EERC®
Energy & Environmental Research Center
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June 3, 2008

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. 2008-0327

Enclosed please find an original and one copy of the proposal entitled "Fischer–Tropsch Fuels Development." 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 a biomass-to-liquid fuel (BTL) technology that has the potential to provide a new industry for the state while providing energy security for the country. The cost share being proposed is legislatively directed funding from the U.S. Department of Energy (DOE). The EERC is committed to completing the project as described in this proposal if the North Dakota Industrial Commission makes the requested grant.

If you have any questions regarding this proposal, please contact me by phone at (701) 777-5243, or by e-mail at bfolkedahl@undeec.org.

Sincerely,

Bruce C Folkedahl
Senior Research Manager

Approved by:

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

BCF/sah
Enclosures

c/enc: Jeff Burgess, NDIC

EERC
Energy & Environmental Research Center

FISCHER–TROPSCH FUELS DEVELOPMENT

EERC Proposal No. 2008-0327

Submitted to:

Karlene Fine

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

Proposal Amount: $189,034

Submitted by:

Bruce C. Folkedahl

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

Bruce C. Folkedahl, Project Manager

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

June 2008

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FISCHER–TROPSCH FUELS DEVELOPMENT

ABSTRACT

The current political and economic climate is driving interest in biomass-to-liquids (BTL) technologies for production of liquid fuels. In addition, the price of oil has ranged from $55 to over $125 a barrel over the past year. Many parameters can affect the estimates, but BTL technologies are estimated to be competitive, with oil at $40 to $45 a barrel. Therefore, the current and projected prices of oil combined with the desire for increased energy security in the United States are creating commercial interest in BTL and the need for systems to test technology developments.

The goal of this proposed work is to prepare pilot-scale testing equipment and perform testing in the areas of Fischer–Tropsch (FT) liquid production, catalyst development, catalyst testing, product upgrade, and process simulation. Biomass-derived syngases will be used for the testing. The FT pilot system will be combined with existing Energy & Environmental Research Center (EERC) gasifiers to provide the capabilities to allow testing of current and newly developed catalysts with syngas from various fuels and at conditions of varied temperature, pressure, and gas composition. The catalyst development and production work will supply catalyst options for varied end-use applications, including use in smaller-scale, distributed fuel production systems. The development of FT technologies to produce liquid transportation fuels from biomass, waste, and coal will provide a new industry for North Dakota as well as helping to provide energy security not only for the state but for the entire country.

The total cost of the proposed 12-month project is $899,820. This includes $710,786 from the EERC's cooperative agreement with the U.S. Department of Energy National Energy Technology Laboratory and $189,034 being requested from the North Dakota Industrial Commission Renewable Energy Fund.

FISCHER–TROPSCH FUELS DEVELOPMENT

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 production of hydrogen-rich syngas under the EERC's National Center for Hydrogen Technology (NCHT). EERC commercial clients and military partners have expressed the need to expand the development and demonstration to include conversion of the coal and biomass-derived synthesis gases to liquid fuels.

The production of Fischer–Tropsch (FT) liquids is not new technology to the industry. Several large companies are making FT liquids at facilities that produce up to 100,000 bbl/day. With the recent increase in oil and gasoline prices, many additional smaller businesses are considering the production of FT liquids. One of the challenges for these small businesses is acquiring a FT catalyst technology. The catalyst technologies are available only if one is willing to pay very high royalty payments to the larger companies.

The product of the FT reactor is a crude oil containing straight-chain hydrocarbons in the range of C1 to C100. The product must be upgraded in order to be utilized as a transportation fuel. Distillation is utilized to separate the products, and the lighter hydrocarbons are recycled back through the FT reactor. The heavier waxes are reduced by hydrocracking to more desirable C7 to C15 hydrocarbons. There is additional interest in tailoring the upgrade process for specific end-use applications to change fuel properties such as flowability, energy density, lubricity, heat transfer, and sealing.

