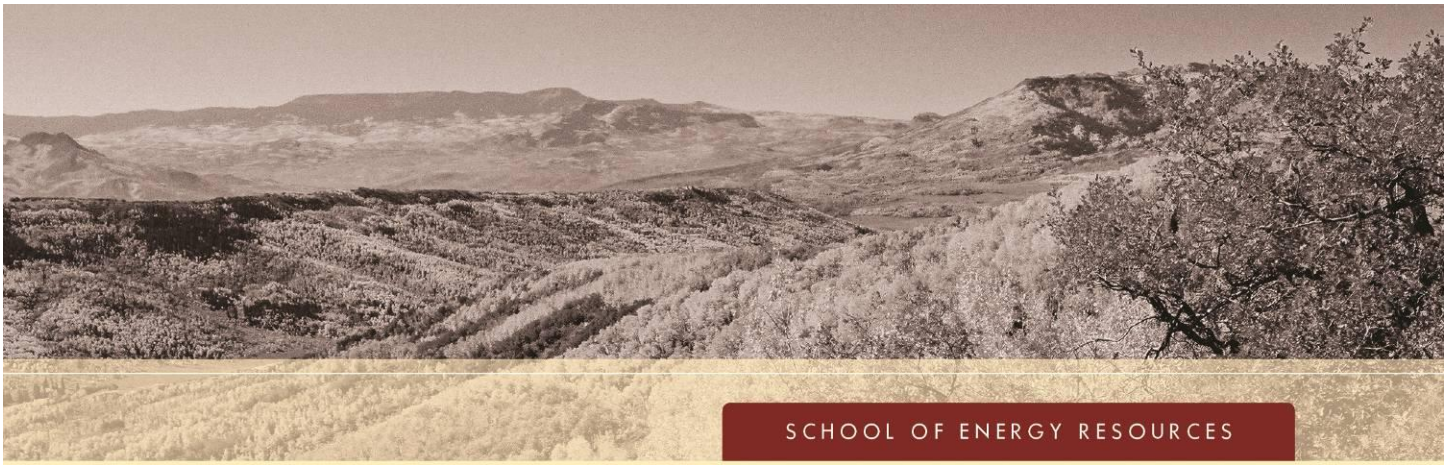

SCHOOL OF ENERGY RESOURCES

2010 Annual Report: The University of Wyoming School of Energy Resources

UNIVERSITY OF WYOMING

2010 ANNUAL REPORT OF THE UNIVERSITY OF WYOMING SCHOOL OF ENERGY RESOURCES

1 October 2010

**Presented to the Joint Minerals, Business and Economic Development Interim Committee,
Joint Appropriations Interim Committee, and the
Joint Education Interim Committee**

UNIVERSITY OF WYOMING
SCHOOL OF ENERGY RESOURCES
Fourth Annual Report, 1 October 2010
[Pursuant to W.S. 21-17-117(f)]

To the Joint Minerals, Business and Economic Development Interim Committee,
Joint Appropriations Interim Committee, and the Joint Education Interim Committee

Submitted by: Mark A. Northam, Director, School of Energy Resources

EXECUTIVE SUMMARY

This document reports growth and development of the School of Energy Resources (SER) at the University of Wyoming during Fiscal Year 2010. SER's objectives are to partner with UW colleges to provide nationally-competitive undergraduate and graduate instruction in energy-related disciplines, to advance Wyoming's energy-related science, technology and economics research, and to support scientific and engineering outreach through dissemination of information to Wyoming's energy stakeholders, community colleges, and government agencies. The University of Wyoming Energy Resources Council (ERC) provides direction to SER regarding the identification and prioritization issues that should be targeted for research and outreach.

Major accomplishments and updates during FY2010 include:

The Energy Resources Council Membership

- Carl Bauer, President of Bauer Consulting and former Director, National Energy Technology Laboratory, US DOE, joined the ERC early in 2010.

Academics

- Dr. Kristina Hufford, SER Assistant Professor of Restoration Ecology joined the Department of Renewable Resources in the College of Agriculture.
- SER supported three visiting faculty on campus.
- The Energy Resource Science Degree program completed its first year.
- Thirty-seven new Graduate Assistantships were awarded.
- The Energy Summer Institute was offered to seventeen high school sophomores and three high school teachers, all of whom completed the two week program.
- Dr. Don Roth, Professor of Molecular Biology and former Dean of the Graduate School succeeded Dr. KJ Reddy as Associate Director of Academics

Research

- Three new Centers of Excellence (formerly called Research Centers) were placed into operations, bringing the total number to nine active Centers.

- The Matching Grant Fund continues to meet the objective of providing UW faculty with an advantage in capturing outside grants. $2.2 million was committed to twenty-three new proposals seeking to capture $10.9 million in outside funds.
- Ninety-two representatives of the uranium industry, state and federal regulatory agencies, and the University met to produce a report that identifies research gaps and opportunities for guidance for the eventual release of a RFP to provide funding for Uranium research. A public opinion survey of in-situ recovery (ISR) was also conducted. SER also conducted a public forum on the future of uranium production in Wyoming.
- $8 million of AML funds dedicated for CO_2 Sequestration Research was leveraged to capture nearly $12 million in outside funding across three projects. Planning is well under way to drill a site characterization well on the Rock Springs Uplift. The Wyoming Legislature appropriated an additional $45 million of AML funds for CO_2 sequestration research.

Outreach

- SER organized and conducted three major conferences during the year.
- SER also organized and/or sponsored 11 other energy outreach events during the year.
- Two colloquium speakers were sponsored by SER.

Development Activities

- Peabody Energy committed $2 million (matched by the state) to the construction of the Energy Resources center, bringing the total raised and matched for the building to $25.4 million.
- SER and the UW Foundation commenced a campaign to raise $2 million in private donations for the "Energy Resources Technology Enterprise Fund". The funds will be matched by the state and will be dedicated to supporting the advanced technical capabilities of the new Energy Resources Center.

The Energy Resources Center

- Contracts were tendered for the architectural firm and the construction manager at risk for the Energy Resources Center.
- Design work and value engineering commenced for the Energy Resource Center.

Financial

- SER's expenditures for the FY2009/2010 Biennium total $17,575,059. Expenditures were lower than the $19,440,742 appropriated by the legislature in the 2008 Legislative Budget Session.
- During the 2010 Legislative Budget session, the legislature appropriated $17,400,000 derived from the AML Fund, and approved up to $2,000,000 to be carried over from unspent appropriations from the prior (FY2009-2010) biennium. The actual amount carried over at the end of FY2010 was $1,865,683.

This report is organized as follows:

INTRODUCTION

Fiscal Year 2010 was the fourth full year of growth and development of the School of Energy Resources (SER) at the University of Wyoming (UW). Significant progress continued in the areas of Academics, Research, and Outreach. In addition, an initial design was created to build the Energy Resources Center. The UW Energy Resources Council met four times during the year as they continue to provide guidance and direction in the aresa of research and outreach.

I. UW Energy Resources Council

The UW Energy Resources Council (ERC), appointed by Wyoming's governor, is responsible for prioritization of research and outreach activities for SER. During FY2010, SER and UW lost a valued mentor and friend, the Honorable Tom Stroock, who passed away in December 2009. Ambassador Stroock served on the ERC since the founding of the school in 2006 and was instrumental in guiding the development and success of SER, as well as the Clean Coal Task Force. Governor Freudenthal appointed Carl Bauer, former director of the National Energy Technology Laboratory, US Department of Energy to fill the position vacated by Tom Stroock's passing.

At the end of FY2010, the standing members of the University of Wyoming Energy Resources Council are:

Ron Harper – Chairman	*CEO and GM, Basin Electric and Basin Cooperative*
Rep. Tom Lockhart – Vice Chairman	*Wyoming Legislature - Chairman, Joint Minerals, Business and Economic Development Committee*
Carl Bauer	*President, Bauer Consulting, Inc and Former Director, National Energy Technology Laboratory, US DOE*
Indy Burke (ex-officio)	*Director Haub School and Ruckelshaus Institute of Environment and Natural Resources*
Thomas Buchanan (ex-officio)	*President, University of Wyoming*
Paul Lang	*Senior Vice President, Operations, Arch Coal Inc.*
James Kleckner	*VP of Operations, Anadarko Petroleum Corp.*
N. Maha Mahasenan	*Principal Advisor, Hydrogen Energy*
Keith O. Rattie	*Chairman of the Board, Questar Corporation*
Sen. Charles Townsend	*Wyoming Legislature -Appropriations and Select Water Committees, Enhanced Oil Recovery Commission*
Rob Wallace	*Manager, Government Relations, GE Energy*

II. Academic Programs

The mission of SER's Academic Program is to develop interdisciplinary undergraduate and graduate programs to prepare the energy workforce of the future for industry, state and federal agencies, and academics. Professor K. J. Reddy served as the Associate Director for Academics for the full year. Effective April 1, Professor Don Roth joined SER on a half-time basis to prepare to assume the position of Associate Director for Academics at the beginning of FY2011.

