SUBTASK 4.2 – COAL GASIFICATION SHORT COURSE

Final Report

(for the period of July 1, 2008, through June 30, 2009)

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SUBTASK 4.2 – COAL GASIFICATION SHORT COURSE

ABSTRACT

Based on a review of research literature, tutorial presentations, and Web sites on gasification, a short course presentation was prepared. The presentation, consisting of about 500 PowerPoint slides, provides at least 7 hours of instruction tailored to an audience's interests and needs. The initial short course is scheduled to be presented September 9 and 10, 2009, in Grand Forks, North Dakota.

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EXECUTIVE SUMMARY

Major utilities, independent power producers, and petroleum and chemical companies are intent on developing a fleet of gasification plants primarily because of high natural gas prices and the implementation of state carbon standards, with federal standards looming. Currently, many projects are being proposed to utilize gasification technologies to produce a synthesis gas or fuel gas stream for the production of hydrogen, liquid fuels, chemicals, and electricity. Financing these projects is challenging because of the complexity, diverse nature of gasification technologies, and the risk associated with certain applications of the technology. The Energy & Environmental Research Center has developed a gasification short course consisting of approximately 500 PowerPoint slides that is designed to provide technical personnel with a broad understanding of gasification technologies and issues, thus mitigating the real or perceived risk associated with the technology. An initial short course is scheduled to be presented September 9 and 10, 2009, in Grand Forks, North Dakota.

SUBTASK 4.2 – COAL GASIFICATION SHORT COURSE

INTRODUCTION

Developing and financing successful coal gasification projects will depend on educated utility owners, independent power producers, chemical companies, and financiers who can correctly judge the commercial viability and economics of the competing first-generation and advanced gasification technologies. Currently, many projects are being proposed to utilize gasification technologies to produce a synthesis gas or fuel gas stream for the production of hydrogen, liquid fuels, chemicals, and electricity because of high natural gas prices and the implementation of state carbon standards, with federal standards looming. The Energy & Environmental Research Center (EERC) has developed a short course on gasification designed to educate potential financiers of the technology. This course is directed toward technical personnel who are interested in gaining a broad understanding of gasification technologies and issues. It should be of interest and value to:

- Technical personnel who are, or will be, involved with evaluating gasification projects, developing novel processes, or technology planning.
- Industrial personnel interested in power generation, petroleum refining, ammonia or methanol production, chemical intermediates using syngas, or production of clean transportation fuels.
- Personnel involved with disposing of municipal solid wastes, residues from petroleum refining or coal benefaction, and other chemical and biological wastes.
- Business decision makers who require sufficient information to make economic and risk assessments.
- All who want to become part of the growing gasification industry.

EXPERIMENTAL

Based on a review of research literature and tutorial presentations (1–10) and Web sites on gasification (11–21), a PowerPoint presentation with speaker notes was prepared.

RESULTS AND DISCUSSION

Slides from the PowerPoint presentation are available upon request. The presentation was made large enough, approximately 500 slides, so that it could provide at least 7 hours of instruction tailored to the audience's interests and needs. The following is a general outline of the short course.

I. Introduction – The introduction sets a temporal and structural framework for the course as well as introduces the EERC and course presenters to the participants.

II. Gasifiers – Types and Applications. Differences in gasification processes are presented in terms of pressure, gas–solid contact, heat production and transfer, fuel feedstocks, and whether the mineral matter is removed as ash or slag. The important characteristics of three types of gasifiers will be described: fixed-bed, fluidized-bed, and entrained-flow. Applications including electricity, synthetic natural gas, liquid fuels, hydrogen, and chemical production are reviewed.

III. Gasification System Reliability

a. Defining the goals of gasification technology. The products to be produced from the gasification process are much broader than those from typical combustion systems. An overview is provided that describes the gasification process and the potential products that can be produced. These include electric power, hydrogen, liquid fuels, gaseous fuels, chemicals, fertilizers, carbon dioxide, and other materials. In addition, with the impetuous for addressing carbon management, the prospect of making the technology carbon dioxide sequestration-ready is discussed. The fuel and gasifier type can significantly affect the fuel gas or syngas quality. Matching the gasifier with the downstream equipment to clean and shift the syngas to specifications of gas turbines, synthesis, and others is critical to system reliability and cost.

b. Maximizing fuel flexibility. Matching fuel characteristics with plant design and operating conditions is a key strength of the EERC that can be utilized by gasification plant developers in minimizing risks. Specific areas of focus include the following:

i. Fuel reactivity – mechanisms and kinetics. Two fundamental processes are described: pyrolysis and gasification. The influence of coal rank on gasification reactivity is discussed, including the roles of intrinsic char reactivity and catalytic activity of coal minerals (e.g., CaO).

