A day of presentations of advanced coal technology research supported by the Clean Coal Technology Research Fund

August 25, 2011
9:00 am – 5:00 pm

UW Conference Center at the Hilton Garden Inn, Laramie WY

Hosted by the CLEAN COAL TASK FORCE and sponsored by UW School of Energy Resources, Wyoming Governor’s Office, and the Wyoming Legislature

Free registration • Lunch provided

Registration site: www.uwyo.edu/ser/clean-coal/symposium
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AGENDA
Clean Coal Technology Fund Research Symposium
August 25, 2011
9:00 am – 5:00 pm

8:00 – 9:00 am    Registration, UW Conference Center Lobby

9:00 – 9:15 am    Welcome and Opening Remarks
Mark Northam, Director, School of Energy Resources
Carl Bauer, Clean Coal Task Force

9:15 – 12 noon    Clean Coal Technology Fund Research Project Presentations
Moderator: Diana Hulme, School of Energy Resources

9:15 – 9:45 am    Geologic Sequestration of CO$_2$ in the Rock Springs Uplift (Southwest Wyoming): Experimentation and Modeling of CO$_2$/Brine Relative Permeability, Hysteresis, Permanent Capillary Trapping and Salt Precipitation
Mohammad Piri, Dept. of Chemical and Petroleum Engineering, University of Wyoming

9:45 – 10:15 am   Demonstration of Hydrogen Production from Wyoming Coal
Joshua Stanislawski, Energy & Environmental Research Center, University of North Dakota

10:15 – 10:45 am  Development of a New Solid Sorbent for CO$_2$ Separation
Bryce Dutcher and Zhuoyan Sun, Dept. of Chemical and Petroleum Engineering, University of Wyoming

10:45 – 11:00 am  BREAK

11:00 – 11:30 am  Construction and Testing of Emery Energy Company’s Hybrid Coal Gasifier
Benjamin Phillips, Emery Energy Company

11:30 – 12:00 noon Coal Electrolysis for the Production of Hydrogen and Liquid Fuels
Gerri Botte, Dept. of Chemical & Biomolecular Engineering, Ohio University

12:00 – 1:00 pm   LUNCH BUFFET - Seating provided in Salon E

1:00 – 5:00 pm    Clean Coal Technology Fund Research Project Presentations, continued
Moderator: Diana Hulme, School of Energy Resources

1:00 – 1:30 pm    Feasibility of Hydrothermal Dewatering for the Potential to Reduce CO$_2$ Emissions and Upgrade Low Rank Coals
Kevin Galbreath, Energy & Environmental Research Center, University of North Dakota

1:30 – 2:00 pm    Pre-Gasification Treatment of Powder River Basin Coals for Improved Advanced Clean Coal Gasifier Design
Alan Bland, Western Research Institute
AGENDA
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2:00 – 2:30 pm  
*Carbon Capture from Coal Flue Gas Carbonaceous Sorbents*  
Mac Radosz, Dept. of Chemical and Petroleum Engineering, University of Wyoming

2:30 – 2:45 pm  
BREAK

2:45 – 3:15 pm  
*Innovative Catalytic Gasification Technology to Maximize the Value of Wyoming’s Coal Resources*  
Renus Kelfkens, GreatPoint Energy

3:15 – 3:45 pm  
*Capture and Mineralization of Carbon Dioxide from Coal Combustion Flue Gas Emissions: Pilot Scale Studies*  
K.J. Reddy, Dept. of Renewable Resources, University of Wyoming

3:45 – 4:15 pm  
*Development & Evaluation of Non-Carbon Sorbents*  
Vijay Sethi, Western Research Institute  
Michael Lucarelli, Novinda Corporation

4:15 – 4:30 pm  
Wrap up and closing remarks

5:00 – 6:00 pm  
RECEPTION - Complimentary beer, wine and snacks – UW Conference Center Lobby
Geologic Sequestration of CO₂ in the Rock Springs Uplift (Southwest Wyoming): Experimentation and Modeling of CO₂/Brine Relative Permeability, Hysteresis, Permanent Capillary Trapping and Salt Precipitation

