Energy & Environmental Research Center

ANAEROBIC TREATMENT OF DAKOTA GASIFICATION COMPANY STRIPPED GAS LIQUOR

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TABLE OF CONTENTS

Continued . . .

TABLE OF CONTENTS (continued)

LIST OF FIGURES

LIST OF TABLES

ANAEROBIC TREATMENT OF DAKOTA GASIFICATION COMPANY STRIPPED GAS LIQUOR

ABSTRACT

The Dakota Gasification Company (DGC) Great Plains Synfuels Plant, located near Beulah, North Dakota, is the only commercial coal gasification plant producing pipeline substitute natural gas (SNG) in the United States. The plant utilizes 18,000 tons/day of lignite coal to produce 170 million cubic feet/day of SNG. Consistent with NDIC eligibility requirements, the proposed project will develop a commercial program for enhanced effluent treatment using bioremediation techniques. The project will show numerous environmental benefits that would need to be established for any potential plant expansion. Further development of commercial coal gasification in North Dakota can only be realized with proper environmental stewardship.

The proposed project consists of several interrelated tasks with the goal of establishing the technical feasibility and economic viability of using an anaerobic microbiologically based process for the treatment of DGC stripped gas liquor. It is expected that the project will demonstrate the potential to upgrade wastewater quality; increase gasifier throughput; enhance the operability of the gasifiers and downstream unit operations; reduce air emissions; and generate a methane gas product. Project deliverables will include a final technical project report along with preliminary process design and economic data for an integrated commercial-scale treatment system.

The Energy & Environmental Research Center (EERC), with assistance from DGC, will conduct the project over an 18-month period. The requested level of funding from NDIC is $130,000. The match requirement for these funds includes $50,000 in cash and $80,000 of in-kind services from DGC. Additional project funding will be requested from the EERC–U.S. Department of Energy Jointly Sponsored Research Program ($120,000), resulting in a total project funding level of $380,000.

ANAEROBIC TREATMENT OF DAKOTA GASIFICATION COMPANY STRIPPED GAS LIQUOR

1.0 PROJECT SUMMARY

The large fluctuations in the cost of energy over the past two years once again illustrate the sensitivity of the U.S. market to changes in foreign energy policy and domestic supplies. In spite of current low energy prices, the fact remains that world petroleum supplies are dwindling and our national dependence on foreign oil supplies continues to increase. It is imperative that the United States continue to develop domestic energy sources. Coal gasification is an important component in the domestic U.S. energy picture and is expected to become even more so in time. However, even as the economics of coal gasification become attractive with supply and demand pressures, water supply and wastewater treatment issues remain as critical obstacles to widespread expansion of commercial operations. In particular, significant improvements to existing wastewater treatment processes will be needed to expand current commercial gasification capacity. This Energy & Environmental Research Center (EERC) project will evaluate the technical feasibility and economic viability of an alternative method of treating coal gasification wastewater that will result in additional methane generation, which supports the North Dakota Industrial Commission (NDIC) objective of developing commercial programs to treat effluent from lignite conversion plants. The Dakota Gasification Company (DGC) Great Plains Synfuels Plant, located near Beulah, North Dakota, is the only commercial coal gasification plant producing pipeline substitute natural gas (SNG) in the United States. The plant utilizes 18,000 tons/day of lignite coal to produce 170 million cubic feet/day of SNG. Additionally, the plant produces phenolics, anhydrous ammonia, ammonium sulfate, and carbon dioxide as by-products of the gasification process and recovers krypton and xenon from an

oxygen purification plant. Recently, a 100-million-cubic-feet/day high-pressure CO_2 pipeline was constructed to southern Saskatchewan oil producers in the Williston Basin for enhanced oil recovery.

The plant is designed as a zero-liquid-discharge facility in that the only water to leave plant boundaries is evaporation from the cooling towers and ponds, a limited deepwell injection capability, and water carried in the ash to the coal mine pit for disposal. The gasification process results in the generation of a wastewater flow of 3000 gpm. The wastewater is processed using gravity separation to remove tars and oils, followed by solvent extraction and steam stripping to remove and recover phenolics and ammonia, respectively. The resultant water, termed stripped gas liquor (SGL), is further treated using cooling towers and multiple-effect evaporators for volume reduction. Blowdown from the evaporation processes is disposed of through injection into the gasifier(s).

The SGL contains significant concentrations of phenols, organic acids, and alcohols that are utilized as a food source by bacteria in the existing treatment system. The result is a microbial growth that contributes to fouling of heat exchanger surfaces in the cooling tower system as well as the multiple-effect evaporators. The SGL also contains diphenolics (catechols) which polymerize in the presence of free oxygen to humic acid-like compounds which impart a black color to the water and are resistant to bacterial degradation. These polymers are not only biorefractory but also contribute to the fouling of heat exchange surfaces. Both the microbial growth and catechol polymers necessitate the use of chemical dispersants and antifoaming agents to reduce fouling and control foaming problems.

The proposed research will investigate the use of an anaerobic biological process to degrade phenolics, catechols, fatty acids, and other organics in the SGL prior to cooling tower treatment. Anaerobic treatment will produce a water with a much lower organic content which will reduce biological growth in the cooling water, resulting in less biofouling and potential for foaming, and

reduce the costs associated with chemically treating the wastewater stream with dispersants and antifoaming agents. Additionally, removal of the catechols under anaerobic conditions will prevent the oxidative polymerization reactions that produce biorefractory compounds, reduce related organic fouling, and result in a conversion from a black to a clear wastewater system. Anaerobic treatment will also remove organic acids and reduce the air emissions associated with air stripping in the cooling towers. Additionally, anaerobic treatment of organic wastes results in the production of methane gas as a metabolic end product.

The proposed process provides a more environmentally acceptable zero-effluent-discharge scenario critical to commercial gasification that will demonstrate the ability to support future commercial expansion with appropriate environmental stewardship. In light of the need for domestic energy security and the role that gasification will play, expansion of the existing DGC facility or the construction of new gasification facilities in North Dakota to meet increasing demands for fuels will be realized, resulting in increased use of lignite.

2.0 PROJECT DESCRIPTION

The overall project will consist of several interrelated tasks with the goal of establishing the technical feasibility and economic viability of using anaerobic treatment of DGC SGL to upgrade wastewater quality and enhance the operability of the heat exchangers, cooling towers, and multiple-effect evaporators, while producing methane gas. Project tasks include collection and acclimation of adapted microorganisms, batch testing to establish a range of treatment conditions to satisfy treatability goals including target levels of catechol reduction, and continuous-flow testing in a small pilot reactor system to verify treatment and develop preliminary process engineering design data. Treatability test and evaluation methodologies are presented below.

2.1 Task 1 – Collection and Acclimation of Anaerobic Cultures

Testing conducted during these treatability studies will utilize bacteria that are adapted to SGL from the DGC wastewater treatment system. This will reduce any potential inhibitory effects and reduce the amount of time needed for microbial acclimation. Anaerobic cultures will be collected by EERC and DGC personnel in conjunction with a project kickoff meeting.

Desirable bacteria will be collected from the existing DGC wastewater treatment system at points where anaerobic conditions are likely to occur. These include microenvironments in the cooling tower sumps identified by DGC personnel as likely anaerobic zones. Additional sample collection points may include anaerobic zones in the heat exchange loop. These bacteria will provide a culture already adapted to constituents in the SGL, which will reduce the amount of time required for acclimation. Samples of SGL will also be collected at this time for use in acclimation and batch testing procedures. Additional samples of anaerobes might also be collected from the anaerobic digester of a local wastewater treatment plant to assure the presence of methanogenic bacteria, if methane production is low in the DGC system samples. These cultures will undergo an acclimation and growth period to allow for the development of a population of microorganisms for batch and continuous-flow process development (Tasks 2 and 3).