OBJECTIVES

The goal of this project is to prepare pilot-scale testing equipment and perform testing in the areas of FT biomass-to-liquids (BTL) production, catalyst development, catalyst testing, product upgrade, and process simulation. Specific objectives include:

- Integrating the FT reactor systems with the EERC's continuous fluid-bed reactor (CFBR) to provide a biomass-derived fuel gas slipstream from the CFBR at up to 400 psig in order to conduct high-pressure tests.
- Produce quantities of a unique iron-based catalyst that can be tested at the EERC in the integrated gasification FT reactor system utilizing biomass as the feedstock.
- Develop an Aspen simulation model capable of predicting liquid fuel formation.
- Develop laboratory-scale capability of upgrading and refining FT liquids into drop-in-compatible liquid fuels.

METHODOLOGY

Activity 1 – FT System Testing

The scope of work for Activity 1 involves testing of the FT pilot system using biomass-derived syngas. This will allow evaluation of the syngas cleanup devices being tested under separately funded projects at the EERC NCHT to determine their suitability for adequately protecting the FT catalyst. This will involve testing on a pilot-scale FT reactor which is currently being constructed under an existing program. Cold-gas cleanup options will also be considered instead of high-temperature sulfur sorbent if insufficient levels of sulfur removal have been demonstrated under the previous program.

Testing with actual biomass-derived syngas will be completed on the FT catalyst as a part of the project. A range of test conditions will be determined based on literature review. The effect of warm-gas cleanup on providing ultralow sulfur levels and the removal of other impurities on the catalyst performance will be determined over the test period.

Activity 2 – Catalytic Development and Production

The catalyst formulation will be developed in conjunction with researchers at Brigham Young University (BYU). The BYU laboratories are capable of producing only 100-gram batches of catalyst. Approximately 12 lb of catalyst will be needed for the test runs with the EERC system. The EERC will work with Dr. Calvin Bartholomew and his staff to scale production of catalyst capabilities at the EERC. BYU has been issued a contract to assist the EERC in catalyst development under a different project.

The catalyst will be produced at the EERC, and samples of the catalyst will be sent back to BYU for reactivity tests to ensure that the catalyst is suitably reactive to perform well in conversion of syngas to liquids. Only when all parties are satisfied with the catalyst formulation will the pilot-scale test be conducted.

Activity 3 – Process Simulation and Product Enhancement

A computer simulation will be developed that will model the entire BTL 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 liquid yields. The Aspen simulation software will be able to provide detailed mass and energy balance information, including a prediction of the liquid fuel volume produced versus the flow of feedstock into the system.

The initial model will help to determine the amount of catalyst needed to convert the syngas from the EERC's bench-scale gasifier. It will also provide insight to the amount of CO to be shifted to produce the proper H_2/CO ratio for FT synthesis. After empirical data are produced from the reactor, the Aspen model will be upgraded to provide more accurate predictions based on the FT catalyst used. The improved model will be able to provide predictions of the impact of feedstock variation on liquid yields.

This activity will also focus on the upgrade and conversion of raw FT liquids to the middle distillates of diesel and gasoline. Distillation and hydrocracking will be used to sort and upgrade the products of the FT reactor. Laboratory-scale systems will be utilized to upgrade a small slipstream of the FT liquids. A laboratory-scale distillation unit will sort the products between the lower hydrocarbons and the heavier waxes. The waxes will be cracked in a laboratory-scale catalytic hydrocracker to the optimum chain length for diesel fuels and gasoline. Gas chromatograph (GC) analyses will be run on the upgraded fuel to determine the range, length, and nature of the carbon chains.

A laboratory-scale reactor will be built and tested that will convert the FT fuel to allow production of a synthesis fuel that has drop-in compatibility with fuels used in today's engines. The system will be built in-house, and the appropriate catalyst will be acquired to perform necessary conversion reactions. The products will be analyzed using a high-resolution GC. Once suitable quantities of the upgraded FT fuel and the carbon rings have been acquired, the fuel will be mixed into a drop-in-compatible blend of liquid fuels. The exact fuel to be blended is still to be determined. This blend will undergo laboratory analysis to determine if it meets the specifications of the fuel to be produced.

Activity 4 – 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 State industry and public institutions.