Mohammad Piri, Dept. of Chemical and Petroleum Engineering, University of Wyoming

Capture and sequestration of carbon dioxide in geologic formations may significantly reduce the release of greenhouse gases to the atmosphere. However, uncertainties in predicting transport properties associated with multiphase flow in geologic reservoirs often make assessment of geologic storage of carbon dioxide a difficult task. In particular, assessment of deep saline aquifers as potential CO₂ sinks involves a complex set of physical and chemical sequestration mechanisms such as displacement of pore brine, dissolution into the aqueous phase, capillary trapping of injected CO₂, and mineralization. In addition, there is a lack of experimental and theoretical work addressing the determination of representative transport properties for CO₂/brine systems under supercritical conditions, experimental and modeling techniques to study CO₂/brine relative permeability, permanent capillary trapping of CO₂, and salt precipitation associated with the sequestration of CO₂ in deep saline aquifers. Core flood experiments are conducted in combination with X-ray computed tomography imaging in order to monitor fluid saturations in rock core samples and measure steady-state drainage and imbibition relative permeabilities as well as their scanning curves. High-resolution imaging is used for detailed mapping of pore structures and identification of trapped CO₂. Modeling efforts include the development of a three-dimensional pore-scale network model able to compute relative permeability and capillary pressure, and a fully dynamic parallel particle-based model of flow and solute transport. The feasibility of deep aquifer sequestration and storage capacity predictions depend on numerical simulators to predict the fate of CO₂ under geologically meaningful conditions. Findings from this investigation are expected to help reduce uncertainties associated with the estimation of CO₂ storage capacity in deep saline aquifers made by the numerical reservoir simulators. This investigation is a collaborative effort between the University of Wyoming (UW) and The Pennsylvania State University (PSU).
9:45 – 10:15 am  Demonstration of Hydrogen Production from Wyoming Coal

Joshua Stanisłowski, Energy and Environmental Research Center, University of North Dakota

In order to facilitate the use of hydrogen in integrated gasification combined-cycle (IGCC) applications or as a transportation fuel, hydrogen-from-coal technologies that are capable of managing carbon will be needed. Many technologies are under development for the separation of hydrogen from coal-derived syngas, and among the most promising are hydrogen separation membranes. Studies indicate a significant IGCC plant efficiency increase can be realized if warm-gas cleanup and hydrogen separation membranes are used in place of conventional technologies. These membranes provide the potential to produce hydrogen while simultaneously separating CO₂ at system pressure. Membrane development to date has primarily occurred on bottle-derived syngas, and the impact of coal-derived impurities is unknown. Gasification syngas typically has many impurities that, if not removed, will poison most hydrogen separation materials. In order to commercialize this promising technology, scale-up to bench- and pilot-scale gasifiers are required so that the impact of impurities can be evaluated.

The Energy and Environmental Research Center (EERC), together with the U.S. Department of Energy’s National Energy Technology Laboratory and the state of Wyoming, has completed a project to evaluate the performance of hydrogen separation membranes on coal-derived syngas. Wyoming coal from the Antelope Mine was gasified, and gas cleanup with hydrogen separation was demonstrated. EERC small pilot-scale gasifiers were used to produce the syngas, and solid sorbents were used for warm-gas cleanup and water–gas shift. Three hydrogen separation membranes were exposed to coal-derived syngas for several hundred hours. The coal-derived impurities that have the potential to impact the membrane performance were characterized in detail. This presentation reviews the results of the gasification, warm-gas cleanup, and membrane tests. An economic analysis is also presented that provides insights into the potential economic advantages of using Wyoming coal with hydrogen separation membranes over conventional low-temperature cleanup technologies.
10:15 – 10:45 am **Development of a New Solid Sorbent for CO₂ Separation**