Microbial acclimation will be carried out in a sealed, 12-L stirred tank reactor with an 8-L nominal operating volume. The reactor will be placed in a water bath to maintain an operating temperature of 95°F. The acclimation reactor system is illustrated in Figure 1. SGL will be fed from an influent storage tank with a nitrogen purge. SGL feed rates will be increased over time during the acclimation period as the culture develops. Biological activity will be monitored through the continuous measurement of gas production. Analysis of the produced biogas will be used to verify the presence of an acclimated culture of methanogenic bacteria. The acclimation reactor will be

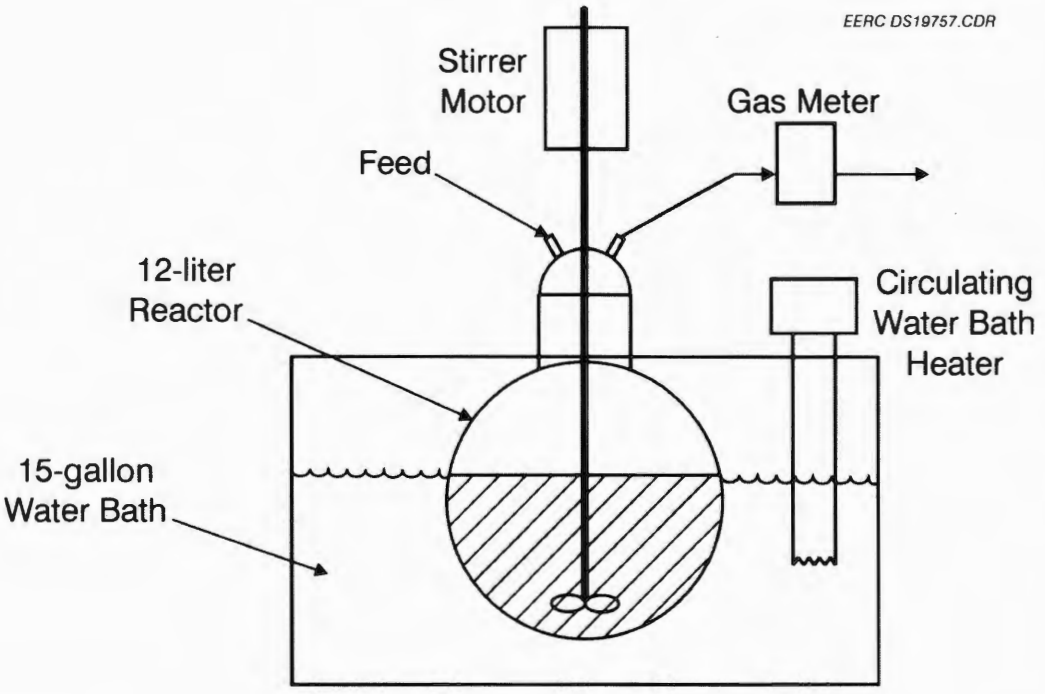

Figure 1. Bench-scale microbial acclimation reactor.

monitored on a daily basis to ensure consistent feed, evaluate gas production, and inspect mixed-liquor temperatures. Additionally, once per day the reactor stirrer will be stopped and the mixed liquor allowed to settle. Supernatant will be removed to bring the operating level to a predetermined level (approx. 8 liters). Periodic analysis of the supernatant will verify catechol destruction.

2.2 Task 2 – Batch Testing

Four key variables have been identified as design considerations or as conditions of potential concern for stable operation of an anaerobic biological reactor for treating the SGL. These four variables are temperature, pH, phenolics loading, and ammonia concentration. The effects of these variables can be most economically answered by performing a set of batch tests. These variables are described below.

Ammonia – Ammonia or a similar form of nitrogen is a required nutrient for biological treatment of the SGL. Ammonia may also be toxic to microbes, especially when in the unionized or "free" form. The two forms of ammonia have a pH-controlled equilibrium as follows: $NH_3 + H^+ \leftrightarrow NH_4^+$, with a pKa of 9.24. At pH values near or above the pKa, the concentration of "free" ammonia increases and may become toxic. A range of ammonia concentrations from as-received to 3000 mg/L will be evaluated, along with a range of pH values. The combination of the two variables will show the levels of both pH and ammonia that may be inhibitory to anaerobic treatment of the SGL.

pH – The pH of the SGL is relatively basic, around 9. Bacteria can tolerate a fairly wide range of pH values, generally between 6 and 8. Extremes of pH affect the ability of the microbes to obtain nutrients and maintain membrane integrity. Although it is likely that the anaerobic activity of the bacteria will result in a mixed-liquor pH somewhat reduced from the as-received pH because of the production of intermediate organic acid end products, pH control may be necessary, especially if ammonia concentrations are high. Tests will evaluate pH effects in the range of 6 to the as-received value.

Phenolics – Phenol and related phenolics are good substrates for bacterial activity. However, they may also be toxic at high concentrations. In addition, and possibly more importantly, the presence of catechols in the DGC SGL results in a black water system upon entering the cooling towers as described above, creating a variety of treatment difficulties. The level of phenolics in typical SGL is not expected to be a problem to a bacterially based treatment system, but upsets in upstream processes could result in much higher concentrations. Concentrations of phenol, and a mixture of cresols and catechol (ratioed according to SGL), will be tested at concentrations from the as-received value to 1000 mg/L. Including total phenolics as a test matrix variable, with catechols

making up the bulk of the phenolics load, will also define the appropriate operating conditions for significant catechol removal.

Temperature – Bacteria are capable of tolerating a wide temperature range. In general, bacteria follow the Q_{10} rule, where a doubling of rate is noted for every 10°C increase in temperature. However, there are limits to the temperatures that can be tolerated, as the bacterial proteins can be denatured at high temperatures. We expect that a temperature of 35°C (95°F) would be optimal, but other temperatures may be desired for better integration into the existing processes. Temperatures of 35°C (95°F), 47.5°C (117.5°F), and 60°C (140°F) will be investigated.

2.2.1 Experimental Design

There are many different types of statistical designs that can be used to arrange experiments so that data about the relationship of independent test variables and the measured result can be gathered in the most efficient manner. One of the simplest methods is a full factorial design. A full factorial design consists of tests performed at all possible combinations of the highest and lowest values of each independent variable, as well as "center point" tests performed at conditions that are halfway between the highest and lowest values. A factorial design assumes that a linear model adequately describes the variations in the measured result as the independent variables change. Nonlinearities (i.e., curvature) are evaluated by comparing the experimental result attained at the center points, with the result calculated from the average of the factorial points. If curvature exists, then additional tests are performed to determine which of the factors is causing the curvature. These additional tests are performed at conditions that are higher and lower than the values tested during the full factorial matrix and are called "star points." It should be noted that curvature does not invalidate the conclusions drawn about the relationships between the variables, but rather indicates that more information must be gathered to better describe the relationships.

Temperature will be tested over the range of 95° to 140°F (with the center point at 117.5°F). The phenolics concentration will be varied over the range of as-received to 1000 mg/L. Ammonia concentration will be tested over the range of as-received to 3000 mg/L. The pH will be varied from 6 to 9 (or as-received). An experimental matrix has been devised using the standard four-factor factorial matrix with four center point tests. The matrix is shown in Table 1. The order of the tests has been randomized so as to minimize any bias, although the center points are spaced uniformly throughout the matrix to ensure as valid an estimate of the variance as possible. If an acceptable level of accuracy is not obtained from the four duplicate center points, replicates of other experimental conditions will be performed.