ANTICIPATED RESULTS

The following results are anticipated:

- Demonstration of an integrated-gasification FT reactor system capable of utilizing biomass as the feedstock to produce liquids.
- Demonstration of pound quantities of unique catalysts for conversion of biomass-derived syngas to liquids.
- A computer simulation model capable of determining the amount of liquid fuel produced versus the feedstock feed rate and capable of determining the impact of system variation on the overall product produced.

- Demonstration of a laboratory-scale capability to upgrade portions of the FT liquid fuels produced to drop-in-compatible fuels.

Facilities, Resources, and Techniques

The EERC has extensive experience in designing, constructing, and operating pilot-scale systems. This project will utilize the EERC's CFBR a schematic of which is shown in Figure 1. The fuel for the CFBR is stored in the feed hopper and fed into the reactor with an auger. The CFBR has a fuel feed rate of approximately 1.8 kg/hr (4 lb/hr). From the reactor, the gas flows into the heated cyclone for initial removal of the larger particulates. The hot-gas filter vessel filters the finer particulates from the syngas. The condensation pots drop out any residue tars and particulates remaining. The CFBR will be integrated with a FT reactor capable of handling the entire syngas output stream of the CFBR or only a portion of it. Additional syngas cleanup technology to remove contaminants from the gas to the low levels required by the catalyst will also be integrated into the system between the CFBR and the FT reactor. Some of this cleanup equipment will come from previous projects and some will be custom built for this project. The CFBR has an online GC for gas analysis, and liquid and gas samples from the FT reactor

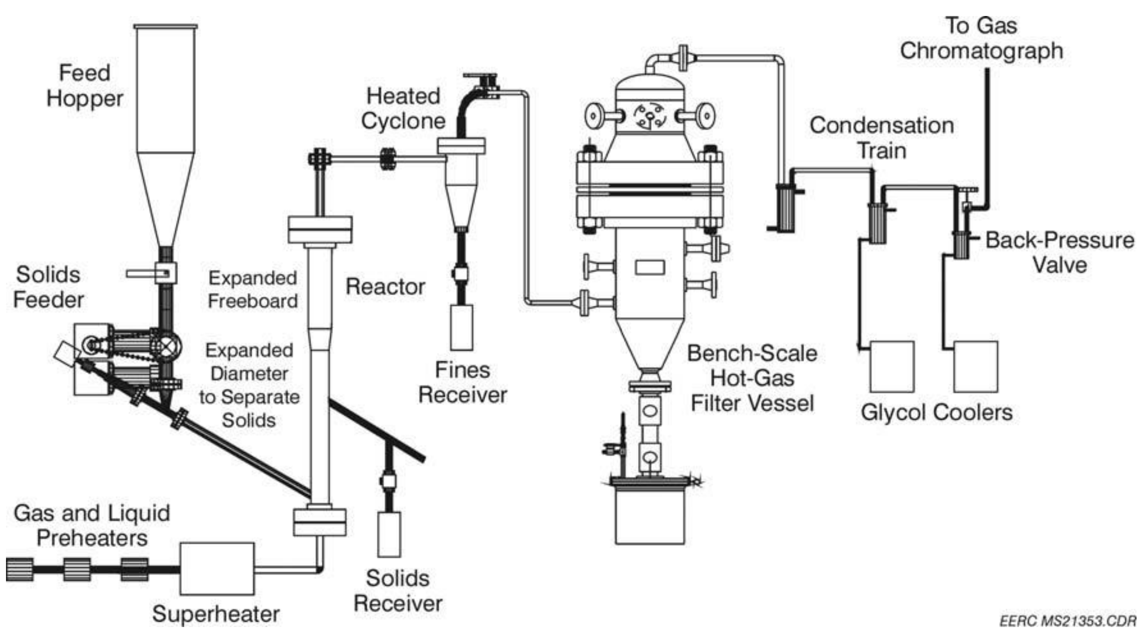

Figure 1. Schematic of the EERC CFBR gasification system.

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.