A. School of Energy Resources Faculty

The SER plan for development called for creating twelve new distinguished faculty positions for teaching, research, and outreach to fill gaps in energy expertise on campus. During previous years, UW academic departments partnered with SER to hire eleven faculty through national and international searches. Dr. Kristina Hufford was the last successful candidate. She reported to UW as an SER Assistant Professor of Renewable Resources, Department of Renewable Resources, College of Agriculture and Natural Resources in April 2010.

SER faculty members currently holding joint appointments with their home departments are:

- Dr. Felipe Pereira, *SER Professor of Mathematics, Department of Mathematics, College of Arts and Sciences*
- Dr. Craig Douglas, *SER Professor of Mathematics, Department of Mathematics, College of Arts and Sciences*
- Dr. Subhashis Mallick, *SER Professor of Geology and Geophysics, Department of Geology and Geophysics, College of Arts and Sciences*
- Dr. Po Chen, *SER Assistant Professor of Geology and Geophysics, Department of Geology and Geophysics, College of Arts and Sciences*
- Dr. John Kaszuba, *SER Associate Professor of Geology and Geophysics, Department of Geology and Geophysics, College of Arts and Sciences*
- Dr. Bruce Parkinson, *SER Professor of Chemistry, Department of Chemistry, College of Arts and Sciences*
- Dr. Maohong Fan, *SER Associate Professor of Chemical Engineering, Department of Chemical and Petroleum Engineering, College of Engineering and Applied Science*
- Dr. Timothy Considine, *SER Professor of Economics, Department of Economics and Finance, College of Business*
- Dr. Guan Qin, *SER Associate Professor of Petroleum Engineering, Department of Chemical and Petroleum Engineering, College of Engineering and Applied Science*
- Dr. Jay Sitaraman, *SER Assistant Professor of Mechanical Engineering, Department of Mechanical Engineering, College of Engineering and Applied Science*
- Dr. Kristina Hufford, *SER Assistant Professor of Renewable Resources, Department of Renewable Resources, College of Agriculture and Natural Resources*

In the fall of 2009, a faculty search was initiated for an SER faculty position in the area of high-temperature catalysis in the Department of Chemical and Petroleum Engineering. The search failed to identify an appropriate candidate despite a national/international search, although the department did hire one of the candidates to fill another opening.

SER faculty members are fully engaged in teaching, research, and outreach activities. They meet monthly as a group to discuss curriculum development, to review ideas for seminars and invited speaker series, to discuss direction of research programs, etc. Most significant of their professional awards and recognitions are listed below:

1. Dr. Bruce Parkinson was elected as a Fellow of the American Association for the Advancement of Science (AAAS).
2. Dr. Guan Qin was invited to a National Science Foundation review entitled Collaboration in Mathematic Geoscience (CMG), April 1-2, 2010.
3. Dr. Craig Douglas was appointed a Visiting Professor of Computer Science at Wuhan University of Technology and at Yale University in October 2009

B. School of Energy Resources Adjunct Faculty

Beginning in Academic Year (AY) 2010, five individuals were appointed as adjunct faculty to SER. Adjunct faculty are judged to contribute expertise that compliments that of the formal SER faculty in pursuit of the academic and research missions of the school. The adjunct faculty members are:

- Dr. Morris Argyle, *Adjunct Associate Professor, Chemical Engineering Department, Brigham Young University*
- Dr. Carrick Eggleston, *Adjunct Professor, Department of Geology and Geophysics, College of Arts and Sciences*
- Dr. Jonathan Naughton, *Adjunct Associate Professor, Department of Mechanical Engineering, College of Engineering and Applied Science*
- Dr. Mohammad Piri, *Adjunct Assistant Professor, Department of Chemical and Petroleum Engineering, College of Engineering and Applied Science*
- Dr. Timothy Slater, *Adjunct Professor, Endowed Chair of Science Education, Department of Secondary Education, College of Education*

C. School of Energy Resources Visiting Faculty

Visiting faculty positions were implemented during the fall of 2009. Visiting faculty positions are intended to achieve the following purposes:

- To fill teaching and research positions with scientists, engineers, and professionals who have attained national or international recognition for their energy-related work but are not candidates for permanent relocation to UW.
- To fulfill energy-related academic or research needs in a college or department that is either temporary, or has not be able to be filled through the recruiting process.
- To provide teaching expertise for seminar courses and courses being taught for the first time.

Visiting faculty members are:

- Dennis Stickley, JD. Dr. Stickley is an SER Visiting Professor of Law in the UW College of Law.
- Dr. Li Deng, *Visiting Scientist at the Rensselaer Polytechnic Institute and a Visiting Researcher at the University of Electro-Communications in Tokyo, Japan*. Dr. Deng is working with researchers in the Department of Mathematics and the Department of Chemical and Petroleum Engineering. She is working on projects involving the NCAR supercomputer and multi-scale modeling of reservoirs.
- Dr. Pierangelo Masarati, *Politecnico di Milano, Milan Italy*. Dr. Masarati is working with UW researchers in the Department of Mechanical Engineering towards the development of a wind turbine aeromechanics simulations platform.
- Dr. Alexander Klimenko, *The University of Queensland, Department of Mechanical Engineering*. Dr. Klimenko led the organizing committee for the 2010 International Advanced Coal Conference and worked with UW research teams in the area of clean coal technology development.

D. Academic Initiatives

This section describes the activities and accomplishments of various academic initiatives undertaken in FY2010.

1. Academic Council (AC)

The Academic Council (AC) represents a broad cross-section of faculty with energy teaching and research interests at UW. Members come from six of the seven UW colleges. Broad participation across UW promotes the interdisciplinary mission of SER. The AC is charged with assisting the Director and Associate Director for Academics on academic directions and grant awards. In addition, the AC advocates for SER programs and serves as an important conduit for SER outreach to the campus and acts as the steering committee for the proposed graduate programs.

Appointments to the AC are for a two-year period. Several members were reappointed to new terms. The members of the AC (new members in *italics*) for the past academic year are listed in Table II-1.

Table II-1. Academic Council Members

Name	Department	Term
KJ Reddy	Associate Director for Academics, SER	Permanent
Indy Burke	Director, Haub School of Environment and Natural Resources	May 2010
John Jackson	Chair, Department of Management and Marketing	May 2010
Peter Stahl	Professor and Director, Department of Renewable Resources	May 2011
Vladimir Alvarado	Professor, Department of Chemical Engineering	May 2011
Carrick Eggleston	Professor, Department of Geology and Geophysics	May 2011
Jinke Tang	Professor, Department of Physics and Astronomy	May 2010
Tim Slater	Professor, Department of Secondary Education	May 2010
Lawrence MacDonnell	Professor, College of Law	May 2012

2. **Energy Resource Science (ERS) Degree program**

A primary objective of the Academic Program is to prepare the future workforce by developing undergraduate and graduate programs for students interested in careers in the energy sector. The UW Board of Trustees approved the establishment of the ERS degree in January 2009. The ERS degree was offered at UW for the first time in the fall of 2009. At the end of AY 2010, seven of nine ERS majors were named to the President's Honor Roll, Dean's Honor Roll or the Freshman's Honor Roll.

A wide variety of activities were carried out to recruit students for the second year of the degree program, including:

- SER was represented at freshman and transfer student orientation, Discovery Days and Campus Pass.
- ERS degree program information was available at Wyoming Union information tables during October 2009 and March 2010.
- SER hosted information tables at the Wyoming State Science Fair in March 2010 and at the Women in Science conference in May 2010.
- An informational letter about the ERS degree program was mailed to undeclared students admitted to UW.

To date there are 23 students enrolled in the undergraduate ERS degree program for AY2010.

The initial ERS curriculum is composed of existing courses from Geology and Geophysics, Engineering, Agriculture, Economics, and Environment and Natural Resources in addition to the normal University Studies Program requirements. Over time, new interdisciplinary courses designed specifically for this degree program will be sponsored and developed to reinforce the curriculum. A curriculum committee was formed in September 2009 to guide the development of the ERS program. Committee members are:

- Dr. K. J. Reddy, chair (replaced by Dr. Don Roth for AY2010)
- Dr. Tim Considine
- Dr. Craig Douglas
- Dr. Maohong Fan
- Dr. Bruce Parkinson
- Dr. Guan Qin

Four additional courses were approved for addition to the ERS program over AY 2010:

- ERS 1000 Energy and Society taught by Dr. Bruce Parkinson. The course is approved to fulfill the University Studies Program Oral Communications requirement.
- ECON/ERS 1300 Oil: Business, Culture and Power taught by Dr. Tim Considine.
- ERS 4990 Special Topics in Energy Resource Science

- ENR 3700 Wyoming Conservation Corps Practicum. This course is offered in the summer and provides ERS students the opportunity to work with the Wyoming Conservation Corps on energy-related projects.