Table 1. Experimental Matrix for Batch Testing of DGC Stripped Gas Liquor

Run Number	Temperature, °F	Total Phenolics, mg/L	pH	Ammonia, mg/L
1	95	1000	6	3000
2	95	As-received	6	2000
3	140	1000	6	As-received
4	117.5	Mid	Mid	Mid
5	140	1000	As-received	3000
6	95	As-received	As-received	3000
7	140	1000	6	3000
8	117.5	Mid	Mid	Mid
9	140	As-received	As-received	3000
10	140	As-received	As-received	As-received
11	140	As-received	6	3000
12	117.5	Mid	Mid	Mid
13	95	As-received	As-received	As-received
14	140	As-received	6	As-received
15	95	1000	As-received	3000
16	117.5	Mid	Mid	Mid
17	140	1000	As-received	As-received
18	95	1000	As-received	As-received
19	95	As-received	6	As-received
20	95	1000	6	As-received

Numerical analysis will be performed using linear regression methods to determine which (if any) calculated effects of the variables are statistically significant, rather than due to random

variability of the data. The presence of curvature will also be checked. If curvature is present, additional experiments will be performed at the star point values (as described earlier) to gather data points that will permit a clearer understanding of the effects of each of the factors. A mathematical model describing the treatment results as functions of each of the independent variables will be developed. The effects of a given variable on the measured treatment level will be plotted over the valid range of each model. The models will be used to predict the conditions at which the best anaerobic treatment will occur. The predicted conditions will be verified during continuous-flow testing performed later in the project.

2.2.2 Setup of the Batch Tests

Concentrated solutions of the various additives and the serum bottles, caps, etc., will be placed in an anaerobic glove box the day before setting up the experiment. A quantity of DGC SGL that was collected fresh under anaerobic conditions and stored in the dark at 4°C will be used as the baseline feed in these tests. This batch of SGL will be characterized with respect to total phenolics (phenol, cresols, and catechol), pH, ammonia, and chemical oxygen demand (COD). The SGL will be titrated to determine the quantity of acid required to achieve the desired pH levels needed for the batch tests. The anaerobic glove box is operated at room temperature with a gas composition of 90% N_2 and 10% H_2. Allowing the experimental reagents and apparatus to sit in this chamber overnight will allow for removal of trace amounts of oxygen prior to setting up the experiment. The following day, a fresh batch of acclimated biomass will be transferred into the chamber and used to set up the batch tests. This acclimated biomass will be characterized with respect to the total and volatile suspended solids (a measure of biomass), soluble COD, and ammonia, and the biomass will have been verified to biodegrade catechol and produce methane.

The batch experiments will follow standard, excepted microbiological testing protocols, each serum bottle will be set up at an intermediate organic loading (i.e., 4 kg COD/g VSS-d) by adjusting the quantity of added biomass in bottles where no additional phenolics are added. The quantity of biomass will be the same in all bottles. Ammonia concentrations will be adjusted by adding a concentrated solution of ammonium bicarbonate. Phenolics concentrations will be adjusted by adding a concentrated solution of phenol, o-, m-, and p-cresol, and catechol, ratioed the same as in the SGL. The pH will be adjusted with a concentrated hydrochloric acid solution (sulfuric acid is undesirable because of the potential effects of sulfide inhibition under anaerobic conditions). The serum bottles will be filled with the biomass, SGL, and additives and capped with butylrubber septa and sealed with aluminum crimp seals in the anaerobic chamber. After sealing, the bottles will be removed, sampled for baseline concentrations of COD and phenols, and incubated at the desired temperatures. The bottles will be incubated at the set temperatures with mixing and in the dark. At intervals of 1 to 2 hours, the gas produced in each bottle will be estimated using a wetted glass syringe. Monitoring of the gas produced will continue for 24 hours or until gas production in the baseline (unamended SGL) has ceased. To measure the gas produced, a 5- or 10-cc glass syringe is prewetted with water and fitted with a 22-gauge or smaller needle; the needle is eased through the septum, allowing the gas pressure in the bottle to push the barrel up until the pressures in and out of the bottle are equal. The volume in the syringe is noted, the syringe removed, and the gas expelled. A plot of the cumulative gas produced in each bottle during the incubation period is prepared. When the batch tests are completed, each bottle will be analyzed for final COD and phenolics concentrations. The total amount of gas produced, the initial rate of gas production, and the COD and phenolics removals will be analyzed by linear regression to show the effects of the four variables

on these parameters. If the variance is unacceptably high or if an analysis of the data shows significant curvature, additional tests will be performed to improve the model.

Analytical tests will be performed as follows: COD will be performed on samples filtered through 0.45-μm-pore-size filters, then analyzed by the standard acid-dichromate method; phenolics will be analyzed by direct aqueous injection onto a capillary column (the method uses an internal standard and can separate and quantitate phenol, catechol, o-cresol, and m-, and p-cresols); biomass will be estimated by standard gravimetric methods; gas analysis will be performed using a refinery gas chromatograph; ammonia will be estimated by the distillation/titration method; and pH will be determined by electrode.

2.3 Task 3 – Continuous-Flow Testing

Continuous-flow pilot testing will be conducted on-site at the DGC Great Plains Synfuels Plant to verify treatment conditions established during batch testing, evaluate process operability under continuous-flow conditions, and develop preliminary engineering design data for a demonstration- or commercial-scale treatment unit. A skid-mounted continuous-flow test unit will be designed and fabricated at the EERC and transported to DGC for operation. Based on EERC experience with gasification wastewaters and a review of available literature on anaerobic treatment of similar wastewaters, upflow fluidized-bed anaerobic treatment of this type of wastewater appears to be most appropriate from operational and economic aspects. Granular activated carbon (GAC) will be used as the fluidizing and support medium for the growth of attached anaerobic bacteria. GAC not only provides for microbial attachment, but also reduces the effects of shock loading by adsorption of organics during periods of interruption in upstream treatment operations. The use of GAC as the growth medium will also significantly reduce overall reactor volume requirements because of the adsorption potential and high biomass concentrations afforded by attached growth.

Approximately 45% of the total anaerobic reactor volume will be GAC. Figure 2 is a schematic representation of the type of reactor that will be constructed at the EERC for on-site, continuous-flow treatment testing of DGC SGL. Influent (SGL) is fed at the base of the reactor and flows upward through a bed of GAC growth support media. Effluent is removed near the top of the column. A recycle loop which returns a portion of the effluent to the head of the treatment unit provides for operation as a completely mixed system and allows for the maintenance of a constant fluidizing velocity. Methane and CO_2 generated from anaerobic decomposition of the organic matter are collected from the top of the reactor vessel. Treated effluent from the anaerobic treatment unit would then be sent on to the cooling towers.