Environmental and Economic Impacts of Under-Way Project

The BTL 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 liquid fuels from under-utilized biomass resources in the state that are of nonfood value, providing for an increased energy security for the country with a lower carbon footprint than traditional fuels. The success of the project will provide the basis for scaling the technology to larger pilot- and demonstration-scale activities that can lead to a new industry in the state of North Dakota which will promote rural economic health and growth via development of regional biomass fuel collection and distribution industries to supply the needed feedstocks for the process.

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:

- Development of a unique catalyst for production of liquid fuels from biomass of value to industry.
- Achievement of successful shakedown and operation of an integrated gasification, syngas cleaning, FT reactor system to produce liquids.
- 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 produced liquids to be upgraded to drop-in-quality liquid fuels.

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. It is likely the results will benefit all of the energy industries of North Dakota such as the oil industry for determining what drop-in-compatible fuels have potential for "greening" their fuel, the coal industry to produce low-carbon emission fuels by cofeeding biomass and coal to the system, and the biofuel industry to transition from food-based biofuel production to the abundant nonfood biomass resources in the state. 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. This will have the added benefit of promoting North Dakota as a leader in energy technology that will give the United States energy security while lowering global carbon emissions.

Background and Qualifications

Much work has been done outside of the EERC in the area of FT fuel production 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.

Specific to fixed-bed gasifiers, the EERC operated the only slagging fixed-bed gasifier in the United States. In addition, the EERC worked with Dakota Gasification Company to optimize the operation of its Lurgi fixed-bed gasifiers by minimizing clinkering and steam usage. The EERC has extensive experience 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 EERC has performed some recent studies linked to FT liquid production that are directly related to this project. Under separate programs at the EERC, laboratory studies have been performed to demonstrate the proof of concept for liquid fuels from syngas including fundamental studies of catalysts where gram-scale production of catalyst material for use in lab-scale reactors has been achieved. Laboratory reactors have been designed and operated on bottled syngas that is a mixture of pure gas components to produce small levels of liquids. Also under a separate project at the EERC, the pilot-scale FT reactor to be integrated with the EERC gasification systems is currently being constructed. Multiple studies at the EERC have focused on syngas cleaning to reduce the contaminant level to very low or zero levels which are needed for protecting the catalyst materials from deactivation. All of this previous work will be utilized to ensure a successful outcome for this project.

The project 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. Dr. Folkedahl is currently in charge of a $1.6 MM project funded by the U.S. Department of Defense that is developing modular gasification systems to be integrated into military installations to provide heat, power, water, and fuels for the installation. Dr. Folkedahl has authored and coauthored numerous publications and presentations.

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, with an emphasis on hot-gas cleanup issues. Dr. Swanson will be responsible for the integration of the FT reactor with syngas cleanup technologies and the CFBR.

Mr. Jason Laumb will be charged with performing the catalyst production and scale-up activities. Mr. Laumb's principal areas of interest and expertise include predicting slag viscosity and boiler performance based on fuel quality and control technologies to remove mercury from combustion systems. He has coauthored several professional publications.

Mr Joshua Stanislowski will perform modeling and fuel upgrading for the project. Mr. Stanislowski is currently involved in projects to develop an entrained-flow gasification system and to integrate syngas cleanup technologies with the gasification system. Mr. Stanislowski's principal areas of interest and expertise include trace element fate through combustion systems, process controls, and experimental design and analysis.

Management

Dr. Folkedahl is the research project manager (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. Technical reports will be prepared to provide a comprehensive presentation of the results. The RPM will ensure that all project participants are informed of these requirements. Progress of the activities according to the approved plan will be constantly monitored by the RPM. Should EERC personnel identify that a change needs to occur, it will be first discussed internally with John Hendrikson, the EERC Program Manager (PM), the RPM, appropriate technical personnel, and EERC upper management. The PM will either accept or reject the change. Should the EERC PM 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. The EERC RPM will provide project personnel with a revised statement of project objectives, budget, and schedules.

Timetable

The proposed scope of research will be conducted over a 12-month period extending from September 1, 2008, through August 31, 2009, as summarized in the table below.