The following courses are currently under development.

- ERS 4900 Capstone – a course designed to provide students with authentic, realistic experience in team scenarios focused on energy asset exploration, development, and management
- Applied Mathematics – a 3-semester sequence to replace the current calculus course sequence
- Thermodynamics course for non-engineers
- Internship Experience in Energy
- Global Experience in Energy Asset Management

In addition, planning is underway for a series of 4 +1 joint bachelor-master degree programs (students focus in specific energy disciplines for 3 years, followed by a transition year taking undergraduate and graduate course and a dedicated year at the graduate level), a 2-year master's program in Energy Asset Management and a novel program in Executive Energy Business where students would complete individual modules for a certificate and/or complete an entire series for a masters degree.

3. **Graduate Assistantship (GA) Allocations**

Talented graduate students working under the direction of UW's faculty are essential to the university's research enterprise. Graduate students at UW are generally supported through Graduate Assistantships (GAs) that pay their tuition and fees as well as a modest stipend, funded through a limited state pool or through external research support. An assured GA, a rare commodity on campus, is a prized resource for any UW faculty member because it provides a significant advantage for recruiting top student prospects.

SER awards GAs through a competitive process and seeks broad distribution across academic units. A call for GA proposals for Academic Years 2010-2011 was issued in October 2008. Fifty-one proposals were evaluated by the Academic Council and twenty-seven GAs were awarded (Table II-2). Subsequently, ten additional GAs were awarded to support specific energy related programs requests that were not directly targeted in proposal request description.

One requirement of each recipient of an SER GA is to deliver an annual report of work completed in the past year. In addition to the written reports received from each faculty advisor, the students present their work in either an oral or a poster presentation at the annual Graduate Research Symposium – held this past year on April 22, 2010. The student abstracts are contained in Appendix A, and written reports are available from SER upon request.

Table II-2. Fall 2010-Spring 2011 SER GA Awards

College	Department	Faculty Advisor	Title
Arts & Sciences	Chemistry	Milan Balaz	Influence of supramolecular organization on energy transfer properties of chromophore-DNA arrays
Arts & Sciences	Chemistry	Bruce Parkinson	Quantum Dot Sensitization: Strategies for Increases in Photovoltaic Solar Cell Efficiencies
Arts & Sciences	Chemistry	Dean Roddick	New Catalyst Strategies for Selective Coal Modification & Liquification
Arts & Sciences	Geography	Steven Prager	Enhancing the School of Energy Resources Geospatial Capacity
Arts & Sciences	Geology & Geophysics	Po Chen	Addressing the Computational Challenges of Time-Lapse, Full-Wave seismic Imaging Using Hybrid Cluster of GPUs & CPUs
Arts & Sciences	Geology & Geophysics	Ken Dueker	Monitoring of Hydrocarbon & Carbon-sequestrated Formations Using Time-lapse Seismic & Electromagnetic Data
Arts & Sciences	Geology & Geophysics	John Kaszuba	Co-Sequestration of CO_2-SO_2 Mixtures Emitted from Coal-Fired Power Plants
Arts & Sciences	Geology & Geophysics	Subhashis Mallick	Monitoring of Hydrocarbon & Carbon-sequestrated Formations Using Time-lapse Seismic & Electromagnetic Data
Arts & Sciences	Mathematics	Stefan Heinz	New Concept for the Gasification of Wyoming Coal
Arts & Sciences	Physics & Astronomy	Jinke Tang	Research & course development in thermal & electrical transport in energy materials
Arts & Sciences	Physics & Astronomy	Wenyong Wang	Ternary Metal Oxide Nanowires for Power Applications
Agriculture	Renewable Resources	Jay Norton	Understanding disruption & recovery of ecological structure & functioning for restoration of disturbed Wyoming ecosystems
Business	Economics & Finance	Timothy Considine	Economic, Technological & Environmental Challenges Facing the Electricity Sector
Education	Secondary Education	Timothy Slater	Interdisciplinary Ph.D. Program for SER GAs in Science Education
Engineering & Applied Science	Atmospheric Science	Robert Field	Understanding of Ozone Precursors
Engineering & Applied Science	Chemistry & Petroleum Engineering	Vladimir Alvarado	Water Chemistry Modification for Improved-Oil Recovery: Chemical, Interfacial & Rheological Mechanisms in Porous Media
Engineering & Applied Science	Chemical & Petroleum Engineering	David Bell	Wyoming Coal Gasification Economics and Process Technology
Engineering & Applied Science	Chemical & Petroleum Engineering	Lamia Goual	Characterization & Bio-Remediation of Dissolved Organic Matter in Wyoming Oilfield Waters
Engineering & Applied Science	Chemical & Petroleum Engineering	Patrick Johnson	Carbon Dioxide Capture via Enzyme Nanoparticle Biocatalysis
Engineering & Applied Science	Chemical & Petroleum Engineering	Patrick Johnson	Enzyme Nanoparticle Synthesis and Characterization for Biofuel Cells and Cellulose Hydrolysis

College	Department	Faculty Advisor	Title
Engineering & Applied Science	Chemical & Petroleum Engineering	Mohammad Piri	Multiphase Flow in Fractured Hydrocarbon Reservoirs
Engineering & Applied Science	Chemical & Petroleum Engineering	Mohammad Piri	CO_2 Sequestration in Deep Saline Aquifers
Engineering & Applied Science	Civil & Architectural Engineering	David Bagley	Microbial BioEngineering & Applied Science for Renewable Energy
Engineering & Applied Science	Civil & Architectural Engineering	Jay Puckett	Building Green & Building Performance-Demonstration, monitoring & validation of predictive energy conservation models
Engineering & Applied Science	Computer Science	Liqiang Wang	Addressing the Computational Challenges of Time-Lapse, Full-Wave seismic Imaging Using Hybrid Cluster of GPUs & CPUs
Haub School of Environment & Natural Resources		Ingrid Burke	New course development: Environmental & Natural Resource Science
College of Law		Jerry Parkinson	Course Development: Introduction to Energy Regulation

4. **Energy Summer Institute**

SER is charged with developing strong and lasting links with Wyoming's K-12 teachers, counselors, and students. Our fourth Energy Summer Institute (ESI) brought 17 high school sophomores (Class of 2013) and 3 high school teachers to UW for two weeks. Participants in the ESI came from Afton, Baggs, Casper, Cheyenne, Cody, Dubois, Glenrock, Lander, Laramie, Moorcroft, and Sheridan. The 2010 program consisted of the following courses:

- *A Chemical Perspective to the Science of Energy*. Chemistry plays a critical role in the generation and storage of energy. The practical use of resources such as fossil fuel, nuclear fuel and solar energy conversion, batteries and rechargeable batteries owe a great deal to advances in chemistry. Various demonstrations and laboratory experiments involved students in endothermic and exothermic reactions, production of fuels through chemical reactions, conversion of chemical energy into electrical energy, and solar energy conversion through chemical means. *(Taught by Dr. Navamoney Arulsamy, Assistant Research Scientist, Department of Chemistry.)*

- *HVAC Systems and Envelope Performance.* In Wyoming and many other states, local authorities and state officials spend significant amounts of money, time, and resources each winter to help low-income families pay their heating bills. Many weatherization programs exist. However, these programs focus only on adding insulation and sealing major air leaks. This class focused on indoor air quality, high-priority energy, comfort factors, and how to improve the energy efficiency of buildings. *(Taught by Dr. Ahmed Megri, Associate Professor, Department of Civil and Architectural Engineering.)*

Once again this year the ESI incorporated additional activities:

- Dr. Joseph Stepans, Professor Emeritus of Secondary Education, UW College of Education, presented a class for the teachers entitled "Integrating Secondary Mathematics and Science in Context of Energy Issues". The class was available for UW graduate school credit.
- Curtis Chopping, a graduate student advised by Dr. John Kaszuba, provided a tour of the co-sequestration lab housed in the Department of Geology and Geophysics.
- Craig Markum, a graduate student advised by Dr. Bruce Parkinson, gave a presentation on the SHArK Project (Solar Hydrogen Activity Research Kit). Dr. Jennifer Schuttlefield showed students how metal oxide compositions are printed on glass plates.
- Geoff Thyne, senior research scientist with the Enhanced Oil Recovery Institute, presented an overview of how enhanced oil recovery works and why it is important to Wyoming.
- A field trip to the National Renewable Energy Laboratory in Golden, Colorado, highlighted wind, geothermal, and solar energy.
- Participants completed a community service project for the Laramie Rivers Conservation District. Trish Penny, education specialist, worked with our group to help with the community gardens being established in LaBonte Park.
- Each student assembled a solar race car and experimented with incandescent and halogen lights to power the cars.
- Additional activities included a visit to Dr. Joseph Stepans' straw bale home located in Curt Gowdy State Park, a visit to the UW Geological Museum, a tour of the new College of Business building, and a visit to the Wyoming Territorial Park.

