leaching Testing System	$ 35,000
Pelletization System	$ 30,000
Physical plant modifications - integrate torrefaction reactor to the CTF Combustor	$ 30,000
Total Equipment	$ 95,000

DEVELOPMENT OF ADVANCED PRETREATMENT TECHNOLOGIES FOR THE PRODUCTION OF CLEAN BIOCOAL/SYNCOAL FROM WOODY BIOMASS, AGRICULTURAL RESIDUES AND MUNICIPAL SOLID WASTE
EERC PROPOSAL #2010-0065

DETAILED BUDGET - EERC RECHARGE CENTERS

			TOTAL
Natural Materials Analytical Res. Lab.	Rate	#	$Cost
CCSEM	$461	19	$ 8,759
Chemical Fractionation	$1,938	15	$ 29,070
Morphology (Hourly)	$287	18	$ 5,166
XRD	$222	18	$ 3,996
XRFA	$174	18	$ 3,132
Subtotal			$ 50,123
Escalation		4%	$ 2,005
Total Natural Materials Analytical Res. Lab.			$ 52,128
Fuels & Materials Research Lab.	Rate	#	$Cost
Ash Determination	$49	18	$ 882
BTU	$74	18	$ 1,332
Dry Sieve	$75	18	$ 1,350
Loss on Ignition (LOI)	$62	18	$ 1,116
Malvern Particle Size	$79	18	$ 1,422
Moisture %	$66	18	$ 1,188
Proximate Ultimate	$209	18	$ 3,762
Sulfur	$71	18	$ 1,278
Subtotal			$ 12,330
Escalation		4%	$ 493
Total Fuels & Materials Research Lab.			$ 12,823
Analytical Research Lab.	Rate	#	$Cost
Chlorine	$54	17	$ 918
Coal Digestion	$172	17	$ 2,924
Filtering	$13	17	$ 221
Sulfide	$47	15	$ 705
Subtotal			$ 4,768
Escalation		4%	$ 191
Total Analytical Research Lab.			$ 4,959
Combustion Test Services	Rate	#	$Cost
Combustion Test Facility (CTF) (Hourly)	$95	272	$ 25,840
Subtotal			$ 25,840
Escalation		4%	$ 1,034
Total Combustion Test Services			$ 26,874
Particulate Analysis	Rate	#	$Cost
101-A & Bench Scale Method 29	$221	22	$ 4,862
EPA Dust Loading	$279	22	$ 6,138
Gas Analyzer Maintenance (Daily)	$78	22	$ 1,716
Lab Use Rate (Hourly)	$172	22	$ 3,784
Mercury CEM (Daily)	$314	22	$ 6,908
Subtotal			$ 23,408
Escalation		4%	$ 936
Total Particulate Analysis			$ 24,344
Fuel Preparation & Maintenance	Rate	#	$Cost
Fuel Preparation & Maintenance (Hourly per piece of equip)	$34	358	$ 12,172
Subtotal			$ 12,172
Escalation		4%	$ 487
Total Fuel Prep. & Maintenance			$ 12,659
Continuous Fluidized-Bed Reactor	Rate	#	$Cost
Continuous Fluidized-Bed Reactor (Hourly)	$91	342	$ 31,122
Subtotal			$ 31,122
Escalation		4%	$ 1,245
Total Continuous Fluidized-Bed Reactor			$ 32,367
Graphics Support	Rate	#	$Cost
Graphics (hourly)	$61	172	$ 10,492
Subtotal			$ 10,492
Escalation		4%	$ 420
Total Graphics Support			$ 10,912
Shop & Operations Support	Rate	#	$Cost
Technical Development Hours	$1.46	3,200	$ 4,672
Subtotal			$ 4,672
Escalation		4%	$ 187
Total Shop & Operations Support			$ 4,859

BUDGET NOTES

ENERGY & ENVIRONMENTAL RESEARCH CENTER (EERC)

BACKGROUND

The EERC is an independently organized multidisciplinary research center within the University of North Dakota (UND). The EERC receives no appropriated funding from the state of North Dakota and is funded through federal and nonfederal grants, contracts, and other agreements. Although the EERC is not affiliated with any one academic department, university faculty may participate in a project, depending on the scope of work and expertise required to perform the project.