ii. Ash and slag behavior. Inorganic component partitioning, transformation (gases, liquids, and solids), and deposition play a critical role in gasification operations that are commonly overlooked.

iii. Emission issues. Defining the range of emissions will be critical to maximizing fuel flexibility. Sulfur, nitrogen, particulate, and mercury and other trace element (e.g., arsenic, cadmium, and selenium) control technologies are discussed. For example, the temperature of mercury control is likely going to dictate hot-gas filter temperature.

iv. Water requirements and wastewater cleanup. Each technology has different requirements for water and water cleanup.

c. Operating and maintenance issues. Based on reliability requirements, suggestions are made on the number of gasifiers, including requirements for spare gasifiers. This is based on past experience in the open literature. An update on planned and ongoing gasification projects is provided.

IV. Status of Gasification System Development Activities – Research and Development Programs. An overview of U.S. Department of Energy and other activities under way is provided.

a. Demonstration programs. An overview of demonstration programs being developed, initiated, and under way is provided.

b. Commercial experience. Status and reliability of commercial systems are discussed.

V. Summary

The course is summarized leading into specific information and discussion of the participants' specific system quandary. In addition to the detailed information that will be available, opportunities will be given to promote interaction among attendees and EERC research personnel in discussions of specific coal gasification issues.

A brochure advertising the short course was prepared (Appendix A). The initial short course is scheduled to be presented September 9 and 10, 2009, in Grand Forks, North Dakota. A mailing list has been established for advertising the course.

CONCLUSIONS

The EERC has developed a gasification short course consisting of approximately 500 PowerPoint slides that is designed to provide technical personnel with a broad understanding of gasification technologies and issues, thus mitigating the real or perceived risk associated with the technology. An initial short course is scheduled to be presented September 9 and 10, 2009, in Grand Forks, North Dakota.

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APPENDIX A

GASIFICATION SHORT COURSE BROCHURE

GASIFICATION SHORT COURSE





September 9–10, 2009

Energy & Environmental Research Center (EERC)
15 North 23rd Street
Grand Forks, North Dakota

Organized and Sponsored by:

EERC
Energy & Environmental Research Center®
UND University of North Dakota
Grand Forks

NCHT

U.S. Department of Energy National Energy Technology Laboratory

Gasification **Short Course**

Course **Description**

The Energy & Environmental Research Center (EERC) has developed a gasification short course designed to provide technical personnel a broad understanding of gasification technologies and issues, thus mitigating the real or perceived risk associated with the technology.

Major utilities, independent power producers, petroleum, and chemical companies are intent on developing a fleet of gasification plants primarily because of high natural gas prices, the availability and cost of coal or other solid hydrocarbons, and the implementation of state and potential federal carbon standards. Currently, many projects are being proposed to utilize gasification technologies to produce a synthesis gas or fuel gas stream for the production of hydrogen, liquid fuels, chemicals, and electricity. Financing these projects is challenging because of the complexity, diverse nature of gasification technologies, and the risk associated with certain applications of the technology.

The diverse nature of gasification processes, depending on the feedstocks, products produced, and environmental goals, will be overviewed. This course will also include an overview of the gasification process and potential products, including electric power, hydrogen, liquid fuels, gaseous fuels, chemicals, fertilizers, carbon dioxide, and other materials. The production of hydrogen will be a key factor in our future energy portfolio. Producing pure hydrogen gas with a low impact on the environment is extremely important to the hydrogen economy. One of the most promising technologies for hydrogen production is coal gasification, initially, and maybe in the longer term. Coal can be a cornerstone for the diverse hydrogen supply mix, with integration of hydrogen production into coproduction of power and synthetic fuels. The United States has more than one-quarter of the world's coal reserves, with a supply that will last over 250 years at current mining rates. Hydrogen production is not new, about 9 million tons of hydrogen is produced annually in the United States, mostly for fertilizers and hydrocracking petroleum. About 12% more coal would need to be mined and converted to hydrogen to serve only one-third of the entire transportation demand.

Who Should **Attend**

This course is directed toward technical personnel who are interested in gaining a broad understanding of gasification technologies and issues. It should be of interest and value to:

- Technical personnel who are, or will be, involved with evaluating gasification projects, developing novel processes, or planning technology.
- Industrial personnel interested in power generation, petroleum refining, ammonia or methanol production, chemical intermediates using syngas, or production of clean transportation fuels.
- Personnel involved with disposing of municipal solid wastes, residues from petroleum refining or coal beneficiation, and other chemical and biological wastes.
- Business decision makers who require sufficient information to make economic and risk assessments.
- All who want to become part of this growing industry.