The continuous-flow reactor will be designed to accommodate a flow rate sufficient to just expand the GAC bed, estimated as a flow of approximately 5 gpm/ft^2. The total reactor volume will be approximately 45 gallons (178 liters). The system will be fabricated and assembled at the EERC

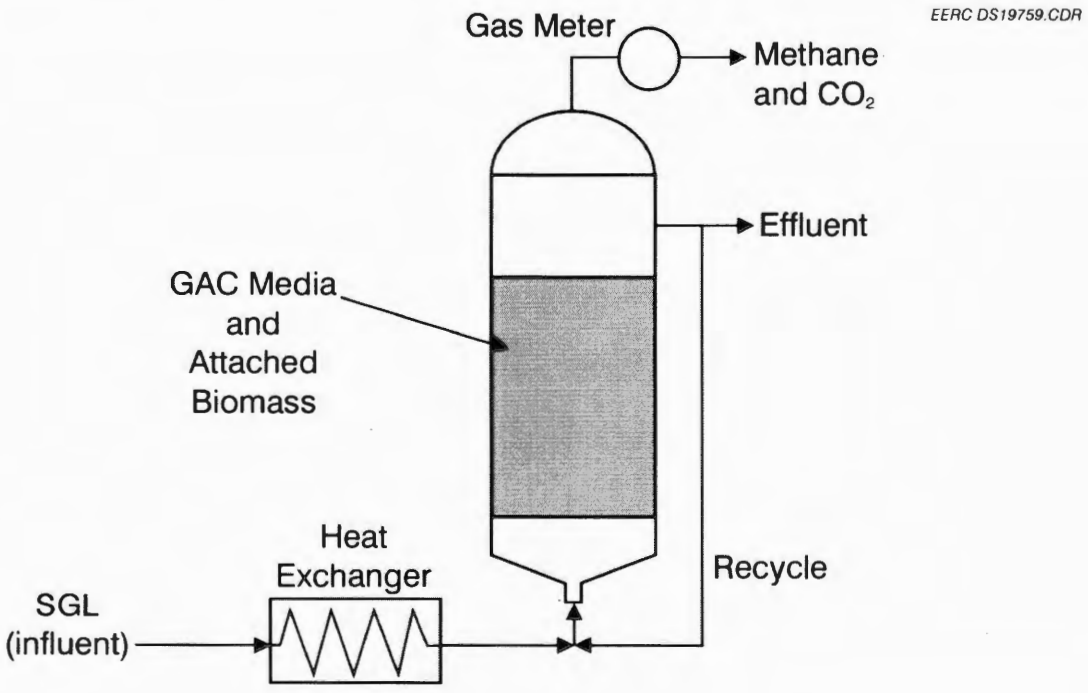

Figure 2. Schematic representation of pilot-scale fluidized-bed reactor system.

which has considerable expertise in the design and construction of demonstration-scale testing equipment. The reactor and associated components will be skid-mounted for ease of transportation and manipulation at DGC. DGC will supply SGL to the pilot unit which will be equipped with an influent heat exchanger to provide close control of mixed-liquor temperatures within the fluidized-bed reactor. Influent flow rate is estimated to range from 135 to 270 gallons per day, depending on process capabilities that can be developed.

The continuous-flow system will be operated under three different organic loading rates measured in terms of mass of COD applied per volume of settled solids per day for the development of process design data. Each of these operating periods will include a period of process acclimation and stabilization, followed by a steady-state sampling and analysis period. The reactor will be seeded with biomass acclimated to the DGC SGL as described above, i.e., anaerobic biomass initially collected from the DGC cooling tower recirculation basin and acclimated to as-received SGL over a 4–5-month period of time. Following reactor construction and installation at the DGC Great Plains Synfuels Plant, the system will be seeded and operated for up to 4 additional months to produce a completely acclimated and stabilized population of anaerobes in the reactor. Routine monitoring during acclimation and stabilization periods will include daily measurement of process temperature, pH, gas production, and influent and recycle flow rates and weekly sampling and analysis of influent and effluent for COD, ammonia, phenolics, organic acids, and alcohols. One of the main objectives of the continuous-flow testing is to demonstrate complete degradation of influent catechols, which have been shown to impart black color to the wastewater upon exposure to oxygen as described above. Significant catechol degradation will be a key parameter to signal stable system operation. The acclimation/stabilization period will be followed by 1 week of steady-state operation for the development of process design information, including kinetic growth coefficients and constituent

removal rates. Steady-state operation and maintenance will include daily sampling and analysis of reactor influent and effluent, as well as the collection of a sample for more detailed chemical characterization to define water quality to the downstream treatment operations (i.e., cooling towers and multiple-effect evaporators). Table 2 provides a list of parameters that will be evaluated during steady-state operation. Following the first and second steady-state operating periods, the organic loading to the reactor will be adjusted and the pilot system will be allowed to acclimate to the new operating conditions for a period of 3 months.

The pilot reactor will be designed such that samples of mixed liquor can be collected for bed material/biomass analysis. The reactor will also be fitted with a device that can be lowered from the top of the reactor to the surface of the settled solids to measure changes in bed volume. Any biogas produced will be passed through a gas meter and totalized, and periodic gas samples will be collected in Tedlar bags downstream of the gas meter for analysis of biogas composition.

2.4 Task 4 – Economic Analysis

Based on the results obtained during continuous-flow testing, preliminary process economics will be assessed. This analysis will include estimates of capital expenditures required to construct a full-scale anaerobic treatment process amortized over an appropriate period and estimates of operating and maintenance costs. These costs will be compared to potential revenue from the process, including revenue from methane generation and decreased demand for chemical additives during cooling tower treatment and operation of the multiple-effect evaporators.

2.5 Task 5 – Reporting

Project status reports will be prepared quarterly throughout the duration of the project. These reports will be submitted to NDIC, the U.S. Department of Energy (DOE), and DGC. A draft final project report will be prepared and submitted to all project sponsors within 30 days of the completion

Table 2. Parameters to Be Analyzed During Steady-State Operation of the Continuous-Flow Pilot Reactor (influent and effluent)

Total Ammonia as NH_3
Ammonia, free as NH_3
Ammonia, fixed as NH_3
Total Suspended Matter
Oil
Total Organic Carbon
Catechols, totals
Phenols + Cresols
Acetonitrile
Propyl Nitrile
Pyrrole
Pyridine
Methanol
Acetone
Methyl Ethyl Ketone
1 and 2-Propanol
Acetic Acid
Propionic Acid
n-Butyric Acid
Isobutyric Acid
COD
BOD[1]
pH
Phosphate as PO_4
Conductivity

[1] Biological oxygen demand.

of all project testing and analysis activities. The draft report will be modified as needed in response to review comments, and a final technical project report submitted.

In addition, a project kickoff meeting and project update meetings with EERC and DGC/Great Plains Synfuels Plant personnel will be held. The results of this research will also be presented at a DOE program review meeting.

2.6 Facilities and Equipment

Established as a federal research and development facility in 1951, the EERC has been a part of the University of North Dakota (UND) since 1983. With a staff of more than 210 talented

scientists, engineers, and support personnel, the EERC is one of the leading developers of energy and environmental technologies in the world. Activities involved in the proposed project will be conducted at both the EERC and at DGC Great Plains Synfuels Plant. Microbial acclimation activities will be conducted at the EERC Remediation Research Laboratory, while batch testing will be conducted at the EERC Environmental Microbiology Laboratory.

2.6.1 Remediation Research Laboratory

The Remediation Research Laboratory offers bench- and pilot-scale testing and evaluation of a variety of unit operations and processes for the treatment of wastewaters, contaminated groundwaters, and soils. These include the use of physical, chemical, and/or biological methods for the evaluation of established treatment technologies, as well as the development of innovative treatment technologies. EERC personnel also provide technical support and evaluation of client technologies through the Remediation Research Laboratory, assisting in continued development and demonstration for commercialization. Bench- and/or pilot-scale facilities are available for the evaluation of the following:

- Air stripping
- Steam stripping
- Solvent extraction
- Activated sludge variations
- Rotating biological contactors
- Innovative biological treatment systems
- Anaerobic treatment systems
- Cooling towers

- Activated carbon adsorption
- Ion exchange
- Ultrafiltration and other filtration variations
- Ozonation
- Chemical precipitation

These processes and operations can be evaluated as individual components or as fully integrated treatment systems. The Remediation Research Laboratory is complemented by analytical support from the Analytical Research Laboratory and microbiological analytical support from the Environmental Microbiology Laboratory. Additionally, specialized equipment, such as modular pilot plants, can be designed and fabricated in the EERC machine shop for use in the simulation of large-scale process evaluation and data collection, which are essential for process development and troubleshooting.