INTELLECTUAL PROPERTY

If federal funding is proposed as part of this project, the applicable federal intellectual property (IP) regulations may govern any resulting research agreement. In addition, in the event that IP with the potential to generate revenue to which the EERC is entitled is developed under this agreement, such IP, including rights, title, interest, and obligations, may be transferred to the EERC Foundation, a separate legal entity.

BUDGET INFORMATION

The proposed work will be done on a cost-reimbursable basis. The distribution of costs between budget categories (labor, travel, supplies, equipment, etc.) is for planning purposes only. The project manager may, as dictated by the needs of the work, incur costs in accordance with Office of Management and Budget (OMB) Circular A-21 found at www.whitehouse.gov/omb/circulars. If the Scope of Work (by task, if applicable) encompasses research activities which may be funded by one or more sponsors, then allowable project costs may be allocated at the Scope of Work or task level, as appropriate, to any or all of the funding sources. Financial reporting will be at the total-agreement level.

Escalation of labor and EERC recharge center rates is incorporated into the budget when a project's duration extends beyond the current fiscal year. Escalation is calculated by prorating an average annual increase over the anticipated life of the project.

The cost of this project is based on a specific start date indicated at the top of the EERC budget. Any delay in the start of this project may result in a budget increase. Budget category descriptions presented below are for informational purposes; some categories may not appear in the budget.

Salaries: The EERC employs administrative staff to provide required services for various direct and indirect support functions. Salary estimates are based on the scope of work and prior experience on projects of similar scope. The labor rate used for specifically identified personnel is the current hourly rate for that individual. The labor category rate is the current average rate of a personnel group with a similar job description. Salary costs incurred are based on direct hourly effort on the project. Faculty who work on this project will be paid an amount over their normal base salary, creating an overload which is subject to limitation in accordance with university policy. Costs for general support services such as contracts and intellectual property, accounting, human resources, purchasing, shipping/receiving, and clerical support of these functions are included in the EERC facilities and administrative cost rate.

Fringe Benefits: Fringe benefits consist of two components which are budgeted as a percentage of direct labor. The first component is a fixed percentage approved annually by the UND cognizant audit agency, the Department of Health and Human Services. This portion of the rate covers vacation, holiday, and sick leave (VSL) and is applied to direct labor for permanent staff eligible for VSL benefits. Only the actual approved rate will be charged to the project. The second component is estimated on the basis of historical data and is charged as actual expenses for items such as health, life, and unemployment insurance; social security; worker's compensation; and UND retirement contributions.

Travel: Travel is estimated on the basis of UND travel policies which can be found at www.und.edu/dept/accounts/policiesandprocedures.html. Estimates include General Services Administration (GSA) daily meal rates. Travel may include site visits, field work, meetings, and conference participation as indicated by the scope of work and/or budget.

Equipment: If equipment is budgeted, it is discussed in the text of the proposal and/or identified more specifically in the accompanying budget detail.

Supplies – Professional, Information Technology, and Miscellaneous: Supply and material estimates are based on prior experience and may include chemicals, gases, glassware, nuts, bolts, and piping. Computer supplies may include data storage, paper, memory, software, and toner cartridges. Maps, sample containers, minor equipment, signage, and safety supplies may be necessary as well as other organizational materials such as subscriptions, books, and reference materials. General purpose office supplies (pencils, pens, paper clips, staples, Post-it notes, etc.) are included in the facilities and administrative cost.

Subcontracts/Subrecipients: Not applicable.

Professional Fees/Services (consultants): Not applicable.

Other Direct Costs

Communications and Postage: Telephone, cell phone, and fax line charges are generally included in the facilities and administrative cost. Direct project costs may include line charges at remote locations, long-distance telephone, postage, and other data or document transportation costs.