5. Summer Math Institute

Sixteen math educators from Cheyenne, Laramie, Riverton and Rock Springs focused on complex systems and scientific computing during the 30th Summer Math Institute at the University of Wyoming. The program was designed to help math instructors incorporate scientific computing into their classrooms and to provide interesting and challenging mathematical activities for their students. Program tuition, fees, supplies and a field trip were completely funded by SER, UW President Tom Buchanan, the College of Arts and Sciences and the Science and Math Teaching Center.

The topic this year was complex systems that abound in science and in everyday life. These systems are composed of a large number of building blocks – called agents – that can interact with each other and with their environment. Participants learned the mathematics necessary to study the emerging phenomena that arise in complex systems, how they self-organize and how they adapt. A field trip to the National Center for Atmospheric Research in Boulder, CO, allowed participants to experience NCAR's on-going research on complex systems such as wildfires, global warming, and ocean currents.

Not only did the institute serve as an educational opportunity, it was also a valuable meeting place for the state's math teachers, who are encouraged to interact in and out of class. Lectures were presented by Dr. Bryan Shader, UW Math Professor. Afternoon problem-solving and computer modeling sessions were facilitated by UW Math PhD student Reshmi Nair.

III. Research

A. The Institute for Energy Research

The Institute for Energy Research is composed of Centers of Excellence (formerly call Research Centers) that are established with seed funding from the SER budget. Each center strives to achieve sustaining support through outside funding, an accomplishment that may take several years. Centers of Excellence bring together faculty and graduate students from multiple disciplines to develop important energy research programs. Accordingly, these centers are expected to evolve with time. New groups may form to work on emerging problems, and some existing centers may disband as their programs are completed. Nine Centers of Excellence were either active or being organized in FY2010.

1. Enhanced Oil Recovery Institute – David Mohrbacher, P.E., Director

The Enhanced Oil Recovery Institute (EORI) is funded primarily by an appropriation from the Wyoming State Legislature. For the FY2009-2010 Biennium, EORI worked with an appropriation of $6.11 million. EORI is overseen by the Enhance Oil Recovery Commission (EORC) which was created in 2004. The EORC consists of eight commissioners appointed by the Governor. In FY2010, the commission included the following members:

- Governor Dave Freudenthal, *ex-officio*
- Senator Charles Townsend, *ex-officio*
- Ron Surdam, State geologist, *ex-officio*
- Lynne Boomgaarden, director, Office of State Lands and Investments
- Gail Chenoweth, Marathon Oil Company
- Bern Hinckley, geologist, Hinckley Consulting
- Jim Neiman, UW trustee
- Peter Wold, president, Wold Oil Properties (Chairman)

Dr. James Steidtmann was appointed to direct EORI in January 2004. Jim announced his retirement from the director's position early in FY2010. A search was mounted to find a qualified replacement for Jim. David Mohrbacher, formerly a petroleum engineer and principal with URS Corporation, was the successful candidate and was appointed Director, EORI in April 2010.

Mission:

EORI and UW scientists and engineers from various disciplines work with oil producers to assist with recovery of Wyoming's stranded oil through:

- Technology Application – Apply existing Enhanced Oil Recovery (EOR) technology and create new knowledge when necessary
- Technology demonstration- Facilitate the testing, evaluation and documentation of EOR technologies in real world settings.
- Technology transfer – Benchmark innovative petroleum industry practices and transfer "know how" to Wyoming operators through workshops and conferences.
- Economic development – Maximize economic potential for application of EOR in Wyoming.

FY2010 Achievements:

- Technology application –
  - ✓ Completed laboratory studies for screening of innovative approaches for low salinity water flooding and chemical flooding on Wyoming reservoirs.
  - ✓ Collected LDAR and outcrop information necessary to characterize natural fracturing for key Wyoming oil producing reservoirs.
  - ✓ Completed laboratory evaluation of surface chemistry affecting multiphase flow in Wyoming reservoirs and analog reservoirs.
- Technology demonstration –
  - ✓ Completing design and implementation of EOR in three Powder River Minnelusa reservoirs.
  - ✓ Completing whole field computer simulations of two reservoirs, in one Minnelusa and one Muddy in the Powder River Basin.
  - ✓ Evaluate use of innovative well conformance technology in the laboratory in partnership with industry to improve carbon dioxide flood performance.
- Technology transfer –
  - ✓ Organized and completed two technology conferences (CO2 EOR Conference in Casper during June 2010 and IOR Conference in Jackson Hole during September 2009). Each conference had record attendance from industry.
  - ✓ Presented numerous technical papers at key industry conferences (see below).
- Economic development –
  - ✓ Completed EOR technical screening evaluations for ten Wyoming operators on multiple Wyoming reservoirs.

Activities and Highlights:

- Hired a new Director for EORI, David Mohrbacher.P.E. – April 2010.
- Hired a senior researcher, Reza Ragati, PhD Petroleum Engineer – August 2010.
- Purchased and installed a third core displacement line for testing of CO_2 foams ($100K).
- Purchased a new spinning drop interfacial tension measurement device (EORI paid $150K of $400K).

Outreach Activities:

- Wyoming Pipeline Meeting (collaborative with the Wyoming Pipeline Authority) – May 2009
- 3rd Annual Wyoming CO_2 Conference Casper, WY June 23 & 24, 2009
- State of the Dominant Estate (collaborative meeting with UW Law School) November 2009

Publications:

- Bouroullec, R. & Tomasso, M, 2009, Stratigraphic architecture and evolution of a sinuous tidal channel: Dry Wash, Cretaceous Upper Ferron Sandstone, Utah. 2009 AAPG Annual Meeting, Denver, Abstract Volume, AAPG, Tulsa. ,
- Pyles, D. R., Jennette, D. C., Tomasso, M., Beaubouef, R. T. & Rossen, C., 2010, Process-related concepts learned from a 3D outcrop of a sinuous slope channel complex: Beacon Channel, Brushy Canyon Formation, west Texas. Journal of Sedimentary Research, 80, 67-96.3
- Tomasso, M., Bouroullec, R., & Pyles, D. R., in press, The use of spectral recomposition in tailored forward seismic modeling of outcrop analogs. AAPG Bulletin
- Tomasso, M., Bouroullec, R. & Pyles, D. R., 2009, Stratigraphic architecture of an interbasinal deep-water conduit, Grand Coyer sub-basin, Eocene-Oligocene Grès d'Annot Formation, SE France: A virtual fieldtrip. Invited presentation, 7th Petroleum Geology Conference, London, Abstract Volume, Geological Society of London, London
- Tomasso, M., Murrell, G., Reyes, B. M., Thyne, G., Forney, G. G. & Shier, D. E., 2010, Regional analysis of the Permian Upper Minnelusa Formation, Powder River Basin, Wyoming: Application to exploration and development. 2010 AAPG Annual Meeting, New Orleans, Abstract Volume, AAPG, Tulsa
- Tomasso, M., Murrell, G., Reyes, B. M., Thyne, G., Forney, G. G. & Shier, D. E., 2010, The Permian Upper Minnelusa Formation, Powder River Basin, Wyoming: Regional analysis and application to exploration and development. Presented as part of the RMS-SEPM luncheon series, Denver, Colorado, February 2010
- Tomasso, M., Murrell, G., Reyes, B. M., Thyne, G., Forney, G. G. & Shier, D. E., 2010, The Permian Upper Minnelusa Formation, Powder River Basin, Wyoming: Regional analysis and application to exploration and development. 2010 RMS-AAPG Annual Meeting, Durango, Abstract Volume, RMS-AAPG, Denver
- Tomasso, M., Reyes, B. M., Martinsen, R. S., Krystinik, L. F.2 & Van Holland, A. R., 2010, Using lidar to characterize and model outcrop analogs: Application to aeolian and shallow marine exposures, Wyoming. Invited presentation, 2010 RMS-AAPG Annual Meeting, Durango, Abstract Volume, RMS-AAPG, Denver
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- Morrow, N.R.: "Low Salinity Waterflooding: Recent Advances, Current Changes, Future Opportunities," SPE Distinguished Author Series, 2010.
- Pu, H., Xie, X. and Morrow, N.R.: "Low Salinity Waterflooding and Mineral Dissolution," Paper SPE134042 to be presented at the 2010 SPE Annual Technical Conference and Exhibition, Florence, Italy, September 20-22, 2010.
- Buckley, J.S. and Morrow, N.R.: "Mechanisms of Oil Recovery by Low Salinity Waterflooding," Paper to be submitted to the International Wettability Symposium, Calgary, Canada, September 6-9, 2010.
- Loahardjo, N., Xie, X., Winoto, W., Buckley, J. and Morrow, N.R.: "Change in Wettability Associated with Increased Oil Recovery by Sequential Waterflooding," Paper to be presented at the International Wettability Symposium, Calgary, Canada, September 6-9, 2010.
- Kumar, M., Fogden, A., Morrow, N.R. and Buckley, J.S.: "Mechanisms of Improved Oil Recovery from Sandstone by Low Salinity Flooding," Paper to be presented at the Annual Meeting of the International Society of Core Analysts, Halifax, Canada, October 4-7, 2010.
- Loahardjo, N., Morrow, N.R., Howard, J. and Stevens, J.: "Application of Magnetic Resonance Imaging to Determination of Reduction in Residual Oil Saturation by Sequential Waterflooding," Paper to be presented at the Annual Meeting of the International Society of Core Analysts, Halifax, Canada, October 4-7, 2010.
- Wickramathilaka, S. and Morrow, N.R. and Howard, J.: "Effect of Salinity on Oil Recovery by Spontaneous Imbibition," Paper to be presented at the Annual Meeting of the International Society of Core Analysts, Halifax, Canada, October 4-7, 2010.
- Fracture Patterns Associated with tightly folded Laramide Structures: The Example of Beer Mug Anticline, Wyoming; AAPG Annual Meeting Poster, New Orleans, April 14, 2010
- Fracture Patterns Associated with Laramide Anticlines, GSA Rocky Mountain Section Meeting Presentation, Rapid City, April 21, 2010
- Thrust faults in the Alcova Limestone: Nature's sand-table experiment, AAPG Rocky Mountain Section Meeting Presentation, Durango, June 13, 2010
- Fracture Variability within the Tensleep Formation, Wyoming Geological Association Annual meeting, Casper, August 5, 2010
- Naturally Fractured Reservoirs Workshop, Society of Petroleum Engineers, October, 2010
- Natural Fracture Patterns in Folded Tensleep Reservoir Sandstones, Wyoming; Paper for RMAG special publication – Structures in the Rockies (2010-11)