2.6.2 Environmental Microbiology Laboratory

Research activities in the Environmental Microbiology Laboratory are divided between supporting research projects at the EERC and conducting specific environmental microbiology projects. Primary areas of research include biodegradation of pollutants and xenobiotics, microbial ecology of the subsurface, and microbial biotechnology. Support projects include studies of nonaqueous enzymes, enzyme immobilization, and in situ bioremediation.

Equipment and facilities are available for general and physiological microbiology research, including a sterilizer, water baths, shakers, incubators, ovens, a pH meter, centrifuges, and balances. Additional equipment includes a phase-contrast microscope, a stereoscope, a Class II laminar-flow hood, low-temperature incubators, an anaerobic glove box, a gas chromatograph with flame ionization detection, a UV-Vis spectrophotometer, an ultrasonicator, an apparatus for macro- and

micro-oxygen uptake assays, an electrolytic respirometer, a carbon dioxide- and oxygen-monitoring open bottle respirometer, apparatus for gel electrophoresis, a gel documentation and image analysis system, and an apparatus for enumerating airborne microbes.

EERC scientists possess extensive experience in the following areas:

- Monitoring biofouling in water-cooling and reuse systems
- Evaluation of biocides for biofouling control
- Use of wood root fungi for decolorization of wastewater
- Growth and testing of Thiobacillus spp. for pyrite oxidation
- Microbial desulfurization of organic compounds
- Determination of the desulfurization pathways of organosulfur compounds
- Parameters controlling amine biodegradation in soils
- Assessment of bioremediation of gas condensates in soils and groundwater
- Denitrification in subsurface agricultural soils
- Role of autotrophic microbes in subsurface sulfur metabolism
- Anaerobic dechlorination of chlorinated solvents
- Humate enhancement for in situ bioremediation of non-aqueous-phase liquids

2.6.3 Equipment

The project team will design a skid-mounted anaerobic treatment system that will be fabricated at the EERC and transported to the DGC Great Plains Synfuels Plant for the conduct of continuous-flow testing (Task 3). The components of this system have been budgeted as supplies. No major equipment will be purchased for this project.

3.0 STANDARDS OF SUCCESS

The standards of success for this project will be measured through the successful demonstration of an economically viable alternative treatment process that is easily integrated into existing plant operations at the DGC Great Plains Synfuels Plant. Technical standards of success will be measured by the ability of the proposed process to achieve a significant reduction in organic contaminants (particularly catechol) to allow enhanced operation of downstream unit operations, result in enhanced gasifier operation, provide environmental benefits, and provide a valuable by-product, i.e., methane. Economic standards of success will be measured by a favorable cost/benefit analysis of the process with a reasonable payback period.

The EERC has an organizationwide quality management system in effect that governs all programs within the organization. This project is required to be in compliance with the *Quality Manual* and any project-specific quality assurance procedures, thus assuring that any requirements relating to quality and compliance with applicable regulations, codes, and protocols are adequately fulfilled.

4.0 BACKGROUND

4.1 EERC Experience with Coal Conversion Wastewater

The EERC has conducted a number of studies related to the treatment of coal conversion wastewater. This includes examination of wastewaters from the gasification of coal, coal liquefaction, and hydrothermal treatment of coal. The EERC has studied wastewaters from various coal gasification technologies, including Lurgi (Great Plains Synfuels Plant), British Lurgi (Scotland), KilnGas (East Alton, Illinois), Texaco, and the EERC fixed-bed slagging gasifier. In the mid-1980s the EERC conducted treatment studies on these wastewaters, including solvent extraction, ammonia stripping, activated carbon treatment, activated sludge, and cooling tower

treatment, and many other chemical and physical processes. In addition, the EERC has conducted extensive research and demonstration of biological treatment systems. These processes have included bench- and pilot-scale treatment using activated sludge, powdered activated carbon treatment (PACT) activated sludge, fluidized-bed treatment, rotating biological contactors, aerobic filters, plug flow, pure oxygen bioreactors, and nitrification/denitrification systems. A major program conducted at the EERC in the early 1980s focused on an examination of the fate and effects of wastewater constituents associated with the proposed operations at the then-under-construction Great Plains Gasification Plant, now known as the DGC Great Plains Synfuels Plant. These operations involved production and treatment of wastewater, both from the EERC gasifier, and later from Great Plains, in a variety of pilot-scale treatment systems and, finally, a demonstration of the operation of a pilot-scale cooling tower with this wastewater. In addition to this program, the EERC constructed and operated a pilot-scale PACT activated sludge treatment system at the Great Plains facility.

The EERC has conducted wastewater treatment research for a number of other wastewaters, including those from municipal and industrial processes. Some of these processes included anaerobic treatment. Specifically, the EERC has examined optimization of anaerobic treatment of sugar beet-processing wastewater, anaerobic treatment of water from the hydrothermal treatment of coal, and anaerobic treatment of water from oil and gas production.

A bench-scale reactor was used to study the anaerobic fluidized-bed treatment of wastewater from hydrotreating Alaska Usibelli lignite (Fraley, 1993). This wastewater contained 117 mg/L of acids, 30 mg/L of phenols, 220 mg/L of alcohols, and 3900 mg/L COD. The bioreactor was a 1.79-L plexiglass column containing 454 g of Filtrasorb 400 GAC. The operating temperature was 35°C, and the hydraulic retention times were 1.8, 0.9, and 0.45 days. The results showed that 25% to 30% of the COD was converted into methane. Much of the COD was biorefractory.

A bibliography listing related EERC research projects on gasification wastewater treatment are included in Section 14.0.

4.2 Other Work on the Anaerobic Treatment of Gasification Wastewaters

Neufeld et al. (1980) examined the anaerobic biodegradation of phenol. They noted phenol removal rates were about 0.08 mg/mg VSS-day, or about 0.5% to 0.8% of the aerobic rate. Process instability was noted at phenol concentrations in excess of 686 mg/L.

Suidan et al. (1980) used a synthetic wastewater with catechol concentrations of 200, 400, and 1000 mg/L in a GAC anaerobic bioreactor. The bioreactor had an empty bed volume of 1.2 L and was charged with 446.6 g of Filtrasorb 400 carbon. The reactor was maintained at 35°C and was operated with recycle. Adaptation occurred over a 3-week period and resulted in significant methane generation. Methane accounted for 97% of the total gas. Catechol was reduced to below detection levels (0.1 mg/L) and was not inhibitory.

Khan et al. (1981) reported using a set of synthetic wastewaters containing phenol and phenol with glucose. They used a pair of reactors, each consisting of three 1.2-L anaerobic fluidized GAC filters. Each column was packed with 446 g of Filtrasorb 400 GAC. The reactors were operated with an empty bed retention time of 9.3 hr and at a temperature of 35°C. At a phenol concentration of 400 mg/L, a phenol removal efficiency of 98.8% was noted, and at 1000 mg/L, phenol removal was 97.9% in the first column.