*Team Members in UW: Maohong Fan, Morris Argyle, Zhuoyan Sun, Leilei He and Bryce Dutcher*

*Team Members in Nanjing University of Technology: Sheng Cui, Xiao-dong Shen, Yong Kong*

*Team Member in Georgia Tech: Ted A. Russell and Sheng Cui*

Two different amine based solid sorbents have been developed for CO₂ separation. The first one is called MEA-TiO₂ (MT) CO₂ sorbent, which is synthesized using pure MEA and a support material, TiO₂. The performance of the MT sorbent on CO₂ separation was investigated in tubular reactors under various experimental conditions. The sorption capacity of the MT sorbent reaches 1.09 mol-CO₂/kg-MT at 45 wt% MEA. Temperature affects the CO₂ sorption capacity considerably, with optimum values of 45°C for adsorption and 90°C for regeneration, while humidity has a small positive effect. The MT sorbent can be regenerated, with a multi-cycle sorption capacity of ~ 0.91 mol-CO₂/kg-MT under the given experimental conditions. The second new amine-based sorbent is briefed as RFAS. Studies show that the CO₂ sorption capacities of RFAS increase considerably with N loading, slowly with increasing temperature (apparently contrary to the prediction with the isothermal equation of exothermic sorption), and gradually with the decease of gas flow rate in the tested range. In addition, CO₂ sorption capacity increases and then decreases as the H₂O:CO₂ mole ratio increases, and the stoichiometric ratio 1:1 is the turning point. The CO₂ sorption capacities achieved by RFAS with 8.07 mmol N/g for air with 400 ppm CO₂ and the CO₂-N₂ gas mixtures containing 1 vol-% CO₂, are 1.78 mmol CO₂/g and 1.92 mmol CO₂/g, respectively, higher than those reported in the most recent literature. The half-CO₂-adsorption and desorption times of RFAS along with temperatures are used to evaluate the dynamics of the sorbent. The adsorbed CO₂ can be completely desorbed at only 80 °C within as short as 30 minutes. Low temperature desorption not only leads to the decrease in energy consumption but also benefits the structure stability of RFAS. The CO₂ sorption capacities of RFAS within 10 sorption-desorption cycles are repeatable. All the results confirm that RFAS is a highly adsorptive, reversibly dynamic, and regenerable sorbent for capture of CO₂ from gas mixtures.
11:00 – 11:30 am  Construction and Testing of Emery Energy Company’s Hybrid Coal Gasifier

Benjamin Phillips, Emery Energy Company

Emery Energy Company is currently completing final construction and commissioning activities on its 10 ton/day coal gasification plant located at the Western Research Institute’s Advanced Technology Center. The Emery technology platform uniquely leverages both fixed-bed with entrained-flow gasification processes in a single reactor vessel in order to maximize cold gas efficiency and maximize feedstock blending opportunities of different coal types and coal blended with biomass. Initial operational testing will include up to 300 hours of test runs on PRB coal from Arch Coal’s Black Thunder mine. Subsequent operations are planned for 2012 and will include extended operational runs on PRB coal and coal/biomass blends while performing additional parametric tests to determine optimum oxygen and steam requirements. The resulting outputs will be used to: 1) support scale up engineering of full commercial size reactors and, 2) support system modeling in ASPEN to predict the overall energy balances, carbon capture and capital costs of Emery technology for IGCC, fuels and chemical applications.
11:30 – 12:00 pm  Coal Electrolysis for the Production of Hydrogen and Liquid Fuels

Gerri Botte, Dept. of Chemical & Biomolecular Engineering, Ohio University
Ana M. Valenzuela-Muñiz, Michael Prudich and Gerardine G. Botte
Center for Electrochemical Engineering Research, Chemical and Biomolecular Engineering Department
Russ College of Engineering and Technology, Ohio University, Athens, OH 45701 botte@ohio.edu

Clean coal technologies for the production of high value chemicals such as H₂, liquid fuels, and refined organic and inorganic compounds with significant impact in the different business (e.g., petrochemical, polymers and plastics, etc.) are very important for national security purposes and preservation of the environment. Ohio University (OHIO) has developed a new technology (apparatus, catalyst, and method) that allows the direct conversion of coal into pure H₂ and other high value chemicals such as liquid fuels, and other organic materials with significant commercial potential. The technology is called “Continuous Coal Electrolytic Cell (CEC).”