COURSE **OVERVIEW**

Day One: Wednesday, September 9, 2009

12:30 p.m. Registration Opens

1:00 p.m. **Welcome and Introductions**

Session 1 – Gasifiers, Types, and Applications

1:15 p.m. **Nature of Gasification Process**: Feedstocks, Products Made, and Environmental Goals

2:00 p.m. **Types of Gasifiers**: Fixed Bed, Fluidized Bed, and Entrained Flow

2:45 p.m. **Gasification Applications**

3:15 p.m. Break

Session 2 – Gasification System Reliability

3:45 p.m. **Defining the Goals of Gasification Technology**

4:15 p.m. **Maximizing Fuel and Flexibility**

5:00 p.m. Adjourn

Day Two: Thursday, September 10, 2009

7:30 a.m. Registration Opens

Session 2 – Gasification System Reliability (continued)

8:00 a.m. **Fuel Reactivity**: Mechanisms and Kinetics

8:45 a.m. **Ash and Slag Behavior**

9:30 a.m. **Emission Issues**: Defining the Range of Emissions Critical to Fuel Flexibility

10:15 a.m. Break

10:45 a.m. **Operating and Maintenance Issues**: Reliability Requirements

Session 3 – Status of Gasification System Development Activities

11:15 a.m. **An Overview of U.S. Department of Energy Projects**

12:00 Noon Lunch (provided)

1:00 p.m. **Demonstration Programs in Development, Initiated, and Ongoing**

1:45 p.m. **Commercial Experience/Opportunities**

2:30 p.m. Wrap-Up/Questions

3:00 p.m. Adjourn

Instructors for this course are qualified experts at the EERC. More information is available at www.undeerc.org/GasificationSC.

The Gasification Short Course will be held at the EERC in Grand Forks, North Dakota.

COURSE **INSTRUCTORS** (minimum of two present at each course)

Dr. Michael L. Jones, Senior Research Advisor

With 30 years of experience, Dr. Jones' principal areas of interest and expertise include management of and technical direction for multidisciplinary science and engineering research teams focused on a wide range of integrated energy and environmental technologies. Specific program areas of interest include gasification of low-rank fuels, matching of fuel characteristics to system design and operating parameters, development of advanced power systems based on low-rank fuels, fundamentals of combustion and gasification, ash deposition in combustion and gasification systems, and analysis of inorganic materials. His current focus is on minimizing the carbon footprint of energy systems, including CO_2 separation and sequestration. Projects emphasize a cradle-to-grave approach from resource assessment, to optimum utilization systems, to minimization of emissions and waste management featuring by-product utilization.

Dr. Michael L. Swanson, Senior Research Manager

Dr. Swanson, Senior Research Manager, is currently involved with the demonstration of advanced power systems such as integrated gasification combined cycle and pressurized fluidized-bed combustors with an emphasis on hot-gas cleanup issues. Dr. Swanson's principal areas of interest and expertise include various gasification processes, fluidized-bed combustion, hot-gas cleanup, Fischer–Tropsch liquid fuel production, coal/biomass reactivity in advanced conversion processes, supercritical solvent extraction, and direct liquefaction of low-rank coals.

Dr. Donald P. McCollor, Technical Manager of Conversion Systems

Dr. McCollor's principal areas of interest and expertise include coal kinetics and inorganic transformation and deposition processes. He has extensive experience in the collection, analysis, and interpretation of data from bench-, pilot-, and full-scale coal conversion systems and in the development of predictive models to assess ash deposition behavior in combustion and gasification systems.

Mr. Jason D. Laumb, Senior Research Manager

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 over 12 years experience with fossil fuel combustion and gasification systems, with a particular emphasis on ash impacts on system performance, liquid fuels production, and air pollution issues related to mercury and fine particulates. He also has experience in the design and fabrication of bench- and pilot-scale combustion and gasification equipment.

Mr. Joshua J. Stanislowski, Research Manager

Mr. Stanislowski is a Research Manager at the EERC. Mr. Stanislowski is involved with gasification, gas cleanup, hydrogen production, liquid fuels production, and systems engineering projects. Mr. Stanislowski's principal areas of interest and expertise include coal gasification, process modeling, and experimental design and analysis. Mr. Stanislowski holds a bachelor's degree in Chemical Engineering from the University of North Dakota.