Printing and Duplicating: Photocopy estimates are based on prior experience with similar projects. Page rates for various photocopiers are established annually by the university's duplicating center.

Food: Food expenditures for project meetings, workshops, and conferences where the primary purpose is dissemination of technical information may include costs of food, some of which may exceed the institutional limit.

Professional Development: Fees are for memberships in technical areas directly related to work on this project. Technical journals and newsletters received as a result of a membership are used throughout development and execution of the project by the research team.

Fees and Services – EERC Recharge Centers, Outside Labs, Freight: EERC recharge center rates for laboratory, analytical, graphics, and shop/operation fees are anticipated to be approved for use beginning July 1, 2009. Only the actual approved rates will be charged to the project.

Laboratory and analytical fees are charged on a per sample, hourly, or daily rate, depending on the analytical services performed. Additionally, laboratory analyses may be performed outside the university when necessary.

Graphics fees are based on an established per hour rate for production of such items as report figures, posters, and/or PowerPoint images for presentations, maps, schematics, Web site design, professional brochures, and photographs.

Shop and operation fees are for expenses directly associated with the operation of the pilot plant facility. These fees cover such items as training, personal safety (protective eyeglasses, boots, gloves), and physicals for pilot plant and shop personnel.

Freight expenditures generally occur for outgoing items and field sample shipments.

Facilities and Administrative Cost: Facilities and administrative cost is calculated on modified total direct costs (MTDC). MTDC is defined as total direct costs less individual items of equipment in excess of $5000 and subawards in excess of the first $25,000 for each award. The EERC Facilities and Administrative rate for commercial entities as proposed in this budget is 60%. The components are as follows: the approved federal rate is 50%; added to the federal rate is an increment of 10%. This increment represents calculated costs that exceed the allowable 26% federal cap on Administrative costs as well as depreciation/use allowance on buildings and equipment purchased with federal dollars.

APPENDIX B

RESUMES OF KEY PERSONNEL

DR. STELIOS ARVELAKIS
Researcher

Energy & Environmental Research Center (EERC), University of North Dakota (UND)
15 North 23rd Street, Stop 9018, Grand Forks, North Dakota 58202-9018 USA
Phone: (701) 777-5405, Fax: (701) 777-5181, E-Mail: sarvelakis@undeerc.org

Principal Areas of Expertise

Dr. Arvelakis's principal areas of interest and expertise include energy from biomass, coal, waste combustion, and gasification. Specific areas of interest include the development of pretreatments for raw materials to improve their use as feedstock for combustion and gasification applications to generate energy and fuels/chemicals; the study of high-temperature inorganic reactions, ash chemistry, corrosion, deposit formation, agglomeration, and fly ash utilization; development of catalytic materials from low-cost agricultural biomass and wastes for pollution control, e.g., mercury capture; and development of methods to capture and use CO_2 from energy/industrial applications for greenhouse gas mitigation.

Qualifications

Fellow, European Union, Improving Human Potential Programme, ENEL, Piza, Italy, 2001.

Ph.D., Chemical Engineering, National Technical University of Athens (NTUA), Greece, 2001. Thesis: "Improving the Biomass Gasification/Combustion Technology via Appropriate Physicochemical pretreatments of the Raw Material"

Fellow, European Union, Access to Research Infrastructure, COPES Research Facility, TU Clausthal, Germany, 1998.

Diploma, Chemical Engineering, NTUA, 1995.