In the CEC a small amount of electric power is applied to a coal-slurry to directly convert the coal into pure clean H₂, liquid fuels and organic compounds, with minimum CO₂ emissions. All this takes place at low temperatures (25-180°C) and pressures (1-2atm). During the CEC process pure H₂ is obtained while the surface of the coal particles (electrolyzed coal char) gets oxidized into lower molecular weight hydrocarbons than coal. The electrolyzed coal char is subjected to extraction with yields in excess of 40% of the dry weight coal. At the same time that the extraction is helping to remove valuable chemicals, is reactivating the surface of the coal particles.

Experiments in the CEC were performed by doing the electrolysis followed for the extraction. The Figure above is presenting the polarization curves of three electrolysis-extraction cycles, confirming that the proposed technology has the capacity of produce hydrogen via electrolysis and at the same time valuable chemicals that can be removed using solvents. Furthermore, the Table is showing the production of H₂ and CO₂ in each cycle (grams of gas per grams of coal introduced to the CEC) as well as the extraction yields obtained in each cycle.

<table>
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<tr>
<th>Cycle</th>
<th>g H₂/g coal</th>
<th>g CO₂/g coal</th>
<th>Eff. of current CO₂ (%)</th>
<th>Extraction yield (g/g coal)</th>
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<td>1</td>
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<td>0.0164</td>
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The production capacity of the system at the moment is about 0.007 grams of H₂ per gram of coal, at 100 mA/cm² and 104°C. Summarizing, OHIO has developed a new technology for the production of H₂ and valuable chemicals using the coal in a clean way, minimizing the emission of pollutants as well as decreasing the solid wastes.
Feasibility of Hydrothermal Dewatering for the Potential to Reduce CO₂ Emissions and Upgrade Low Rank Coals

Kevin Galbreath, Energy & Environmental Research Center, University of North Dakota

The feasibility of implementing a hot-water-drying (HWD) process for the co-benefit of low-rank coal drying/upgrading and CO₂ reduction was evaluated. A material balance and an economic analysis were performed using information obtained in the literature and bench-scale HWD experiments. Two Powder River Basin subbituminous coals from the Antelope and Buckskin Mines in Wyoming and two lignite coals from the San Miguel and Falkirk Mines in Texas and North Dakota, respectively, were hot-water-dried in a bench-scale (7.6-L) autoclave. HWD was effective in removing moisture and increasing the heating value of the four coals. An economic analysis, however, indicates that using HWD for reducing CO₂ emissions from coal is not economically viable given historical carbon credit prices in Europe. If carbon credit prices were to rise and consistently stay in the $100 to $200 range, then HWD would be a viable technology for CO₂ emission reductions. HWD was also effective in removing Hg, O₂, and Na₂O from most of the coals except the San Miguel coal. Trace element screening analyses (Ni, Al, Ba, Be, Ca, Cd, Cr, Cu, Fe, K, Mg, Mn, Na, Si, V, Zn, As, Ti, Zn, Co, and Pb) of process waters from the HWD Antelope and San Miguel coals indicated that only Ca and Na were present in significant concentrations (≥ 400 ppm). None of the heavy metals regulated under the Resource Conservation Recovery Act exceeded the concentration limits established by the U.S. Environmental Protection Agency. The gaseous products from the HWD of coals were predominantly CO₂, O₂, N₂, CH₄, and CO. The San Miguel coal also evolved significant amounts of H₂ and H₂S during HWD.
1:30 – 2:00 pm  Pre-Gasification Treatment of Powder River Basin Coals for Improved Advanced Clean Coal Gasifier Design

Alan Bland, Western Research Institute

Wyoming coal has an efficiency disadvantage in Integrated Gasification Combined Cycle (IGCC) due to its high moisture content and derating at high elevation. WRI’s WRITECoal™ process can increase gasifier and IGCC power efficiency, decrease emissions, liberate water offsetting water consumption and allows CO₂ recycle as an oxidant.