Mr. Kevin C. Galbreath, Research Manager, Environmental Health

Mr. Galbreath supervises projects involving fuel property characterization, fuel additives, ash deposition, and pollutant emissions and control. His principal areas of interest and expertise include trace element emissions, transformations, and speciation; trace element modes of occurrence in fuels; anthropogenic emission effects on ambient air quality; fuel quality assessment; ash and deposit formation mechanisms; and mitigation of deposit formation in gasifiers and utility boilers. He employs full-, pilot-, and bench-scale gasification and combustion systems in solving fundamental problems relating to fossil, biomass, and waste fuels utilization.

SPONSORS

Energy & Environmental Research Center

The EERC is a research, development, demonstration, and commercialization facility recognized as one of the world's leading developers of cleaner, more efficient energy technologies as well as environmental technologies to protect and clean our air, water, and soil. Operating like a business, the EERC is a high-tech, nonprofit branch of the University of North Dakota. The EERC currently employs more than 330 people and is aggressively expanding its staff. The Center was founded in 1951 as the Robertson Lignite Research Laboratory, a federal facility under the U.S. Bureau of Mines. It became a federal energy technology center under the U.S. Department of Energy (DOE) in 1977 and was defederalized in 1983. Today, the EERC leverages and enhances government research dollars by developing working partnerships with industry, government, and the research community. Since 1983, the EERC has had nearly 1100 clients in all 50 states and 51 countries. In FY2008, 94% of its contracts were funded by nonfederal entities.

National Center for Hydrogen Technology (NCHT)

The EERC was designated the National Center for Hydrogen Technology (NCHT) in 2004 in recognition of over 50 years of researching, testing, and integrating technologies for a wide variety of energy systems, including producing hydrogen from fossil and renewable fuels, gas separation and purification, and hydrogen utilization. The EERC has the experience, expertise, and facilities to take a lead role in developing, in concert with its industry and government partners, all aspects of the hydrogen economy. Current and pending contracts in the NCHT include more than $60 million in funding for producing clean hydrogen from fossil fuels; developing innovative hydrogen on-demand production systems; producing hydrogen from renewable sources; creating technologies for hydrogen separation, purification, and storage; developing hydrogen-dispensing systems; and integrating new technologies for hydrogen fuel cell vehicles and other end uses.

U.S. Department of Energy National Energy Technology Laboratory Through the EERC's FY08 Fossil Energy Base Cooperative Agreement

The National Energy Technology Laboratory (NETL) plans and implements its programs to accomplish the overall goals and objectives of DOE. NETL serves as the focal point for science and technology development in fossil energy and related environmental control technologies. Through the new Strategic Center for Natural Gas (SCNG), NETL will drive an integrated planning process for natural gas technologies within DOE and will coordinate DOE's natural gas programs in gas supply, transmission, distribution, reliability, and end use. SCNG will identify research and policy support gaps; plan programs to fill these gaps; initiate research to meet future natural gas supply deliverability, reliability, and utilization requirements; and provide strong support for DOE's development of natural gas-related policies. With the four focus areas, NETL will provide cutting-edge research and development (R&D) leadership in gas energy system dynamics, carbon sequestration, computational energy science, and ultraclean fuels. Through partnerships, NETL will continue to utilize the full resources of the laboratory system to address fossil energy-related issues. NETL concentrates on the application of science and engineering principles to execute its mission.

HOTEL AND **TRAVEL**

Make the most of your time at the short course by staying at the preferred course hotel, the Canad Inns Grand Forks.* The Canad-certified 4-star, newly constructed Canad Inns Destination Center is located on South 42nd Street, a short distance from the EERC.

Room Packages

As a Gasification Short Course attendee, you are eligible for a special room rate of $60/night plus tax for single/double occupancy. A block of rooms has been reserved for the night of September 9, 2009. Make your reservation early because the discounted rate is only in effect until August 16, 2009, and rooms are subject to availability.