Special Activities, Skills, and Training

- International patent application on novel methods for the pretreatment of biomass residues for combustion/gasification applications, summer 2008.
- Reviewer, Thermochimica Acta, Energy and Fuels, Fuel, Chemosphere, Journal of Air and Waste Management Association, and Journal of Hazardous Materials.
- Member, American Chemical Society.
- Chemical Analyst, Greek Army, Army Oil Analysis Program (AOAP): Detection of metals and heavy metals (Cr, Ni, Fe, Ag, Cu, Pb) in the lubricants used in army vehicle internal combustion engines in order to prevent their catastrophic failure.
- Techniques applied to combustion, gasification, biomass, waste, and materials science research such as scanning electron microscopy–energy-dispersive x-ray analysis (SEM–EDX), hot-stage SEM–EDX, x-ray diffraction (XRD), hot stage XRD, thermal analysis techniques (differential thermal analysis, thermogravimetric analysis, differential scanning calorimetry), atomic absorption spectroscopy, ion chromatography, FT-Raman, x-ray

photoelectron spectroscopy, focused ion beam–secondary ion mass spectroscopy, high-temperature viscosity–rheology of silica-rich silicate melts; various techniques of sample preparation and characterization; use of fluidized beds and fixed beds as well of various high-temperature reactors for combustion/gasification/corrosion/inorganic reactions tests.

Computer Skills
FactSage thermodynamic calculation software

Professional Experience
April 2009–Present: Researcher, EERC, UND, Grand Forks, North Dakota.

2008–2009: Researcher, Natural Resources Research Institute (NRRI), University of Minnesota, Duluth, Minnesota.

2006–2008: Researcher, Technical University of Munich, Department of Mechanical Engineering, Chair of Energy Systems, Munich, Germany.

2006–2008: Postdoctoral Research Fellow, Improving Human Potential Programme, Marie Curie Intra-European Fellowship (IEF) Programme, Technical University of Munich, Department of Mechanical Engineering, Chair of Energy Systems, Germany.

2005–2006: Researcher, Max Planck Institute for Iron Research, Duesseldorf, Germany.

2005: Researcher, Joint Research Centre of the European Union, Clean Energy Technology Unit, Petten, The Netherlands.

2004–2005: Researcher, University of Limerick, Materials and Surface Science Institute, Limerick, Ireland.

2003: Visiting Researcher, EERC, UND.

2001–2003: Research Assistant Professor, Technical University of Denmark, Department of Chemical Engineering, CHEC Research Group, Denmark.

2001: Researcher, EUROFLAM Project, ENEL Research Centre, Piza, Italy.

1999–2001: Chemical Analyst, Greek Army Chemistry Laboratory, Army Oil Analysis Program, Greece.

1998: Researcher, CUTEC Institute, COPES Programme, Germany.

1996–1997: Teaching Assistant, Course “Mass and Energy Balances,” NTUA, Chemical Engineering Department, Athens, Greece.

1996: Member of the Organizing Committee, Seminar on “Best Uses of Biological Resources in New Industrial and Energy Applications,” NTUA, COMETT, Athens, Greece.

1996: Trainee, "Biomass Summer School, organized by the Austrian Biomass Association and the Austrian Ministry of Science, Transport and the Arts, Graz, Austria.

1994: Trainee in Seminar on "Best Uses of Biological Resources in New Industrial and Energy Applications," NTUA, EU COMETT Programme, Athens, Greece.

Publications and Presentations
Has authored and coauthored numerous technical publications.

DR. BRUCE C. FOLKEDAHL
Senior Research Manager
Energy & Environmental Research Center (EERC), University of North Dakota (UND)
15 North 23rd Street, Stop 9018, Grand Forks, North Dakota 58202-9018 USA
Phone: (701) 777-5243, Fax: (701) 777-5181, E-Mail: bfolkedahl@undeerc.org

Principal Areas of Expertise

Dr. Folkedahl's principal areas of interest and expertise include biomass conversion to energy; biomass to fuels and chemicals; and development of methodologies to mitigate the effects of inorganic components on the performance of combustion, gasification, and air pollution control systems; fuel inorganic transformations and deposition and development of predictive models to assess these processes. He is also interested in the study and development of high-temperature materials for aggressive environments and the kinetics of mercury speciation in combustion systems.

Qualifications

Ph.D., Materials Science and Engineering, Pennsylvania State University, 1997.
B.S., Computer Science, University of North Dakota, 1990.