ID	Title/Description	Planned Completion Date	Actual Completion Date
Activity 1	Fischer –Tropsch System Testing		
M1	Initial System Design	11-01-08	
M2	System Construction	3-15-09	
M3	System Shakedown and Testing Complete	5-27-09	
Activity 2	Catalyst Development and Production		
M1	Catalyst Formulation	10-04-08	
M2	Bench Scale Catalyst Derived	12-15-08	
M3	Scale up of Catalyst Processing	2-31-09	
Activity 3	Process Simulation		
M1	Process Simulation Model Complete	11-01-08	
Activity 4	Project Management		
M1	Kickoff Meeting	9-02-08	
M2	Project Completion/Review Meeting	5-24-09	
M3	Draft Final Report	6-24-09	
M4	Final Report	8-26-09	
M5	Quarterly Reporting Oct. 08, Jan. 09, April 09, July 09	10-30-08 start	

EQUIPMENT TO BE FABRICATED OR PURCHASED

Activity 1 – FT System Testing

Approximately $145K in equipment will be needed to complete this activity. This will include modifications to a reactor system to integrate it with the EERC CFBR system. Also included will be all of the ductwork and piping required for integrating the syngas-cleaning equipment. Some of the syngas-cleaning components will also need to be modified or built from scratch to accommodate the reactor vessel for FT conversion to liquids.

Activity 2 – Catalytic Development and Production

Approximately $65K in equipment will be needed to monitor the system (BET and pore-size distribution analyzer $40K, and $10K for a chemisorption system). The remaining budget will consist of steel, control systems, and materials for the construction activities.

Activity 3 – Process Simulation and Product Enhancement

The laboratory-scale liquid fuel upgrade system is expected to cost $10,000, with the breakdown as follows:

- Distillation column – $500
- Catalytic hydrocracker and catalyst – $4500
- Product upgrade reactor and catalyst – $5000

Activity 4 – Project Management

None.

BUDGET

The total cost of this project is $899,820. This includes $710,786 from the U.S. Department of Energy and $189,034 in cost share requested from the NDIC Renewable Energy Fund. It is anticipated that one to three industrial sponsors will be also be involved in this project. Potential industrial partners for this project are ICM Inc., an ethanol production facility design-and-build firm; Rentech Inc., a FT catalyst developer; Great River Energy, an electrical generation and transmission company; and Falkirk Mining Company, a lignite-mining company in North Dakota. Supporting cost-share documentation will be provided as it is received.

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 is not confidential.

PATENTS AND RIGHTS TO TECHNICAL DATA

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

FISCHER-TROPSCH FUELS DEVELOPMENT
NORTH DAKOTA RENEWABLE ENERGY
PROPOSED PROJECT START DATE: 9/1/08
EERC PROPOSAL #2008-0327