The project objectives were to assess the technical performance and economic viability of the WRITECoal™ IGCC process and to acquire the general engineering and costing data needed for scale-up demonstration.

The results of testing include:

- WRITECoal™-treated PRB coal is a low-moisture (<1.5 %), low-sulfur (<0.6%), high heating value (11,000+ Btu/lb), and low mercury (< 0.04 ppm) coal with a high O₂ content compared to bituminous coals. The condensate from the WRITECoal™ treatment of PRB coal was found to be of sufficient quality for use in the plant.
- Gasification testing of the WRITECoal™ product demonstrated a reduction (40%) in residence time for char conversion, high carbon conversion (>73%) during devolatization and high overall carbon conversion (>99%).
- Gasifier modeling indicated WRITECoal™-produced syngas had low CO₂ content, and high CO + H₂ content, heating value and cold gas efficiency (> 88%), while bench-scale gasifier tests confirmed an increase in CO in the syngas with recycle CO₂, reflecting an efficient O₂ use.
- Modeling of the WRITECoal™ IGCC system (90% CO₂ capture) showed an increase in the net IGCC plant efficiency (4.3%) over IGCC without WRITECoal™ and the WRITECoal™ IGCC technology economics indicate Total Capital Requirement for the WRITECoal™ case of $5,300/kW for WRITECoal™ IGCC compared to $5,700/kW for the recently published NETL case without WRITECoal™ modifications. Estimated levelized cost of electricity for the WRITECoal™ case was reduced 1.1 cents/kWh compared to the same IGCC configuration without WRITECoal™ modifications.

In summary, WRITECoal™ gasification/IGCC can be applied to any commercial gasifier and will produce a syngas that has economically viable use for power generation and chemical manufacturing.
2:00 – 2:30 pm  **Carbon Capture from Coal Flue Gas Carbonaceous Sorbents**

*Maciej Radosz, Kaspars Krutkramelis, Bryce Dutcher, Hertanto Adidharma*

*Soft Materials Laboratory, Department of Chemical and Petroleum Engineering, University of Wyoming and Supercritical Fluids LLC  radosz@uwyo.edu*

A Carbon Filter Process (CFP) captures CO₂ on a carbonaceous sorbent that requires no compression or refrigeration. Such a sorbent is CO₂-phlic and hence uniquely selective at near ambient temperatures, easy to keep at constant sorption temperature, and easy to regenerate under vacuum, because its heat of sorption is low. CFP allows for flexible recovery (up to at least 95%) and flexible purity (up to at least 95%). This technology has been pilot tested in a small trailer-mounted unit, funded by the State of Wyoming and Electric Power Research Institute, at two coal-fired power plants in summer 2010, one at PacifiCorp’s Jim Bridger Power Plant in Wyoming and one in Xcel’s Pawnee Power Plant in Colorado. This talk will focus on a new approach to sorbent regeneration, namely, a steam-aided-vacuum regeneration, and preliminary technical and economic data¹. An example of secondary citations is given below:

Innovative Catalytic Gasification Technology to Maximize the Value of Wyoming’s Coal Resources

Key Contacts:
Dr. Pat Raman
Senior Vice President Research, Development, and Technology
praman@greatpointenergy.com
(312) 564-4680