Professional Experience

2001–Present: Senior Research Manager, EERC, UND. Dr. Folkedahl's responsibilities include studies of biomass combustion in conjunction with conventional combustion for electricity generation; research on the fundamental mechanisms of ash deposition and fouling during cofiring of biomass fuels with coal; process development for the conversion of biomass feedstocks to fuels, chemicals, and value-added products; and studies of corrosion and development of high-temperature materials to withstand aggressive combustion environments.

2000–2001: Product Manager, 3M Industrial Mineral Products Division, Little Rock, Arkansas. Dr. Folkedahl's responsibilities included managing a crushing and screening business unit 24-hr/day, 7-day/week manufacturing operation, including hiring, training, and directing 40 employees; managing a $12,000,000 annual budget; forecasting budgets; developing and implementing cost reduction plans; and developing automated labor-reducing equipment and routines.

1999–2000: Senior Product Engineer, 3M Industrial Mineral Products Division, St. Paul, Minnesota. Dr. Folkedahl's responsibilities included developing ceramer-coated roofing granules, developing automated dry powder-handling system for slurry-making process, investigating the mechanism of fluorine alkalinity reduction and coating enhancement in roofing granules, and investigating mechanisms of rust formation in mild steel storage tanks for roofing granules.

1994–1998: Graduate Assistant, Pennsylvania State University, University Park, Pennsylvania. Dr. Folkedahl's responsibilities included proctoring and grading exams and teaching lab classes.

Thesis work consisted of development of a neural network model of inorganic ash viscosity in high-temperature systems; development of an image analysis program to identify graphitizability of cokes; and statistical cluster analysis of the chemical composition of ash deposits in electrical generation boilers.

1989–1999: Research Scientist, EERC, UND. Dr. Folkedahl's projects and responsibilities included corrosion studies of high-temperature alloys, modeling of slag and silicate material viscosities, and crystallization studies of coal. Other responsibilities included design, development, and maintenance of analytical software; development and implementation of new analysis techniques; and operation and performance analysis with x-ray diffraction, x-ray fluorescence, scanning electron microscopy, and processing and manipulation of raw data.

Publications and Presentations

Has authored or coauthored over 40 publications, including technical contract reports, symposium papers, and journal articles.

DOUGLAS R. HAJICEK
Research Manager/Senior Design Engineer
Energy & Environmental Research Center (EERC), University of North Dakota (UND)
15 North 23rd Street, Stop 9018, Grand Forks, North Dakota 58202-9018 USA
Phone: (701) 777-5172, Fax: (701) 777-5181, E-Mail: dhajicek@undeerc.org

Principal Areas of Expertise

Mr. Hajicek's principal areas of interest and expertise include pressure piping design; atmospheric fluidized-bed combustion; the design, construction, and/or procurement of bench- and pilot-scale research equipment; and coal gasification.

Qualifications

B.S., Mechanical Engineering, University of North Dakota, 1976.
Registered Professional Engineer, State of North Dakota.

Professional Experience

2000–Present: Research Manager, Advanced Power Systems Group/Design Engineer, EERC, UND. Mr. Hajicek's responsibilities include the successful contractual operation, procurement of funding, and reporting activities associated with several pilot- and laboratory-scale gasification and combustion facilities at the EERC. Since 1999, he has also served as a Senior Design Engineer, where he has overall responsibility to ensure that code requirements are met for all construction, modifications, and operations of high-pressure systems at the EERC.

1989–2000: Senior Research Engineer, Systems Development, EERC, UND. Mr. Hajicek's responsibilities included the design and construction of a MW_{th} pulverized coal-fired slagging combustor for advanced heat-transfer materials testing; design of a state-of-the art bench-scale pressurized fluidized-bed reactor and high-temperature combustor simulator for trace metal studies; operation of existing pilot plant facilities associated with fluidized-bed combustion; and design, construction, and operation of 1-MW_{th} circulating fluidized-bed combustion test facility. He also assists with planning, project supervision, execution, and reporting of funded projects and the procurement of funding for new projects.