2. Coal Bed Natural Gas Center – Dr. Michael A. Urynowicz, Director

Mission:

The mission of the Coal Bed Natural Gas Center of Excellence is to promote education, research and outreach that support the development of renewable, clean burning coal bed natural gas (CBNG) within the state of Wyoming and around the world.

Recent discoveries related to the biogenic origin of natural gas within the Powder River Basin and other large coal fields in the United States have provided researchers with new opportunities for solving some of the critical energy challenges that we face as a society. The Coal Bed Natural Gas Center is dedicated to transforming these and other scientific advances into practical solutions that help redefine our energy future.

FY2010 Achievements:

Our research consortium is in the process of patenting and commercializing several new technologies related to enhancing secondary biogenic coal bed natural gas production. The inventors met with the UW Research Products Center to discuss an exclusive licensing agreement between the University and a new start-up company. A broad provisional patent is expected to be filed by the end of the August 2010.

Supportive Partners:

Current supportive partners include Ciris Energy, Inc., General Electric, and WyTex Ventures. Research scientists in the center are in the process of establishing an industrial consortium of supporting partners which will include many of the coal and coal bed methane producers in the Powder River Basin.

Funded research projects during the July 1, 2009 – June 30, 2010 period:

- Proposal for Clean Coal Technology Research, Wyoming Clean Coal Technology Fund, 2010 – $4,788,712. Principal Investigator: Ciris Energy, Inc., Centennial, CO.
- Enhanced Production of Biogenic Natural Gas from Coal. School of Energy Resources Matching Grant Fund, 2009. $70,589 as direct UW/SER match. Co-PI: Franco Basile (Chemistry Department).

Outreach Activities/Publications:

- A white paper on secondary biogenic coal bed natural gas is in preparation, expected to be completed by January 2011.
- A steering committee is being established to organize the First International Conference on Secondary Coal Bed Natural Gas to be held at the University of Wyoming either during the summer of 2011 or 2012.

3. Center for Photoconversion and Catalysis – Dr. Bruce A. Parkinson, Department of Chemistry, Director; Dr. Carrick M. Eggleston, Department of Geology and Geophysics, Associate Director.

Mission:
The mission of CPAC is to find new material to convert light into both electrical and chemical energy and to develop the closely related catalytic chemistry needed to utilize new and conventional energy forms cleanly and efficiently. Primary goals of the center are finding more affordable and efficient ways to convert sunlight into useful energy forms and optimizing chemical catalysts to both minimize energy losses and maximize yields in processes such as biomass conversion, production of photogenerated fuels and transformations of fossil energy sources into clean fuels.

FY2010 Achievements:

CPAC currently comprises 16 faculty with relevant research interests from six UW departments, including Chemical and Petroleum Engineering, Chemistry, Physics and Astronomy, Geology and Geophysics, and Electrical and Computer Engineering. As the center coalesces, the number of participants is expected to change. Its undergraduate researchers, graduate assistants and postdoctoral fellows, as well as visiting scientists and laboratory equipment, will be supported by funding from government agencies, foundations, private industry and via matching grants from the School of Energy Resources. CPAC is currently seeking both seed money from SER and co-funding from granting agencies to support research topics relevant to industry and government agencies. Solar-energy related proposals submitted to both NASA and DOE have been met with positive review, though awards are still pending. Many of the current CPAC faculty also have current CPAC-related funded research.

One example of research facilitated by the CPAC collaborative group is the NASA Space Grant support for photocatalytic research that was awarded to Bruce Parkinson and Carrick Eggleston in 2009. The outcome of initial research was successful, and NASA is reviewing a follow-on proposal to support a full study.

The CPAC is a center in-the-making, so publications and other outcomes of an existing center are not yet available. CPAC looks forward to a productive future as the need to find better photoconversion and catalysis technology becomes more acute in our collective energy future.

4. Wyoming Reclamation and Restoration Center – Professor Peter Stahl, Director

Mission:

The mission of the WRRC is to:
- educate students, professionals and the general public on the topics of Land Reclamation and Ecosystem Restoration,
- facilitate research and disseminate information on effective technologies and best management practices for reclamation of disturbed lands in Wyoming, and

- provide assistance to clientele seeking practical solutions for restoring or reclaiming disturbed lands.

Supportive Partners:

WRRC has received support in various forms from a number of organizations including the State of Wyoming, the Bureau of Land Management, the Wyoming Game and Fish Department, and private industry.

FY2010 Achievements:

The Wyoming Reclamation and Restoration Center has been fortunate in hiring a number of highly qualified individuals in the past year to help us in our mission. Dr. Kristina Hufford, a Restoration Ecologist and Plant Geneticist, was hired as SER Assistant Professor in the Department of Renewable Resources. Dr. Lyle King, from Greybull, has been hired as a Research Scientist to work on identifying most effective technologies and best management practices for reestablishing sagebrush on reclaimed bentonite mined lands. WRRC recently hired Calvin Strom as a Research Scientist to assist with research on reclamation of natural gas well pads in southern and western Wyoming as well as contribute to outreach activities.

BLM funded two research projects to be conducted by WRRC: one to investigate effective technologies and best management practices for revegetation of gas well drill pads, and the other to investigate effective technologies and best management practices for reestablishing sagebrush on bentonite mined lands in the Bighorn Basin.

Graduate and undergraduate students in the College of Agriculture and Natural Resources formed a Reclamation Club – ROaR (Restoration, Outreach and Research) – affiliated with the American Society of Mining and Reclamation.

Outreach Activities/Publications:

WRRC was active in outreach activities over the past year:

- Two Extension Bulletins were published on reclamation topics: Overview of Critical Components (of a Reclamation Plan) and Seeding Essentials for Reclaiming Disturbed Land. Both are available through the WRRC website and the CES website.
- Two more extension bulletins are currently in press: Pre-disturbance Inventories on Development Sites and Wildlife Habitat Considerations in Reclamation.
- In April 2010, WRRC organized and hosted the first Wyoming Reclamation and Restoration Symposium at the Hilton Garden Inn in Laramie. This event was a great success and drew about 140 attendees.
- WRRC also presented a number of Reclamation 101 Workshops around the state in Rawlins, Pinedale and Buffalo (Ucross) to educate interested individuals on the basic concepts and practices important to Land Reclamation. These Workshops were well attended and more will be presented this fall.

5. Advanced Coal Technologies Center – Professor O. A. Plumb, Director

Mission:

The Advanced Coal Technologies Center (ACTC) conducts research to develop advanced technologies to increase the flexibility of coal and to reduce the carbon footprint of converting coal to energy.

Wyoming coal is a major source of fuel for generation of our nation's electricity. It also holds considerable promise for improving our nation's energy security as technologies are developed to gasify and convert coal to synthetic fuels and petrochemicals. Continued use of coal faces significant challenges in light of growing concerns over the role of carbon dioxide (CO_2) in forcing climate change. Coal has the highest carbon content among the fossil fuels, so there is pressure from some groups to reduce our reliance on coal. In order to preserve and grow reliance on coal, new technologies that convert coal to cleaner and more flexible fuels must be developed.