Great Point energy’s bluegas™ Technology converts coal and pet coke into a pipeline-quality substitute natural gas (SNG) by using catalytic “hydromethanation” technology. This advanced technology configuration (V3.0) uses injection of a modest amount of oxygen into the hydromethanation reactor (HMR). Bench scale testing at North Dakota University’s Environmental Engineering Research Center (EERC) and at GPE’s R&D laboratories in Chicago was completed. The GPE HMR proprietary performance model was validated. The results were included in a techno-economic assessment with competitive gasification technologies completed with the assistance of Jacobs Consulting. Test results confirmed that direct oxygen injection to the HMR poses no unusual or extraordinary scale-up risk. Oxygen, steam and coal could be fed to even small reactors without creating local hotspots from the partial oxidation exotherm. Exposure to oxygen in the process has no adverse impact on catalyst activity or recovery. Jacobs Consultancy study showed that GPE’s V3.0 bluegas™ process economics are attractive and significantly better than other commercial gasification technologies. Overall, this project successfully established the technical and economic feasibility of commercializing GPE’s V3.0 bluegas™ process for converting Wyoming PRB coal to SNG.
Multiple CO₂ capture and storage (CCS) processes are required to address anthropogenic CO₂ problems. Mineral carbonation (MC), a process of converting CO₂ into stable minerals (mineralization), has been studied extensively to store CO₂. However, most of the MC studies have been largely investigated at laboratory scale. A pilot scale accelerated mineral carbonation (AMC) process consisting of a moisture reducing drum (MRD), a heater/humidifier, and a fluidized-bed reactor (FBR) was developed. The pilot scale AMC process was tested by reacting flue gas with fly ash particles at one of the largest coal-fired power plants (2120 MW) in the USA. The experiments were conducted over a period of 2 hr at ~ 300 SCFM flow-rates, at a controlled pressure (115.1 kPa), and under different flue gas moisture contents (2-16%). The flue gas CO₂ and SO₂ concentrations were monitored before and during the experiments by an industrial grade gas analyzer. Fly ash samples were collected from the reactor sample port from 0-120 minutes. Control and flue gas treated fly ash samples were analyzed for total inorganic carbon (C), sulfur (S), mercury (Hg), metal water solubility, metal toxicity, and mineral fractionation. Control and flue gas samples were also subjected to SEM-EDS (scanning electron microscope and energy dispersive spectrometry) and TGA (thermal gravimetric analysis). Results suggested significant mineralization of flue gas CO₂, SO₂, and Hg (without separation) within 10-15 minutes of reaction. Among different moisture conditions, ~16% showed highest mineralization of flue gas CO₂, SO₂, and Hg. For example, an increase of almost 4% in CaCO₃ content of fly ash was observed. Results also suggest that AMC process is cost-effective with minimum carbon footprint and can be retrofitted to coal-fired power plants (existing and/or new) to minimize flue gas emissions into the atmosphere.

*Corresponding author e-mail: katta@uwyo.edu
3:45 – 4:15 pm Development & Evaluation of Non-Carbon Sorbents

Vijay Sethi, Western Research Institute
Project Team: Western Research Institute, Novinda Corp.

Currently, several versions of powder activated carbon (PAC) are the only commercially available sorbent control technology for the capture of mercury in pulverized coal combustion units. With the proper installation and operation, they are capable of capturing about 90% of the mercury present in the unit’s flue gas. Although, PAC can be an effective tool for mercury capture, it can create problems in rendering the fly ash, produced by the coal combustion, incompatible for its beneficial use in Portland cement.

The objective of this project was to test Novinda Corporation’s non-carbon mercury sorbents and further develop them to be as effective as the activated carbons in their mercury removal while rendering them fully compatible with the beneficial use of the coal-fired power plant fly ash. The compositions were developed and tested based on Wyoming clay as a substrate with a chemical amendment that imparted mercury affinity to the sorbent particles.

Previous work has shown that mercury emissions reduction levels are highly dependent on the Air Pollution Control Devices (APCD) employed at the back-end of the coal-fired installation. In that regard, WRI’s combustion test facility (CTF) was modified to allow for testing the sorbents in various back-end plant configurations such as a bag house, an electrostatic precipitator (ESP), and with a spray dryer and a bag house (SDA/bag house) combination.