BUDGET

CATEGORY			**TOTAL**		**ND Renewable Energy SHARE**		**DOE SHARE**	
LABOR		Rate	Hrs	Cost	Hrs	Cost	Hrs	Cost
Folkedahl, B.	Project Manager	$ 52.88	942	$ 49,813	175	$ 9,254	767	$ 40,559
Laumb, J.	Principal Investigator	$ 42.38	230	$ 9,747	35	$ 1,483	195	$ 8,264
Stanislowski, J.	Principal Investigator	$ 32.43	670	$ 21,728	165	$ 5,351	505	$ 16,377
Swanson, M.	Research Scientist/Engineer	$ 54.98	540	$ 29,689	65	$ 3,574	475	$ 26,115
--------------	Senior Management	$ 64.41	259	$ 16,682	43	$ 2,770	216	$ 13,912
--------------	Research Scientist/Engineer	$ 36.18	1,777	$ 64,292	355	$ 12,844	1,422	$ 51,448
--------------	Research Technician	$ 23.64	718	$ 16,974	-	$ -	718	$ 16,974
--------------	Technology Dev. Mech.	$ 28.55	1,180	$ 33,689	1,180	$ 33,689	-	$ -
--------------	Technical Support Services	$ 19.31	70	$ 1,352	-	$ -	70	$ 1,352
				$ 243,966		$ 68,965		$ 175,001
Escalation Above Base		1%		$ 2,440		$ 690		$ 1,750
TOTAL DIRECT HRS/SALARIES			6,386	$ 246,406	2,018	$ 69,655	4,368	$ 176,751
Fringe Benefits - % of Direct Labor - Staff		53.3%		$ 131,334		$ 37,126		$ 94,208
TOTAL FRINGE BENEFITS				$ 131,334		$ 37,126		$ 94,208
TOTAL LABOR				$ 377,740		$ 106,781		$ 270,959
OTHER DIRECT COSTS								
TRAVEL				$ 23,059		$ 4,612		$ 18,447
EQUIPMENT > $5000				$ 220,000		$ -		$ 220,000
SUPPLIES				$ 9,514		$ 3,784		$ 5,730
COMMUNICATION - PHONES & POSTAGE				$ 944		$ 184		$ 760
PRINTING & DUPLICATING				$ 1,885		$ 200		$ 1,685
FOOD				$ 1,000		$ 1,000		$ -
OPERATING FEES & SVCS								
Natural Materials Analytical Res. Lab.				$ 10,054		$ -		$ 10,054
Fuels & Materials Research Lab.				$ 727		$ -		$ 727
Process Chem. & Dev. Lab.				$ 270		$ -		$ 270
GC/MS Lab.				$ 2,626		$ -		$ 2,626
Fuel Prep. and Maintenance				$ 388		$ -		$ 388
Continuous Fluidized-Bed Reactor				$ 10,908		$ -		$ 10,908
Graphics Support				$ 2,636		$ -		$ 2,636
Shop & Operations Support				$ 1,585		$ 1,585		$ -
Outside Lab. – Brigham Young University				$ 2,000		$ -		$ 2,000
TOTAL DIRECT COST				$ 665,336		$ 118,146		$ 547,190
FACILITIES & ADMIN. RATE - % OF MTDC			VAR	$ 234,484	60%	$ 70,888	50%	$ 163,596
TOTAL PROJECT COST				$ 899,820		$ 189,034		$ 710,786

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.

DETAILED BUDGET - TRAVEL

RATES USED TO CALCULATE ESTIMATED TRAVEL EXPENSES

DESTINATION	AIRFARE	LODGING	PER DIEM	CAR RENTAL	REGIST.
Unspecified Destination (USA)	$ 950	$ 150	$ 64	$ 75	$ 525
Salt Lake City, UT (Brigham Young University)	$ 800	$ 100	$ 49	$ 50	$ -
Morgantown, WV (via Pittsburgh, PA)	$ 1,130	$ 190	$ 54	$ 51	$ -

PURPOSE/DESTINATION	NUMBER OF TRIPS	NUMBER OF PEOPLE	NUMBER OF DAYS	AIRFARE	LODGING	PER DIEM	CAR RENTAL	MISC.	REGIST.	TOTAL
Conference/Unspecified Dest. (USA)	2	2	4	$ 3,800	$ 1,800	$ 1,024	$ 600	$ 320	$ 2,100	$ 9,644
Meet with Catalyst Team/Salt Lake City, UT	1	2	3	$ 1,600	$ 400	$ 294	$ 150	$ 120	$ -	$ 2,564
Project Review Meeting/Morgantown, WV (Pittsburgh, PA)	3	2	3	$ 6,780	$ 2,280	$ 972	$ 459	$ 360	$ -	$ 10,851
TOTAL ESTIMATED TRAVEL										$ 23,059

FISCHER-TROPSCH FUELS DEVELOPMENT
EERC PROPOSAL #2008-0327

DETAILED BUDGET - EQUIPMENT

Fabricated Equipment	**$COST**
Modifications to Reactor system (Activity 1)	
Temperature Sensors & Supporting Equipment	$ 10,000
Refractory	$ 12,000
Stainless Steel Piping	$ 5,000
Mass Flow Controllers	$ 12,000
Bolting Material	$ 3,000
Valves	$ 15,000
Welding Supplies	$ 3,000
Insulation	$ 6,000
Safety Materials	$ 2,500
Flanges	$ 8,000
Booster Pumps	$ 20,000
Stainless Steel Tubing	$ 3,000
Steam Generator	$ 3,000
Desulpherization Vessel	$ 4,000
Condensing pots	$ 2,000
Analyzer Bank	$ 35,000
Miscellaneous components	$ 1,500
Total Estimated Cost: Modification to Reactor System	$ 145,000
Liquid Fuels Upgrade System (Activity 3)	
Distillation Column	$ 500
Catalytic Hydrocracker and Catalyst	$ 4,500
Product Upgrade Reactor and Catalyst	$ 5,000
Total Estimated Cost: Liquid Fuels Upgrade System	$ 10,000