FY2010 Achievements/Partnerships:

Existing expertise at UW and the Western Research Institute (WRI) is significant. In addition, Wyoming has invested significantly in creating assets and funding for research and demonstration in this area. SER is actively developing collaborative relationships – both domestically and internationally – that will significantly increase the depth and scope of our expertise.

The partnership between the State of Wyoming (through UW) and GE Energy to build the High Plains Gasification – Advanced Technology Center (HPG-ATC) will provide a globally significant asset for conducting research in the areas of coal conversion and clean fuels. The recognition of potential represented by this investment is a major factor in developing collaborative relationships, especially with international entities:

- Australia's Commonwealth Scientific and Industrial Research Organization (CSIRO) coal research leadership are exploring way to collaborate with UW based on expertise and research asset sharing.
- UW joined a consortium led by West Virginia University and including other academic, government lab, and industry research organizations in submitting a proposal to the DOE for funding as one of three Joint US/China Clean Energy Research Centers. A decision is still pending, but if successful, the award will be significant and important in future collaboration in this research space. UW is leveraging the HPG-ATC in this proposal. GE Energy is one of the industry partners, with a commitment of additional support to the consortium.

UW is developing a broad research program to advance coal conversion technologies, particularly those that are optimized for Wyoming's low sulfur, sub-bituminous coal and for Wyoming's relatively high elevation. In FY2009, Arch Coal, Inc. became a corporate partner in that regard. Arch committed a gift of $1.5 million to UW that will be matched by the state. Half of that gift and match will go toward endowing the ACTC. In FY2010,

Peabody Energy made a commitment of $2 million to UW that will also be matched by the state. Those funds were dedicated to establishing an Advanced Coal Research Laboratory within the new Energy Resources Center.

Outreach Activities:

SER and the University of Queensland (Australia) jointly sponsored the International Advanced Coal Conference: The Case for Cooperation – June 23-25, 2010 in Laramie. The conference followed a meeting between UW and UQ held in Australia in the spring of 2008, and brought together an international group to present latest developments in advanced coal technologies. A primary goal was to explore possibilities for future collaborative efforts. A discussion of the outcomes of this effort is included under the narrative relating to the conference in section IV. B. 3., below.

6. Center for Fundamentals of Subsurface Flow – Professor L. F. Pereira, Director; Professor Mohammad Piri, Associate Director

Mission:

The Center for Fundamentals of Subsurface Flow (CFSF) seeks to develop fundamental interdisciplinary research in the area of multiphase multi-component flow through porous media aimed at state-of-the-art experimentation and modeling to ensure present and future access to subsurface energy resources. The center integrates research groups in experimental science, mathematical modeling and computational science from various UW departments and institutes and strives to create advanced knowledge and tools of use to industry. CFSF plans to create opportunities for training of high-caliber researchers and graduates for Wyoming's and the nation's energy work force.

CFSF was formally established in January 2010 by 12 founding faculty from three departments at UW (Chemical and Petroleum Engineering, Geology and Geophysics and Mathematics). Members selected Professors Felipe Pereira (Mathematics and SER) and Mohammad Piri (CPE and SER) to be the Director and Associate Director, respectively, during the first biennium.

FY2010 Achievements:

The CFSF released its first RFP in FY2010. Approximately $2.5 million (over three years) was targeted for this notice. After a systematic and careful review of the submitted research proposals, the awards were made for a period of 12 months. Awards can be renewed for a maximum period of 36 months. The PIs are required to focus on fundamentals of multiphase flow in porous media in two topic areas:

- Sequestration of CO_2 in geologic formations, e.g., deep saline aquifers and oil and gas reservoirs.
- Recovery of natural gas from unconventional reservoirs characterized by low permeability.

The approved projects – listed below – were announced in July 2010:

1. *High Performance Computing for Subsurface Flow Simulation*, Craig Douglas, Dept. of Mathematics and SER.
2. *Simulation of CO_2 Injection in Deep Saline Aquifers with Mathematical Verification & Physical Validations*, Frederico Furtado, Dept. of Mathematics.
3. *A Bayesian Framework for Enabling Predictive Simulation & Uncertainty Quantification in History Matching Geological Models for CO_2 Injection*, Victor Ginting, Dept. of Mathematics.
4. *Fundamental Investigation of Wettability in Supercritical-CO_2/Brine/Rock Systems at Reservoir Conditions: Impact of Co-contaminants*, Lamia Goual, Dept. of Chemical and Petroleum Engineering.
5. *On the Development of the UW-team Simulator for the Injection of CO_2 in Deep Saline Aquifers*, Felipe Pereira, Dept. of Mathematics and SER.
6. *Impact of Co-contaminants Injected with Supercritical CO_2 on Fundamental Flow Properties of Sequestration Schemes in Deep Saline Aquifers: Experimentation and Modeling*, Mohammad Piri, Dept. of Chemical and Petroleum Engineering.
7. *Multi-scale & Multi-physics Modeling of Unconventional Gas Development*, Guan Qin, Dept. of Chemical and Petroleum Engineering.
8. *An Integrated Well Location Optimization Study for Commercial-Scale CO_2 Storage in a Deep Saline Aquifer*, Ye Zhang, Dept. of Geology and Geophysics.

The approved projects involve collaboration among scientists in the center and from other institutions. These joint projects formed the basis for a proposal submitted to the US DOE as cost share for external funding.

Outreach Activities/Publications:

- Chen, G. Qin and R.E. Ewing, "Adaptive Finite Element Approximations on Non-Matching Grids for Second-Order Elliptic Problems", *Numer. Meth. PDEs*, to appear.
- M. Cui, H. Chen, Z. Chen, R.E. Ewing and G. Qin, "Reliable and Efficient Error Control for An Adaptive Galerkin-Characteristic Method for Convection-Dominated Diffusion Problems", Advances in Computational Mathematics, to appear.
- L. Bi, G. Qin,Y. Efendiev, M.S. Espedal, "An efficient upscaling procedure based on Stokes-Brinkman model and discrete fracture network method for naturally fractured carbonate karst reservoirs", (SPE), Proceeding of International Oil & Gas Conference and Exhibition, Beijing, P.R. China, 10-12 June, 2010.

7. Wind Energy Research Center – Associate Professor Jonathan Naughton, Director

Mission:

The Wind Energy Research Center (WERC) seeks to establish the pre-eminent wind energy laboratory for theoretically, computationally, and experimentally addressing the primary issues that require further understanding to significantly improve wind turbine performance over their current levels. WERC partners with other academic institutions, government laboratories, and industry with complementary capabilities in the U.S. and abroad.

Faculty members in Electrical Engineering, Mechanical Engineering, Atmospheric Science and Mathematics participate in WERC, and aim to establish research in areas of modeling the wind inflow to turbines, turbulence, geophysical flows, and large-scale weather forecasting.

FY2010 Achievements:

The number of personnel involved in WERC has continued to grow. Seventeen faculty are now performing funded wind-related research. Several graduate students (12 M.S. and 4 PhD), three post-doctoral students, and a visiting research scientist are currently working on wind energy related problems.

WERC continues to develop ties with key institutions to strengthen opportunities for collaboration and funding:

- Industry is interested in both research capabilities and potential our workforce candidates.
  - ✓ BP continues its interactions with WERC after providing significant funding in 2008.
  - ✓ GE Energy funded 4 mini projects during 2009. One of these projects that focused on tower designs has been continued into 2010.
- Relationships have been strengthened at the National Renewable Energy Laboratory (NREL), Sandia National Laboratories, NASA-Ames Research Center, and the National Center for Atmospheric Research.
  - ✓ WERC submitted several joint proposals with NREL. A proposal was funded by DOE in August 2009 that provided means for pursuing joint work.
  - ✓ WERC is simulating a flatback airfoil in which Sandia has interest.
  - ✓ A collaborative effort was started with NASA-Ames concerning wind turbine maintenance.
  - ✓ Jonathan Naughton and Manjinder Singh have collaborative work ongoing with NCAR, and Dimitri Mavriplis and Stefan Heinz both have sabbaticals at NCAR next year.
- We continue to pursue relationships with several academic institutions that complement our expertise.
  - ✓ A proposal was submitted to DOE on offshore wind by a consortium of 9 schools and GE (Ohio State, Illinois, Case Western, Clemson, Virginia Tech, the University of Mississippi, Notre Dame, and Wyoming).

WERC members continue to submit proposals as opportunities arise.

- Mark Balas and Jonathan Naughton received three years of funding ($450 k from DOE and a $100k match from SER) to investigate how to characterize and control wind turbine blade flows.
- Jonathan Naughton was successful in obtaining $200k in funding from DOE in workforce development.
- David Walrath has been successful in collaborating with Z4 Energy to obtain funding through the SBIR program ($70k)

WERC continues to pursue development of its experimental facilities to complement its personnel development and computational resources.