During the course of the project, several sorbent chemistries were developed and tested. Fifty-four test runs were completed to evaluate sorbent performance in various APCD configurations. A total of nineteen test runs were conducted with a bag house configuration, twenty-eight runs with an ESP (both in energized and de-energized modes), and five runs with the SDA/bag house combination. The conducted tests investigated the effect of such variables as, flue gas temperature, sorbent composition, and sorbent injection rate on the mercury emissions reduction.

The sorbents developed have achieved Hg removal efficiencies as high as 90% across the bag house, SDA/bag house combination and >70% across the ESP at commercially viable sorbent injection rates. These removal efficiencies are comparable to those achieved with activated carbon sorbents, but with the added advantage that the fly ash is fully compatible as a cement additive.

The results of this project not only increased the technical understanding of the specified field but also helped with the potential business benefits of use and manufacture within Wyoming and the potential contribution of improving the environment within the State.
## ATTENDEE LIST
*(as of August 22, 2011)*

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<th>Name</th>
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<td>Foulke, Thomas</td>
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<td>Fry, Victoria</td>
<td>Wyoming Public Service Commission</td>
<td>Cheyenne, WY</td>
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<tr>
<td>Galbreath, Kevin</td>
<td>University of North Dakota Energy &amp; Environmental Research Center</td>
<td>Grand Forks, ND</td>
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Clean Coal Technology Fund Research Symposium – 08/25/2011
ATTENDEE LIST
(as of August 22, 2011)

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Muniz, Ana
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GreatPoint Energy, Inc.
Montgomery, TX

Lessig, Bruce
Bureau of Land Management
Casper, WY

Murphy, Tom
City of Gillette
Gillette, WY
<table>
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<td>University of Wyoming, School of Energy Resources, Laramie, WY</td>
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<td>Puckett, Jay</td>
<td>University of Wyoming, College of Engineering &amp; Applied Science, Laramie, WY</td>
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<td>Omar, Khalid</td>
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<td>Radosz, Mac</td>
<td>University of Wyoming, Department of Chemical &amp; Petroleum Engineering, Laramie, WY</td>
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<td>Reddy, K.J.</td>
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<td>Palmerlee, Dave</td>
<td>University of Wyoming, Board of Trustees, Buffalo, WY</td>
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<td>Parhami, Parviz</td>
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<td>Pence, Stan</td>
<td>Consulate General of Canada-Denver, Denver, CO</td>
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<tr>
<td>Runyan, Sam</td>
<td>Cheyenne, WY</td>
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## ATTENDEE LIST

*(as of August 22, 2011)*

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<thead>
<tr>
<th>Name</th>
<th>Institution/Business</th>
<th>Location</th>
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<tr>
<td>Sethi, Vijay</td>
<td>Western Research Institute</td>
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<td>Short, Jay</td>
<td>Ciris Energy, Inc.</td>
<td>Centennial, CO</td>
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<tr>
<td>Spaulding, Elizabeth</td>
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<td>Stanislawski, Josh</td>
<td>University of North Dakota</td>
<td>Grand Forks, ND</td>
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<td>Sun, Zhuoyan</td>
<td>University of Wyoming</td>
<td>Laramie, WY</td>
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<td>Tanner, Allen</td>
<td>Enhanced Oil Recovery Institute</td>
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<td>Valenzuela Muniz, Ana</td>
<td>Ohio University</td>
<td>Athens, OH</td>
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<td>Walia, Daman</td>
<td>ARCTECH, Inc.</td>
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<td>Laramie, WY</td>
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<td>Wilson, Mark</td>
<td>Tri-State Generation &amp; Transmission Association</td>
<td>Westminster, CO</td>
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<td>Yetter, Laura</td>
<td>Wyoming Public Service Commission</td>
<td>Cheyenne, WY</td>
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