The treatment of wastewater from the Grand Forks slagging fixed-bed gasifier was studied by Cross et al. (1982). The treatment train consisted of a Rashig ring packed anaerobic filter, followed by an expanded-bed GAC anaerobic filter. The anaerobic reactors had an empty bed volume of 13 L. The Rashig ring reactor was operated as plug flow, while the GAC reactor was fluidized by an upflow rate of 13.3 $m^3/m^2/h$ (5 gpm/ft^2). The wastewater contained 26,900 mg/L COD, 5600 mg/L

of phenol, and 5300 mg/L of ammonia with a pH of 8.2. This wastewater was diluted 10:1 for feeding, with a hydraulic retention time (HRT) of 1 day. The results showed that the two reactors removed 87% of the COD, 93% of the phenol, and 99% of the cresols at a steady-state loading of 2.5 kg COD/m^3-d.

The treatment of a synthetic wastewater containing 70 mg/L of acids, 374 mg/L of monohydric phenols, 205 mg/L of dihydric phenols, and 870 mg/L of ammonia was studied by Suidan et al. (1983a). The treatment train consisted of a Berl saddle packed anaerobic filter, followed by an expanded-bed GAC anaerobic filter, then an aerobic completely stirred tank reactor (CSTR) for nitrification. The empty bed volume of the anaerobic reactors was 11 L. A recycle ratio of 10:1 was used and a bed expansion of 24%. The GAC reactor contained 2.4 kg of Calgon Filtrasorb 400. A temperature of 35°C was used. Results showed that the Berl saddle reactor removed very little organic matter. The GAC reactor showed steady-state efficiencies of 90% for COD with a stoichiometric release of methane.

Suidan et al. (1983b) reported on the treatment of wastewater from the Morgantown fluid-bed gasifier. The treatment train consisted of a Berl saddle packed anaerobic filter, an expanded-bed GAC anaerobic filter, and an aerobic CSTR for nitrification. The empty bed reactor volumes totaled 11 L. The GAC reactor was packed with 2.4 kg of GAC and was maintained with a bed expansion of 25%. The wastewater was diluted to 10% and had the following composition when diluted: COD, 1775 mg/L; phenols, 463 mg/L; and ammonia, 1040 mg/L, with a pH of 8.48. The first-stage reactor removed very little organic matter. The GAC reactor showed excellent results, with 97% COD reduction at steady state.

Harper et al. (1983) examined the treatment of raw wastewater from the Grand Forks slagging fixed-bed gasifier with Indianhead lignite at dilutions of 10% to 12%. The treatment train consisted

of a pair of fluidized GAC anaerobic filters. The reactors were 20.2 L in empty bed volume and contained 4 kg of Filtrasorb 400 GAC. The flow rate was set to provide an empty bed retention time of 1.2 to 1.4 days with a recycle ratio of 950:1. Removal efficiencies were high (ca. 70% of COD) until the carbon became saturated with cresols or other inhibitory compounds. Partial replacement of the carbon resulted in rapid improvement in removals and in gas production.

Cross et al. (1986) reported on the treatment of raw effluent from the EERC gasifier. The treatment train consisted of a Rashig ring packed anaerobic filter, followed by an expanded-bed GAC anaerobic filter, and then an aerobic CSTR for nitrification. At a feed of 10% raw water, good removals were obtained, with a total empty bed retention time of 2 days. The loading rate was 2.5 kg COD/m^3/d, with removal efficiencies of 87% for COD, 78% for total organic carbon (TOC), 93% for phenol, and 99% for cresols. Inhibitory substances tended to accumulate on the carbon, requiring frequent carbon replacement. Replacement of more than 25% of the bed material at a time resulted in upset.

Blum et al. (1986) reported using serum bottle studies to examine the biodegradability and toxicity of a range of 24 gasification wastewater constituents. The following constituent removals were found: 91% of phenol at 1000 mg/L, 83% of resorcinol at 500 mg/L, 100% of catechol at 500 mg/L, 47% of catechol at 1000 mg/L, 80% of *p*-cresol at 500 mg/L, 53% of pyridine at 250 mg/L, and 66% of benzoic acid at 2000 mg/L were biodegraded. An anaerobic filter with an 18-hr HRT degraded 99% of 1890 mg/L of phenol, 99% of 890 mg/L of resorcinol, 50% of 470 mg/L of catechol, 93% of 180 mg/L of *p*-cresol, and 90% of 80 mg/L of 3-ethylphenol. Phenol, resorcinol, and catechol were degraded to methane. Concentrations showing 50% inhibition of acetate methanogenesis were 1500 to 3000 mg/L of phenol, 2000 to 4000 mg/L of catechol, and 750 to 2500 mg/L *p*-cresol.

The treatment of high-strength H-coal wastewater was reported by Fedorak and Hrudey (1986). The raw water was diluted and fed to anaerobic methanogenic cultures. Feed strength was 2% to 4%, with a total phenolics concentration of 7456 mg/L and a COD of 21,100 mg/L. Concentrations of total phenolics and *o*-cresol were inhibitory. Results showed a tendency for *o*-cresol accumulation, as it was not biodegraded.

Fox et al. (1988) used a synthetic gasification wastewater that contained the following: acids, 70 to 350 mg/L; phenols, 555 to 2395 mg/L; catechol, 80 to 400 mg/L; and ammonia 725 to 1200 mg/L. The treatment train consisted of a Rashig ring packed anaerobic filter, followed by an expanded-bed GAC anaerobic filter. Loading rates, based on COD, were 1.07 to 2.17 kg/m^3-d. Overall COD removals were greater than 90%. Inhibition of bioactivity was noted at the highest loading after the carbon was saturated. The inhibition was attributed to the cresols and 2,4-dimethylphenol.

Fedorak et al. (1990) examined the effect of anilines and hydantoins on anaerobic treatment. They found that these compounds were not inhibitory to methanogenesis of phenols at concentrations expected in coal gasification wastewater.

Nakhla and Suidan (1995) used coal gasification wastewater in an anaerobic GAC reactor. At a COD loading of 4.7 $kg/m^3/d$, treatment performance was not impacted by dilution, regardless of the GAC replacement rate. Treatment efficiency was 94% for COD removal, 98%–99% for phenol removal, and virtually complete for dimethylphenol removal. Full-strength wastewater was not treatable at COD loading rates higher than 10 $kg/m^3/d$. The SRT (solids retention time) was 21 days, and the HRT was 4–8 hr. Bioactivity was not affected by the toxicity of the wastes.

5.0 QUALIFICATIONS

The proposed project will be a coordinated effort between the EERC and DGC. The EERC will assume the responsibility for overall project management. The Project Manager, Mr. Dan Stepan, will be responsible for the overall technical direction of the program, monitoring project schedules and budgets, ensuring the timely completion of all project tasks, and contributing to and reviewing deliverables to ensure accuracy, clarity, and completeness. Mr. Stepan is a Senior Research Manager at the EERC with over 10 years of experience as a principal investigator and project manager on a variety of projects ranging from water and wastewater treatment to remediation of soils and groundwaters. He has authored or coauthored numerous reports and publications related to gasification wastewater treatment. He has a B.S. in Civil Engineering and an M.E. in Water Resource Management and Sanitary Engineering. Mr. Stepan is a member of the American Water Works Association (AWWA), the Water Environment Federation, and the American Society of Civil Engineers.