WERC's educational activities have also continued to expand.

- A proposal for an interdisciplinary M.S. in Wind Energy was submitted to the administration, and funds to support outstanding students in this program have been awarded by DOE. The focus is to prepare students for careers in wind energy.
- Lines of communication between WERC and Laramie County Community College (LCCC) are established. LCCC has one of the premier wind technician training programs in the country. Currently, Jonathan Naughton sits on their advisory board.

Outreach Activities/Publications:

WERC members attended the past two AWEA conferences helping to man a booth paid for by the Wyoming Business Council. Plans are being made to have a booth solely for highlighting educational opportunities in Wyoming next year.

In conjunction with SER and Cooperative Extension, outreach efforts related to wind energy have been quite active:

- Dozens of presentations were made to civic groups in the region, including the Laramie Economic Development Corporation, Rotary Club, Lions Club, and the Laramie Engineers Club.
- Cooperative Extension, SER, and WERC have assumed responsibility for the State's anemometer loan program, although it will be run differently from the program previously administered by the Wyoming Business Council.
- Cooperative Extension, SER, and WERC applied for funding under DOE's wind for schools program.

Supportive Partners:

BP, GE Energy, Rocky Mountain Power, KB Energy, Z4 Energy, DOE, NREL, Sandia National Labs.

8. Carbon Management Institute – Ron Surdam, Director

Mission:

The primary objective of the Carbon Management Institute (CMI) is to ensure that the University of Wyoming and relevant state agencies have the expertise, experience and relationships necessary to accelerate the collaborative development of the science, technology, and techniques required to effectively and efficiently store and utilize carbon in Wyoming and the Rocky Mountain region.

FY2010 Achievements:

At present, CMI has three main projects:

1. Site characterization of the highest-priority geologic forms for CO_2 storage in Wyoming (WY-CUSP),
2. Design and development of integrated carbon management scenarios for each of the major Wyoming Laramide Basins,
3. Support for the Shaanxi/Wyoming Partnerships' effort to establish a CO_2 storage demonstration in the Ordos Basin, China.

In all three of these projects, CMI involves colleagues across UW and the Wyoming State Geological Survey (WSGS).

The most noteworthy, recent, activities of CMI are outlined in the following list:

- Completion of a contract with Geokinetics to acquire a 3D seismic survey and Electromagnetic survey in the vicinity of the proposed Rock Springs Uplift stratigraphic test well
- Final review of the UW/Baker-Hughes contract to drill the Rock Springs stratigraphic test well
- Preparation of the WY-CUSP Phase I communication and outreach plan
- Collaboration with Baker Hughes in designing the stratigraphic test well: providing stratigraphic tops, casing points, selected log tools and coring intervals
- Initiation of data collection with respect to outcrop studies, regional structural determinations, detailed stratigraphic studies, evaluation of containment-mineralization-brine characteristics and preliminary performance assessments
- Leading a field trip for Shaanxi Provincial Director of Development and Reform Commission Zhu and the Shaanxi Vice Governor (now Governor) Zhao

Outreach Activities/Publications:

CMI project reports were presented to the Joint Agriculture and Joint Minerals Committees, the Governor's Energy Advisor, and the UW Energy Resources Council. Presentations describing the Rock Springs Uplift Characterization Project were given at the national AAPG meetings in New Orleans, the DOE National Carbon Management meetings in Pittsburg, the International Advanced Coal Technology Conference in Laramie, the Annual UW Business School Conference, the Wyoming Infrastructure Authority Conference, the Petroleum University of Xian, the Shaanxi Provincial Department of Development and Reform, and the Wyoming Environmental Quality Council.

Supportive Partners:

CMI's extramural supportive partners include, but are not limited to Baker-Hughes, Inc., Exxon/Mobil, Geokinetics, EmTek, Los Alamos National Laboratory, Lawrence Livermore National Laboratory, National Energy Technology Laboratory, WSGS, Shaanxi Provincial

Institute of Energy Resources and Chemical Engineering, and the Shaanxi Provincial Development and Reform Commission.

9. Center for Energy Economics and Public Policy – Professor Tim Considine, Director

Mission:

The mission of the Center for Energy Economics and Public Policy (CEEPP) is to develop rigorous economic analysis to understand how modern challenges represented by expansion of the world economy over the next generation will impact energy markets and macroeconomic growth.

The stresses that global demands put on the world energy complex were evident during 2008, culminating with triple digit oil prices. These pressures likely will be even more acute as societies seek to significantly reduce greenhouse gas (GHG) emissions. Choices and tradeoffs must be made among the mix of emerging technologies for significant GHG emissions reductions without disrupting supply of reliable energy at affordable cost. Economic analysis estimates the costs and benefits of these choices and attempts to understand their impact on markets. As the nation's largest energy exporter, Wyoming is profoundly affected by developments in world energy markets and by energy policy decisions. Government and industry decision makers need to understand how these forces affect national and international markets and the challenges that lie ahead.

FY2010 Achievements:

The Center currently is engaged projects addressing:

- Economic and environmental impacts of unconventional natural gas production
- State and regional analysis of greenhouse gas emissions control policies and renewable energy portfolio standards
- Global value of coal
- Regional pricing of natural gas
- Estimating the costs and economics of carbon capture and storage
- Assessing the economics of wind power development.

These projects will be completed over the next two academic years, resulting in a series of well-written reports accessible to a wide audience.

Supportive Partners:

In addition to support from SER, in kind support has been obtained from:

- Wyoming Mining Association
- Marcellus Shale Coalition & American Petroleum Institute
- The World Bank

- The Manhattan Institute
- The Bechtel Foundation & the Communications Institute
- University of Southern California, College of Engineering
- Jackson Sustainability Initiative, City of Jackson, & Lower Valley Energy
- World Coal Institute and Coal Industry Advisory Board both based in Europe

Outreach Activities:

- Panel discussion at the Manhattan Institute on natural gas in New York State (February, 2010)
- Briefing to U.S. Congress on the economic impacts of Powder River Basin coal (July 2010)
- Invited briefing to U.S. Congress on shale gas production (September, 2010)
- Invited keynote address on Powder River Basin coal to Rocky Mountain Mining Institute in Sheridan Wyoming (September, 2010)
- Invited keynote address on the economic impacts of gas drilling to the Developing Unconventional Gas (DUG) conference in Pittsburgh, PA (November, 2010)

Publications:

- Considine, T.J. and D. Larson "Substitution and Technological Change under Carbon Cap and Trade," revised July 2010, under review The Energy Journal.
- Considine, T.J., R. Watson, J. Sparks, R. Entler. (2009) "An Emerging Giant: Prospects and Economic Impacts of Developing the Marcellus Natural Gas Play," The Pennsylvania State University, Department of Energy and Mineral Engineering.
- Considine, T.J., (2010a) "The Economic Impacts of the Pennsylvania Marcellus Shale Natural Gas Play: An Update," The Pennsylvania State University, Department of Energy and Mineral Engineering, May 2010.
- Considine, T.J. (2010b) "The Economic Impacts of the Marcellus Shale: Implications for New York, Pennsylvania, and West Virginia," American Petroleum Institute, http://www.api.org/policy/exploration/hydraulicfracturing/upload/API%20Economic%20Impacts%20Marcellus%20Shale.pdf, July 2010.
- Considine, T.J. (2010) "The Economic Value of World Coal Production," Chapter in F. Clemente, ed., Hard Facts: the global value of coal" World Coal Institute and Coal Industry Advisory Board.
- Mason, Charles F., "On Stockpiling Natural Resources," *Resource and Energy Economics*, submitted.
- van't Veld, Klas, C.F. Mason, and A. Leach (2009) "Economic Co-optimization of Enhanced Oil Recovery and Carbon Sequestration" re-submitted to *Resource and Energy Economics*.

B. Matching Grants Fund

UW is a research university, so faculty and academic professionals engage in research as part of their job assignments. Successful research programs require significant external funds (grants and contracts) to meet their objectives. This is especially true in the energy arena. The funds are

required for, among other things, support of undergraduate and graduate students, post-doctoral research staff, purchase of critical equipment, and summer salary for principal investigators.

The national landscape for funding is highly competitive. For instance, proposals to national agencies such as the Department of Energy and the National Science Foundation often have success rates of 20-30 percent or less. As a result, review panels are forced to choose among many excellent proposals. Subtle differences, such as an institution's commitment to help support the research, may dictate any proposal's fate. The Matching Grant Fund (MGF) provides significant additional leverage to already strong UW proposals, thereby improving the chances of capturing external funding.