1984–1989: Research Engineer, Combustion and Environmental Systems Research Institute, EERC, UND. Mr. Hajicek's responsibilities included design, construction, and operation of a pilot plant facility used in research programs associated with fluidized-bed combustion. He also assisted with the design, construction, and modification of new and existing research equipment and in planning, supervision, execution, and reporting of funded projects for the fluidized-bed combustion of low-rank coals and other fuels.

1983–1984: Research Supervisor, Fluidized-Bed Combustion, Energy Research Center. Mr. Hajicek's responsibilities included planning, supervision, execution, and reporting of funded projects on the fluidized-bed combustion of low-rank coals and other fuels. Pilot-scale facilities are used to address such problems as sulfur capture, NO_x production, and bed agglomeration.

1977–1983: Mechanical Engineer, Grand Forks Energy Technology Center, U.S. Department of Energy. Mr. Hajicek's responsibilities included coordination between in-house management and contractor to accomplish a test program on a 200-lb/hr coal-fired fluidized-bed combustor; modifications and maintenance to keep the fluidized-bed combustor operational; design and construction of a continuous-gas-flow, high-temperature furnace and related systems used in conjunction with an optical system for the observation and analysis of burning coal particles in a simulated flue gas atmosphere; design, construction, and evaluation of a 300-lb/hr ion-exchange system for the removal of sodium from coal; and design, construction, and operation of a gaseous and liquid effluent sampling system used to obtain material balances and samples for chemical analysis from a 1-ton/hr slagging fixed-bed gasifier. He also assisted with data reduction for the slagging fixed-bed gasifier.

Professional Memberships
American Society of Mechanical Engineers

Publications and Presentations
Has authored or coauthored over 40 publications.

DR. MICHAEL L. SWANSON
Senior Research Manager
Energy & Environmental Research Center (EERC), University of North Dakota (UND)
15 North 23rd Street, Stop 9018, Grand Forks, North Dakota 58202-9018 USA
Phone: (701) 777-5239, Fax: (701) 777-5181, E-Mail: mswanson@undeerc.org

Principal Areas of Expertise

Dr. Swanson's principal areas of interest and expertise include pressurized fluidized-bed combustion (PFBC), integrated gasification combined cycle (IGCC), hot-gas cleanup, coal reactivity in low-rank coal (LRC) combustion, supercritical solvent extraction, and liquefaction of LRCs.

Qualifications

Ph.D., Energy Engineering, UND, 2000. Dissertation: Modeling of Ash Properties in Advanced Coal-Based Power Systems.
M.B.A., UND, 1991.
M.S., Chemical Engineering, UND, 1982.
B.S., Chemical Engineering, UND, 1981.

Professional Experience

2004–Present: Adjunct Professor, Chemical Engineering, UND.

1999–Present: Senior Research Manager, EERC, UND. Dr. Swanson is currently involved in the demonstration of advanced power systems such as PFBC and IGCC, with an emphasis on hot-gas cleanup issues.

1997–1999: Research Manager, EERC, UND. Dr. Swanson managed research projects involved with the demonstration of advanced power systems such as PFBC and IGCC, with an emphasis on hot-gas cleanup issues.

1990–1997: Research Engineer, EERC, UND. Dr. Swanson was involved with the demonstration of advanced power systems such as PFBC and IGCC, with an emphasis on hot-gas cleanup issues.

1986–1990: Research Engineer, EERC, UND. Dr. Swanson supervised a contract with the U.S. Department of Energy (DOE) to investigate the utilization of coal–water fuels in gas turbines. Designed, constructed, and operated research projects that evaluated the higher reactivity of LRCs in short-residence-time gas turbines and diesel engines.

1983–1986: Research Engineer, EERC, UND. Design, construction, and operation of supercritical fluid extraction (SFE) and coal liquefaction apparatus; characterization of the resulting organic liquids and carbonaceous chars; and preparation of reports.

1982–1983: Associated Western Universities (AWU) Postgraduate Fellowship, Grand Forks Energy Technology Center, U.S. Department of Energy, Grand Forks, North Dakota. Dr. Swanson designed and constructed a SFE apparatus.