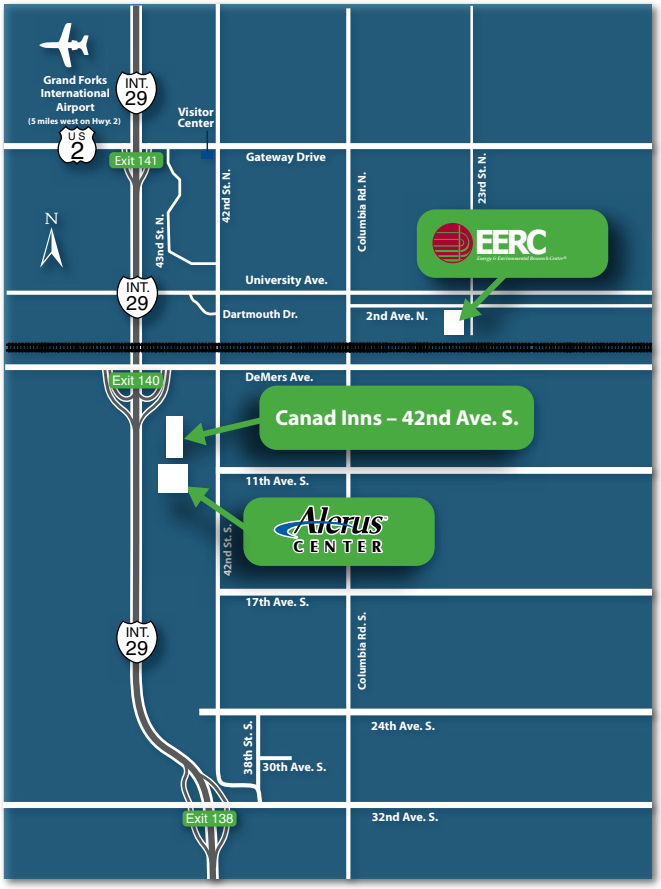
To make your reservation, call (701) 772-8404 and ask for the EERC Gasification Short Course room block.

About the Hotel

Canad Inns provides the convenient location, modern environment, and service excellence of a 4-star hotel. Near the EERC and Grand Forks's popular shopping areas, Canad Inns Destination Center is just minutes away from event centers and shopping facilities. The hotel offers 201 superior guest rooms with queen- or king-sized beds, including theme suites with jacuzzi, kid's theme rooms, executive suites, and penthouse suites. All rooms have high-speed Internet access (wireless and data port), guest voice messaging, flat-screen TVs with premium cable, coffee maker, hair dryer, iron and board, and small refrigerator.

*The Canad Inns does not provide shuttle service to and from the airport.

Hotel Location Map



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REGISTRATION GASIFICATION SHORT COURSE

Four Easy Ways to Register!

Online
www.undeerc.org/GasificationSC/registration

By Phone
Call LaRae Foerster at (701) 777-5246.

By Fax
Fax your registration form to (701) 777-5181 ATTN: Accounting.

By Mail
Mail your completed registration form and check to:
UND Energy & Environmental Research Center
ATTN: Accounting
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

Please type or print clearly or register online at www.undeerc.org/GasificationSC.

☐ Dr. ☐ Mr. ☐ Ms. Name _____
Last First Middle Initial

Preferred Name to Use on Name Tag _____

Title/Position _____

Employer/Company _____

Mailing Address _____

City, State, Zip Code _____

Daytime Telephone Number _____ Fax Number _____

E-Mail Address _____ Web Site (URL) _____

☐ I have special dietary requirements. ☐ I have special access needs.

Please state clearly your requirements _____

Registration Rates

Registration fees give you an all-access pass to everything taking place at the Gasification Short Course, including admission into the sessions, one continental breakfast, two breaks, lunch, and course materials. Price breakdowns are listed below.

Regular Short Course Registration (through August 21)	**US$1000**
Late Short Course Registration (after August 21)	**US$1200**

Method of Payment

Note: Payment in U.S. funds only.

UND Federal Tax ID#: 45-6002491

Total Amount Due: **US$**

☐ Check (personal or company)

Please make checks payable to **UND Energy & Environmental Research Center**
Mail checks to: UND Energy & Environmental Research Center, Attn: Accounting, 15 North 23rd Street, Stop 9018, Grand Forks, ND 58202-9018

OR
Credit Card: ☐ VISA ☐ MasterCard ☐ American Express ☐ Discover

Credit Card Number _____ Expiration Date _____

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Affiliated with:

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___ Government and Regulatory
___ Research/Academia
___ Other: _____

Primary Areas of Interest in the Gasification Couse:

___ Liquid Fuels
___ Hydrogen
___ Gasification Technology
___ Ash Behavior
___ Polution Control
___ Power
___ Other: _____

Cancellation Policy

Those who are unable to attend the course are encouraged to send a substitute at no additional charge. Cancellations received after August 1, 2009, will be assessed a $250 fee. No refunds will be given for cancellations received after August 21, 2009.

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GASIFICATION SHORT COURSE





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