Mr. Richard Shockey is a Research Engineer at the EERC. He received his B.S. in Chemistry from the University of North Dakota in 1972. Prior to his current position at the EERC, Mr. Shockey was employed with Stearns-Roger, Inc., in Rapid City, South Dakota, for 1½ years at the CO_2 acceptor gasifier project and in Grand Forks, North Dakota, for 4 years on the slagging fixed-bed gasifier project. He has also worked for the Pillsbury Company potato-processing plant in the quality assurance and microbiological labs as well as being responsible for waste disposal and wastewater treatment. Mr. Shockey's principal areas of interest and expertise include coal gasification as well as gasification, industrial and municipal wastewater treatment, and chemical analysis. He has worked with numerous gasification wastewaters, including Great Plains Gasification Associates, Beulah, North Dakota; hydrogen production, mild gasification, the transport reactor development unit, and

the slagging fixed-bed gasifier at the EERC; KilnGas Gasifier, Alton, Illinois; BGC-Lurgi Gasifier, Westfield, Scotland; Texaco Gasifier, Tennessee Valley Authority facility, Mussel Shoals, Alabama, and Cool Water facility, Dagget, California. He has designed, constructed, and operated numerous pilot- and bench-scale wastewater treatment units, including several pilot-scale units operated on gasification wastewaters from the gasification plant at Beulah.

Mr. John Gallagher is a Research Microbiologist at the EERC. He has been conducting research on biological wastewater treatment and biodegradation of contaminants for the past 18 years. The focus of these activities has been gasification wastewater, where he has conducted a variety of bench- and pilot-scale biotreatment operations, both conventional and novel. In the last 3 years, he has focused on the biodegradation of contaminants associated with the production of oil and gas. In addition, a special focus has been on anaerobic processes. He has more than 17 publications in the treatment of gasification wastewaters. He received his B.S. and M.S. in Bacteriology from North Dakota State University.

Mr. Thomas Moe is a Research Engineer in the Water Resources Group at the EERC. He received his B.S. in Geological Engineering from the University of North Dakota in 1982 and his M.E. in Water Resource Management and Sanitary Engineering from the University of North Dakota in 1990. Currently, Mr. Moe is serving in the position of Coordinator of the Red River Water Management Consortium, a collection of municipal, industrial, and rural entities working together to develop water management strategies within the Red River Basin. Mr. Moe has experience in the areas of industrial wastewater treatment and reuse and pilot- and bench-scale wastewater testing. This includes responsibility for a bench-scale treatability program involving three separate coal gasification wastewaters and numerous treatment techniques. Duties under the coal gasification wastewater treatment testing project included system construction, operation, data handling, and data

reduction. Mr. Moe also has experience in biomass fuels combustion performance and evaluation and has provided engineering assistance on pilot-scale testing of various combustion systems, including fluidized-bed and pulverized coal-fired units. Mr. Moe provided operations and data reduction assistance for sulfur recovery research at the Great Plains facility in 1988. Prior to his current position at the EERC, Mr. Moe was a graduate researcher in the Civil Engineering Department at the University of North Dakota.

6.0 VALUE TO NORTH DAKOTA

The proposed process provides a more environmentally acceptable zero-effluent-discharge scenario critical to commercial gasification that will demonstrate the ability to support future commercial expansion with appropriate environmental stewardship. In light of the need for domestic energy security and the role that gasification will play, expansion of the existing DGC facility or the construction of new gasification facilities in North Dakota to meet increasing demands for fuels will be realized, resulting in increased use of lignite.

This project will demonstrate an alternative method for the treatment of SGL. The proposed process would result in significant degradation of catechol and other organic constituents from the SGL. This would produce a number of positive environmental/economic benefits:

1. Conversion from a black water to a clear water treatment system with significantly lower organic loading to the cooling tower, which will lead to reduced biological fouling of heat exchange surfaces and increased efficiency.
2. Reduction in suspended solids will also result in increased efficiency of the cooling water loop, with reduced fouling of the heat exchangers.
3. The resultant increases in evaporative capability will result in less blowdown to the gasifiers which will allow coal throughput and increased gas production.

4. Reduced nutrient (PO_4), antifoaming, and dispersant addition requirements to the cooling tower recirculation system because of lower organic loading. This will reduce operating costs and the potential for atmospheric discharge of these additives in cooling tower drift.
5. Reduced organic loading to the cooling towers will result in reduced atmospheric emissions, less odor, and fewer problems with drift in the surrounding area.

7.0 MANAGEMENT

The overall project management structure is illustrated in Figure 3. The project manager, Mr. Dan Stepan, will be responsible for the overall coordination of the project. Ms. Claudia Miller will serve as the point of contact at DGC for technical and analytical support. Mr. John Gallagher will be the task manager for activities under Tasks 1 and 2. Mr. Richard Shockey will serve as the task manager for activities under Task 3. Mr. Stepan will also serve as task manager for Tasks 4 and 5.

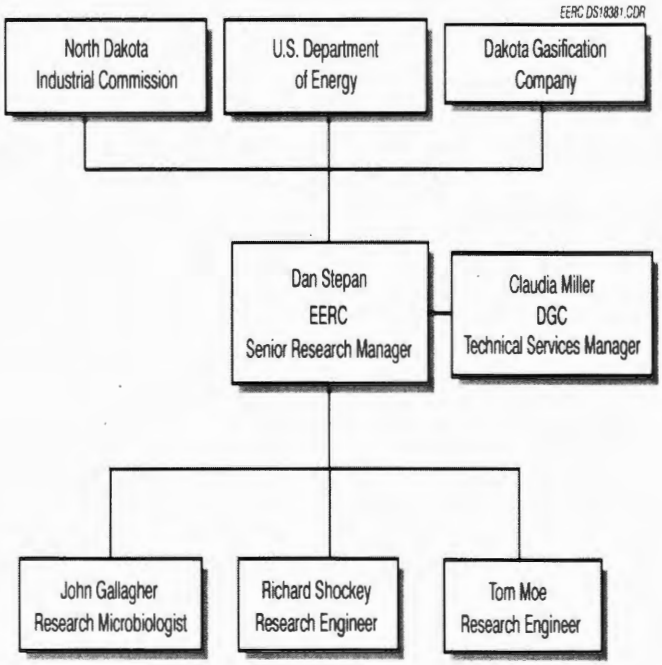

Figure 3. Project management chart.

The EERC will provide all necessary supplies and labor to conduct the proposed research as outlined. DGC will provide a site location and necessary connections for the continuous-flow test unit, as well as technical support reviews of system design and test plans, assistance with data, interpretation, and report reviews.

A project kickoff meeting and periodic project review meetings will be held throughout the project to ensure communication throughout the project. Further, a significant part of the project will be conducted at the gasification facility, which will allow for daily communication between EERC and DGC personnel. Quarterly reports will be prepared throughout the project period and submitted to all project sponsors.

8.0 TIMETABLE

The proposed project will be conducted over a period of 18 months. A project kickoff meeting will be held at DGC to initiate project activities. Samples of anaerobic cultures of bacteria and SGL for use in Task 1 and 2 activities will be collected at that time. We anticipate an accelerated 4–5-month period for acclimation of microbial cultures because of the use of adapted microorganisms from the DGC wastewater system. Task 2 will then be conducted over the fourth month of the proposed project. Based on results gleaned from Task 2 batch tests, specifically the ability of the acclimated biomass to significantly degrade catechol, a go–no-go decision will be made prior to proceeding on to subsequent tasks. Information from Task 2 test results will be used to design the continuous-flow test unit. Task 3, continuous-flow testing, will be conducted over the next 12 months and will include design, fabrication, and operation of the treatment system. Task 4, economic analysis, will be conducted when Task 3 steady-state operating data become available. Task 5, reporting, will be conducted throughout the duration of the project. A time line for the project is shown as Table 3.

9.0 BUDGET

The total project cost, on a cost-reimbursable basis, is $380,000. Of this cost, the EERC requests that NDIC provide $130,000.

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 the NDIC project manager or key technical contributor.
- A short overview of NDIC.

10.0 MATCHING FUNDS

DGC will provide $50,000 in cash and $80,000 of in-kind support toward the proposed effort. These funds will be matched with $130,000 from NDIC. This will subsequently be matched with EERC–DOE Jointly Sponsored Research Program funds of $120,000, for a total project funding level of $380,000.