Publications and Presentations
Has authored or coauthored numerous publications.

APPENDIX C

LETTERS OF COMMITMENT

1333 N. California Ave Ste 450
Walnut Creek, CA 94596

AGNI CORPORATION

Dr. Stelios Arvelakis
Energy & Environment Research Center
University of North Dakota
15 North 23rd St., Stop 9018
Grand Forks, ND 58202-9018

Sub: Support for Biomass Pre-treatment and Combustion / Gasification Project at EERC

Dear Dr. Arvelakis,

On behalf of Agni Corporation, I would like to express our interest to contribute an investment of $150,000 for research at the Energy & Environmental Research Center on the project entitled *Development of Advanced Pretreatment Technologies for the Production of Clean Bio-Coal/Syncoal from Woody Biomass, Agricultural Residues and Municipal Solid Waste.* Our understanding is that our investment contribution will be leveraged by matching funding from the U.S. Department of Energy and the North Dakota Renewable Energy Fund grant up to a total of $800,000.

We understand the Scope of Work of this project to be:

1. Pretreat woody biomass, agricultural residues such as, but not limited to: wheat straw, DDGS, corn stover, switchgrass and waste materials, including refuse-derived fuels, to produce clean bio-coal\syncoal using the torrefaction plus leaching pretreatment process.

2. Perform pilot-scale combustion and gasification tests to demonstrate the efficient utilization of the produced bio-coal/syncoal without emission and ash-related problems.

3. Develop an initial design of a demonstration pretreatment plant to utilize the torrefaction plus leaching process to produce commercial quantities of clean bio-coal/syncoal.

Agni Corporation intends to support the proposed project in the form of cash cost share, which is contingent upon the successful execution of an appropriate research contract, including but not limited to, the corresponding IP, usage and distribution rights. This letter expresses our intention and should be considered as such and not a legally binding commitment by Agni Corporation.

If you have any questions, please don't hesitate to contact me.

Sincerely,

Sumer S. Johal
CEO, Agni Corporation
+1 408.476.1190
sumer.johal@agnicorporation.com

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1-888-SEA-2SKY

December 31, 2009

Dr. Stelios Arvelakis
University of North Dakota
Energy & Environmental Research Center
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018
Phone: (701) 777-5405
Fax: (701) 777-5181

Dear Sirs

Re: Confirmation of Understanding for the Development of Advanced Pretreatment Technologies for the Production of Clean Bio-Coal/Syncoal from Woody Biomass, Agricultural Residues and Municipal Solid Waste

We write this letter confirming our conversations leading up to this point. Sea2Sky Corporation is committed to supporting renewable energy and advanced bio-fuels project development and early stage companies that are developing innovative technology. Sea 2 Sky Corporation and The University of North Dakota, Energy & Environmental Research Center desire to collaborate on the **Development of Advanced Pretreatment Technologies for the Production of Clean Bio-Coal/Syncoal from Woody Biomass, Agricultural Residues and Municipal Solid Waste.** Sea2Sky agrees to in accordance with the terms of this letter contribute $150,000 cash that will be leveraged by matching funding from a U.S. Department of Energy and North Dakota Renewable Energy Fund grant up to a total of $800,000.

This funding will be to perform research at the North Dakota Energy & Environmental Research Center on the project entitled "Development of Advanced Pretreatment Technologies for the Production of Clean Bio-Coal/Syncoal from Woody Biomass, Agricultural Residues and Municipal Solid Waste."

Sea2Sky intends to support the proposed project in the form of a cash contribution which is contingent upon the successful agreement and execution of an appropriate research contract between Sea 2 Sky and Energy & Environmental Research Center. By entering into this Memorandum of Understanding each party acknowledges that its represents the current intention of each party but that this Memorandum by itself, creates no legal obligation on either party to proceed further or have obligation to each other.