Other Equipment	
BET and Pore Size Distribution Analyzer (Activity 2)	$ 52,000
Chemisorption System (Activity 2)	$ 13,000
	$ 65,000
Total Equipment	$ 220,000

FISCHER-TROPSCH FUELS DEVELOPMENT
EERC PROPOSAL #2008-0327

DETAILED BUDGET - EERC RECHARGE CENTERS

		TOTAL	
Natural Materials Analytical Res. Lab.	Rate	#	$Cost
CCSEM	$412	3	$ 1,236
Chemical Fractionation	$1,408	3	$ 4,224
Morphology (Hourly)	$228	8	$ 1,824
Point Count	$504	3	$ 1,512
XRD	$217	3	$ 651
XRFA	$169	3	$ 507
Subtotal			$ 9,954
Escalation		1%	$ 100
Total Natural Materials Analytical Res. Lab.			$ 10,054

Fuels & Materials Research Lab.	Rate	#	$Cost
Ash Determination	$32	3	$ 96
BTU	$50	3	$ 150
Moisture %	$47	3	$ 141
Proximate Analysis	$60	3	$ 180
Sulfur	$51	3	$ 153
Subtotal			$ 720
Escalation		1%	$ 7
Total Fuels & Materials Research Lab.			$ 727

Process Chemistry. & Dev. Lab.	Rate	#	$Cost
CHN (Sample)	$89	3	$ 267
Subtotal			$ 267
Escalation		1%	$ 3
Total Process Chemistry & Dev. Lab.			$ 270

GC/MS Laboratory	Rate	#	$Cost
GC/MS (Hourly)	$65	40	$ 2,600
Subtotal			$ 2,600
Escalation		1%	$ 26
Total GC/MS Laboratory			$ 2,626

Fuel Preparation & Maintenance	Rate	#	$Cost
Fuel Preparation & Maintenance (Hourly per piece of equip)	$24	16	$ 384
Subtotal			$ 384
Escalation		1%	$ 4
Total Fuel Prep. & Maintenance			$ 388

Continuous Fluidized-Bed Reactor	Rate	#	$Cost
Continuous Fluidized-Bed Reactor (Hourly)	$90	120	$ 10,800
Subtotal			$ 10,800
Escalation		1%	$ 108
Total Continuous Fluidized-Bed Reactor			$ 10,908

Graphics Support	Rate	#	$Cost
Graphics (hourly)	$58	45	$ 2,610
Subtotal			$ 2,610
Escalation		1%	$ 26
Total Graphics Support			$ 2,636

Shop & Operations Support	Rate	#	$Cost
Technical Development Hours	$1.33	1,180	$ 1,569
Subtotal			$ 1,569
Escalation		1%	$ 16
Total Shop & Operations Support			$ 1,585

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 anticipated to be approved for use beginning July 1, 2008, 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, 2008. 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.

APPENDIX A

RESUMES OF KEY PERSONNEL

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 coal inorganic transformations and deposition; development of predictive models to assess these processes; 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. 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 mechanism 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 neural network model of inorganic ash viscosity in high-temperature systems; development of image analysis program to identify graphitizability of cokes; and statistical cluster analysis of 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 XRD, XRF, SEM, 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

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

JASON D. LAUMB
Research Manager
Energy & Environmental Research Center (EERC), University of North Dakota (UND)
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Phone: (701) 777-5114, Fax: (701) 777-5181, E-Mail: jlaumb@undeerc.org

Principal Areas of Expertise
Mr. Laumb's principal areas of interest and expertise include biomass and fossil fuel conversion for energy production, with an emphasis on ash effects on system performance. He has experience with trace element emissions and control for fossil fuel combustion systems, with a particular emphasis on air pollution issues related to mercury and fine particulates. He also has experience in the design and fabrication of bench- and pilot-scale combustion equipment.