11.0 TAX LIABILITY

The EERC, a research organization within UND, which is an institution of higher education within the state of North Dakota, is not a taxable entity.

Table 3. Expected Time Line for Continuous-Flow Process Development DGC Treatment System

	Month								
Milestone	1–2	3–4	5–6	7–8	9–10	11–12	13–14	15–16	17–18
Task 1 – Biomass Acclimation	■	■	■						
Task 2 – Batch Testing		■	■						
Task 3 – Continuous-Flow Testing									
System Design and Construction			■						
Reactor Seeding Loading Rate 1			■	■	■				
Steady State 1					■				
Loading Rate 2					■	■			
Steady State 2							■		
Loading Rate 3							■	■	
Steady State 3								■	
Task 4 – Economic Analysis								■	
Task 5 – Reporting		■		■	■		■	■	■
	▲ Kick-Off Meeting								
			▲ Go–No-Go Decision						

12.0 CONFIDENTIAL INFORMATION

Confidential information is neither contained in this proposal nor anticipated as a result of these research activities.

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SUMMARY BUDGET

ANAEROBIC TREATMENT OF DAKOTA GASIFICATION COMPANY
STRIPPED GAS LIQUOR
NDIC / DAKOTA GAS / DOE
PROPOSED PERIOD OF PERFORMANCE: 5/1/02-11/30/03
EERC PROPOSAL #2002-0023-R2

CATEGORY	TOTAL HRS	TOTAL $COST	DAKOTA GAS SHARE HRS	DAKOTA GAS SHARE $COST	NDIC SHARE HRS	NDIC SHARE $COST	EERC JSRP SHARE HRS	EERC JSRP SHARE $COST
TOTAL DIRECT LABOR	2,883	$ 85,024	373	$ 10,949	1,377	$ 39,357	1,133	$ 34,718
FRINGE BENEFITS		$ 46,763		$ 6,022		$ 21,646		$ 19,095
TOTAL LABOR		$ 131,787		$ 16,971		$ 61,003		$ 53,813
OTHER DIRECT COSTS								
TRAVEL		$ 24,708		$ 5,000		$ 8,601		$ 11,107
COMMUNICATION - PHONES & POSTAGE		$ 410		$ 96		$ 96		$ 218
OFFICE (PROJECT SPECIFIC SUPPLIES)		$ 900		$ 200		$ 300		$ 400
SUPPLIES		$ 24,900		$ 5,900		$ 8,668		$ 10,332
GENERAL (FREIGHT, FOOD, MEMBERSHIPS, ETC.)		$ 725		$ 300		$ 200		$ 225
FEES		$ 15,645		$ 4,000		$ 5,548		$ 6,097
TOTAL OTHER DIRECT COST		$ 67,288		$ 15,496		$ 23,413		$ 28,379
TOTAL DIRECT COST		$ 199,075		$ 32,467		$ 84,416		$ 82,192
FACILITIES & ADMIN. RATE - % OF MTDC	VAR	$ 100,925	54%	$ 17,533	54%	$ 45,584	46%	$ 37,808
TOTAL ESTIMATED COST		$ 300,000		$ 50,000		$ 130,000		$ 120,000
COST SHARE - IN-KIND DGC		$ 80,000		$ 80,000		$ -		$ -
TOTAL PROJECT		$ 380,000		$ 130,000		$ 130,000		$ 120,000

NOTE: Due to limitations within the University's accounting system, the system does not provide for accumulating and reporting expenses at the Detailed Budget level. The Summary Budget is presented for the purpose of how we propose, account, and report expenses. The Detailed Budget is presented to assist in the evaluation of the proposal.

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, or other agreements. Although the EERC is not affiliated with any one academic department, university academic faculty may participate in a project, depending on the scope of work and expertise required to perform the project.

The proposed work will be done on a cost-reimbursable basis. The distribution of costs between budget categories (labor, travel, supplies, equipment, subcontracts) is for planning purposes only. The principal investigator may, as dictated by the needs of the work, reallocate the budget among approved items or use the funds for other items directly related to the project, subject only to staying within the total dollars authorized for the overall program. The budget prepared for this proposal is based on a specific start date; this start date is indicated at the top of the EERC budget or identified in the body of the proposal. Please be aware that any delay in the start of this project may result in an increase in the budget. Financial reporting will be at the total project level.

Salaries and Fringe Benefits

As an interdisciplinary, multiprogram, and multiproject research center, the EERC employs an administrative staff to provide required services for various direct and indirect support functions. Direct project salary estimates are based on the scope of work and prior experience on projects of similar scope. Technical and administrative salary charges are based on direct hourly effort on the project. 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. For faculty, if the effort occurs during the academic year and crosses departmental lines, the salary will be in addition to the normal base salary. University policy allows faculty who perform work in addition to their academic contract to receive no more than 20% over the base salary. Costs for general support services such as grants and contracts administration, accounting, personnel, and purchasing and receiving, as well as clerical support of these functions, are included in the EERC facilities and administrative cost.

Fringe benefits are estimated on the basis of historical data. The fringe benefits actually charged consist of two components. The first component covers average vacation, holiday, and sick leave (VSL) for the EERC. This component is approved by the UND cognizant audit agency and charged as a percentage of direct labor for permanent staff employees eligible for VSL benefits. The second component covers actual expenses for items such as health, life, and unemployment insurance; social security matching; worker's compensation; and UND retirement contributions.

Travel

Travel is estimated on the basis of UND travel policies, which include estimated General Services Administration (GSA) daily meal rates. Travel includes scheduled meetings and conference participation as indicated in the scope of work.

Communications (phones and postage)

Monthly telephone services and fax telephone lines are generally included in the facilities and administrative cost. Direct project cost includes line charges at remote locations, long-distance telephone, including fax-related long-distance calls; postage for regular, air, and express mail; and other data or document transportation costs.

Office (project-specific supplies)

General purpose office supplies (pencils, pens, paper clips, staples, Post-it notes, etc.) are provided through a central storeroom at no cost to individual projects. Budgeted project office supplies include items specifically related to the project; this includes duplicating and printing.

Data Processing

Data processing includes items such as site licenses and computer software.

Supplies

Supplies in this category include scientific supply items such as chemicals, gases, glassware, and/or other project items such as nuts, bolts, and piping necessary for pilot plant operations. Other items also included are supplies such as computer disks, computer paper, memory chips, toner cartridges, maps, and other organizational materials required to complete the project.

Instructional/Research

This category includes subscriptions, books, and reference materials necessary to the project.

Fees

Laboratory and analytical fees are established and approved at the beginning of each fiscal year, and charges are based on a per sample or hourly rate depending on the analytical services performed. Additionally, laboratory analyses may be performed outside the University when necessary.

Graphics services fees are based on an established per hour rate for overall graphics production such as report figures, posters for poster sessions, standard word or table slides, simple maps, schematic slides, desktop publishing, photographs, and printing or copying.

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

General

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

Membership fees (if included) 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 as well as by the research team directly involved in project activity.

General 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), transportation, rental of facilities, and other items incidental to such meetings or conferences.

Facilities and Administrative Cost

The facilities and administrative rate (indirect cost rate) included in this proposal is the rate that became effective July 1, 1995. 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[1] and subcontracts/subgrants in excess of the first $25,000 of each award.

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[1] The equipment threshold is stated at $5000 in anticipation of the pending Facilities and Administrative Cost Rate Agreement. The proposal has been submitted to the Department of Health and Human Services with a stated effective date of July 1, 2001.