The current understanding of the Scope of Work to be undertaken is to:

1. Pretreat woody biomass, agricultural residues such as wheat straw, DDGS, corn stover, switchgrass and waste materials, including refuse-derived fuels, to produce clean bio-coal\syncoal using the torrefaction plus leaching pretreatment process.

2. Perform pilot-scale combustion and gasification tests to demonstrate the efficient utilization of the produced bio-coal/syncoal without emission and ash-related problems.

3. Develop an initial design of a demonstration pretreatment plant to utilize the torrefaction plus leaching process to produce commercial quantities of clean bio-coal/syncoal.

We send this letter to you as confirmation of our understanding of our discussions, If you understanding differs, please advise by return.

Yours truly

Sea 2 Sky Corporation

David Siebenga, CEO

Novaspect

December 18, 2009

Dear Dr. Arvelakis:

Novaspect Inc, an Emerson Process Management LBP (local business partner) has been working with Novaspect Inc, Renewable Energy Group agrees to contribute $75,000 'in kind' that will be leveraged by matching funding from a U.S. Department of Energy and North Dakota Renewable Energy Fund grant up to a total of $800,000. Novaspect Inc., is committed to supporting renewable energy and advanced biofuels project development and early stage companies that are developing innovative technology.

This funding will be to perform research at the Energy & Environmental Research Center on the project entitled "Development of Advanced Pretreatment Technologies for the Production of Clean Bio-Coal/Syncoal from Woody Biomass, Agricultural Residues and Municipal Solid Waste."

Novaspect Inc., intends to support the proposed project in the form of 'in kind' cost share, which is contingent upon the successful execution of an appropriate research contract.
The 'in kind' cost share will include the use of resources (engineering, process control architecture design and layout, process control instrumentation and valving engineering and other) to develop an initial design of a demonstration pretreatment plant.

Scope of Work:

1. Pretreat woody biomass, agricultural residues such as wheat straw, DDGS, corn stover, switchgrass and waste materials, including refuse-derived fuels, to produce clean bio-coal\syncoal using the torrefaction plus leaching pretreatment process.

2. Perform pilot-scale combustion and gasification tests to demonstrate the efficient utilization of the produced bio-coal/syncoal without emission and ash-related problems.

3. Develop an initial design of a demonstration pretreatment plant to utilize the torrefaction plus leaching process to produce commercial quantities of clean bio-coal/syncoal.

Sincerely,

J Chmielewski

Jacek Chmielewski
Renewable Energy Business Unit Manager - Project Execution Team
Novaspect Inc. **Emerson Process Management LBP**
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THERMOGON INTERNATIONAL

December 27, 2009

Energy & Environmental Research Center
University of North Dakota
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018
Att'n: Dr. Stylianos Arvelakis

Dear Sirs:

Thermogon International LLC ("Thermogon") intends to contribute $200,000 that will be leveraged by matching funding from a U.S. Department of Energy and North Dakota Renewable Energy Fund grant up to a total of $800,000. This funding will be used to perform research at the Energy & Environmental Research Center on the project entitled "Development of Advanced Pretreatment Technologies for the Production of Clean Bio-Coal/Syncoal from Woody Biomass, Agricultural Residues and Municipal Solid Waste."

Thermogon intends to support the proposed project in the form of cash cost share, which is contingent upon the successful execution of an acceptable research contract.

Scope of Work:

1. Pre-treat woody biomass, agricultural residues such as wheat straw, DDGS, corn stover, switchgrass and waste materials, including refuse-derived fuels, to produce clean bio-coal\syncoal using the torrefaction plus leaching pretreatment process.

2. Perform pilot-scale combustion and gasification tests to demonstrate the efficient utilization of the produced bio-coal/syncoal without emission and ash-related problems.

3. Develop an initial design of a demonstration pretreatment plant to utilize the torrefaction plus leaching process to produce commercial quantities of clean bio-coal/syncoal.

Pending execution of contracts, this letter serves as an expression of interest and shall not be construed as a legally binding commitment by Thermogon.

Best regards,

Nicholas Mitsos, CEO