Qualifications
M.S., Chemical Engineering, University of North Dakota, 2000. Thesis: Predicting Slag Viscosity from Coal Ash Composition.
B.S., Chemistry, University of North Dakota, 1998.

Professional Experience
2001–Present: Research Manager, EERC, UND. Mr. Laumb's responsibilities include supervising projects involving bench-scale combustion testing of various fuels and wastes; supervising a laboratory that performs bench-scale combustion and gasification testing; managerial and principal investigator duties for projects related to the inorganic composition of coal, coal ash formation, deposition of ash in conventional and advanced power systems, and mechanisms of trace metal transformations during coal or waste conversion; and writing proposals and reports applicable to energy and environmental research.

2000–2001: Research Engineer, EERC, UND. Mr. Laumb's responsibilities included aiding in the design of pilot-scale combustion equipment and writing computer programs that aid in the reduction of data, combustion calculations, and prediction of boiler performance. He was also involved in the analysis of current combustion control technology's ability to remove mercury and studying the suitability of biomass as boiler fuel.

1998–2000: SEM Applications Specialist, Microbeam Technologies, Inc., Grand Forks, North Dakota. Mr. Laumb's responsibilities included gaining experience in power system performance including conventional combustion and gasification systems; a knowledge of environmental control systems and energy conversion technologies; interpreting data to predict ash behavior and fuel performance; assisting in proposal writing to clients and government agencies such as NSF and DOE; preparing and analyzing coal, coal ash, corrosion products, and soil samples using SEM/EDS; and modifying and writing FORTRAN, C+ and Excel computer programs.

Professional Memberships
American Chemical Society

Publications and Presentations
Has coauthored numerous professional publications

JOSHUA J. STANISLOWSKI
Research Engineer
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Principal Areas of Expertise
Mr. Stanislowski's principal areas of interest and expertise include fossil fuel combustion for energy conversion with emphasis on trace element control, gasification systems analysis, combustion and gasification pollution control, and process modeling. He has extensive experience with process engineering, process controls, and project management. He has a strong background in gauge studies, experimental design, and data analysis.

QUALIFICATIONS

B.S., Chemical Engineering, University of North Dakota, 2000.
Six Sigma Green Belt Certified, August 2004.

Professional Experience:
2005–Present: Research Engineer, EERC, UND, Grand Forks, North Dakota. Mr. Stanislowski's areas of focus include mercury control technologies and coal gasification. His responsibilities involve project management and aiding in the completion of projects. His duties include design and construction of bench- and pilot-scale equipment, performing experimental design, data collection, data analysis, and report preparation. His experience also includes low-rank coal gasification, warm-gas cleanup, and liquid fuels production modeling using Aspen Plus software.

2001–2005: Process Engineer, Innovex, Inc., Litchfield, Minnesota.

- Mr. Stanislowski was responsible for various process lines including copper plating, nickel plating, tin–lead plating, gold plating, polyimide etching, copper etching, chrome etching, and resist strip and lamination. His responsibilities included all aspects of the process line including quality control, documentation, final product yields, continuous process improvement, and operator training. He gained extensive knowledge of statistical process control and statistical start-up methodology. Mr. Stanislowski was proficient with MiniTab statistical software and utilized statistical analysis and experimental design as part of his daily work.

- Mr. Stanislowski designed and oversaw experiments as a principal investigator; wrote technical reports and papers, including standard operating procedures and process control plans; presented project and experimental results to suppliers, customers, clients, and managers; created engineering designs and calculations; and performed hands-on mechanical work when troubleshooting process issues. He demonstrated ability to coordinate activities with varied entities through extensive project management and leadership experience.

1998–2000: Student Research Assistant, EERC, UND. Mr. Stanislowski worked on a wide variety of projects including data entry and programming for the Center for Air Toxic Metals® (CATM®) database, contamination cleanup program development, using aerogels for emission control, and the development of a nationwide mercury emission model.

Publications and Presentations
Has coauthored several publications