SER's fourth call for proposals for the FY2010 MGF was issued in September. The call was modified from previous calls to explain changes in the way MGF proposal approval is administered to provide more flexibility in timing to meet the needs of principle investigators who submit proposals under a wider range of deadlines. The funding limit was also raised from $100 thousand to $250 thousand to accommodate proposals seeking larger grants. Faculty interest remained high – well over 50 proposals were submitted, and 23 were approved for commitments.

There is significant lag-time between the submission of a research proposal and announcement of awards. Funds are committed at the time of submission in order to improve UW's success rate. This circumstance builds significant uncertainty into the distribution of funds. Often, there are several vintages of MGF funds working in any fiscal year, and commitments almost always carry over. In FY2010, commitments from FY2008 and FY2009 were honored, and new commitments that will carry over into FY2011 were made.

MGF Commitments

Commitments have been made to provide matching funds through this program in FY2007, 2008, 2009, and 2010 (Appendix B).

1. Ten projects received funding from those committed to in FY2007.
   a. $510,200 in SER funds captured $1,990,800 in outside funding for a total research value of $2,501,000.
   b. Overall leverage of SER funds was 4:1
   c. One successfully completed project ("Integration of a Structural Water Gas Shift Catalyst with a Vanadium Alloy Hydrogen Transport Device") was the recent recipient of a $1.5 million DOE grant for scale-up engineering.
2. Twelve projects received funding from those committed to in FY2008
   a. $829,022 in SER funds captured $4,046,349 in outside funding for a total research value of $4,875,371.
   b. Overall leverage of SER funds was 5:1.
3. Seven projects received funding from those committed to in FY2009
   a. $538,952 in SER funds captured $2,461,318 in outside funding for a total research value of $3,000,270.
   b. Overall leverage of SER funds was 5:1

   c. The outside award for one project proposal from FY2009 is still pending. SER still has a $100,000 commitment to this project.
4. SER made commitments to 23 proposals in FY2010
   a. SER's committed $2,192,773 to seek $10,897,121 in outside funding for a total research value of $13,089,894.
   b. Overall leverage of SER funds would be 5:1 if all submittals are successful
   c. At the end of FY 2010, four of the 23 projects had been funded leaving 19 projects pending.
   d. SER's remaining commitment from FY2010 is $1,977,273.

Research Topics

There is a stipulation in each call for proposals to the MGF program that research must be energy related. Understandably, the range of research topics has been diverse. To date, topics have included the following:

- Clean coal research
- Flow through porous media
- CO_2 sequestration in deep aquifers
- Biological degradation of organic waste for fuel cell development
- Impact of foreign policy on energy security in the USA
- Production and sustainability of biofuels in Wyoming
- Groundwater monitoring and management
- Arid lands reclamation – soils, microbes, and vegetation
- Solar energy: photoelectrochemical- and organic-based cells
- Chemical reactivity of novel catalysts
- Aerodynamics and control of wind turbines
- Oil and gas production and recovery
- Economic impact of enhanced oil recovery and carbon capture storage
- Drivers of electrical energy demand
- Soil and plant reclamation
- Impact of energy development on habitat and migration of wildlife species.

Outside agencies for the above topics are diverse and include:

- Department of Energy
- American Chemical Society – Petroleum Research Fund
- National Science Foundation
- Institute for Global Environmental Strategies
- Bureau of Land management
- Center for Revolutionary Solar Photo-Conversion

With four years of experience in administering the MGF, it appears that the original intent – providing significant additional leverage to already strong UW proposals – is being fulfilled. To date, state funds are being leveraged at a rate of 5-to-1 for successful projects. SER will

continue to monitor the success of the program and implement revisions to procedure as warranted to ensure that the funds are used to create an advantage for UW research.

C. Uranium Research Fund

Pursuant to 2009 General Session Laws, Chapter 159, Section 339 appropriated $1.6 million of AML funds to SER to conduct Uranium Research with the following guidance:

The School of Energy Resources under the direction of the University of Wyoming Energy Resources Council and in consultation with the Wyoming mining industry may develop:

(A) A research program for uranium under the school of energy resources at the University of Wyoming. This program shall focus on optimizing the economic recovery of the resource through groundwater restoration, research on waste water management and the development of a seminar to educate the public and the industry about uranium and uranium extraction;

(B) A program at the school focusing on technology transfer that would help industry with access to and application of existing in situ recovery processes. The program shall be designed to promote research and technology transfer efforts;

(C) A database which would include information concerning uranium exploration, development and production;

(D) A research program which would focus on future production of uranium resources in Wyoming; and

(E) Other programs as identified by the energy resources council.

Activity since 2009 General Session legislation:

Uranium Extraction Workshop: Identifying the Challenges and Opportunities for *Research* – September 2009

- 92 representatives of the uranium industry, state and federal regulatory agencies, and the University of Wyoming gathered in Cheyenne on September 22-23, 2009, "*to determine the challenges and opportunities where the University of Wyoming can make significant contributions through research to optimize the economic recovery of uranium".* The public workshop to identified research gaps and opportunities for guidance for the eventual release of a RFP to provide funding for research.
- Initial plans for the public forum on ISR, including a proposal for a survey of public opinions and guidance for the forum content was outlined through detailed discussion.
- Report of findings, including the list of research recommendation, is found at: http://www.uwyo.edu/sersupport/docs/conferences/2009/uraniumworkshop/UraniumWorkshopFinalReport_10132009.pdf

Below is a summary list of high priority research recommendations (extracted from the report) identified by participants in the workshop:

A. Exploration and Production – Development of non-invasive alternatives to exploratory drilling
   1. Use of isotopes to trace groundwater flow paths and location of deposits
   2. Development of surface geophysical and soil geochemical methods for locating redox boundaries at depth, including helium and radon tracers
   3. Use of oil well database for identifying deep disposal well zones and characteristics
   4. Remote sensing/trace hole geophysics
   5. Slim-hole drilling techniques
B. Operations
   1. Development of more effective lixiviants
   2. Development of in-situ devices and better methods for groundwater monitoring
   3. Development of improved methods for waste water management, treatment, and use
   4. Determining cause of reduced flow over time
C. Restoration
   1. Reducing water use
   2. Development of effective bioremediation Methods
   3. Modeling and monitoring of natural attenuation for aquifers
D. Regulation
   1. Precedents and future options to address overlapping
   2. Options for granting ISR Underground Injection Control (UIC) permits.
   3. Methods for background baseline analysis
   4. Effectiveness of historic restoration methods and likelihood of post-restoration migration of recovery fluids to an adjacent non-exempt USDW
   5. Framework for long term risk management
E. Assessment and Communication of the Safety and Sustainability of In-Situ Recovery of Uranium
   1. Objective analysis of the historic actual risk to the public of ISR
   2. Effective means for communicating to the public about the relative risk of ISR
   3. Developing a sustainable model for ISR in relation to other resource needs and uses.

Preparations: The Future of Uranium Production in Wyoming – A Public Forum on In-Situ Recovery – August 4, 2010 in Laramie

WYSAC in February 2010 conducted Public Opinion Survey on In-Situ Recovery to determine the most important topics for the forum. Survey results can be found on the following website: http://www.uwyo.edu/sersupport/docs/conferences/2010/uraniumforum/WYSAC_Uranium_Report_201008_SRC-1004.pdf

A forum steering committee formed with the following membership:

- Kevin Fredrick, Manager, Ground Water Section, Water Quality Division, Wyoming Department of Environmental Quality
- Richard Garrett, Energy and Legislative Advocate, Wyoming Outdoor Council
- Wayne Heili, Vice President, Mining & Engineering, Ur-Energy USA
- Dr. KJ Reddy, Professor, Renewable Resources, UW

- Donna Wichers, Senior Vice President, Uranium One, Americas
- Dr. Jeri Anderson, Health Physicist, National Institute of Occupational Safety and Health, Division of Surveillance, Hazard Evaluations and Field Studies, Center for Disease Control and Prevention

Goals of the Forum

- Provide interested members of the public an opportunity to learn about *in situ* uranium production as well as the benefits and risks associated with uranium production from leading experts in health, environmental protection, and uranium extraction.
- Provide an opportunity for individuals concerned about uranium production to share and discuss their concerns with representatives of industry, government, health and environmental protection organizations, and the academic community.
- Provide members of the public and individuals across a broad spectrum of sectors with diverse perspectives and experiences to learn about each other's interests and concerns.

C. Clean Coal Research Fund

Activities under the Clean Coal Research Fund are reported separately to the Joint Minerals, Business and Economic Development Interim Committee. See 2010 Report of Clean Coal Task Force.

D. Carbon Management Research Fund

2009 Wyoming General Session Laws, Chapter 159, Section 339 appropriated $8 million in AML funds to SER to support the CO_2 Sequestration Research. In June 2009, UW President Tom Buchanan and Governor Dave Freudenthal appointed a five-person Wyoming Carbon Sequestration Steering Committee to, prioritize the allocation of funds. Members of that steering committee are:

- Rob Hurless, Energy and Telecommunications Advisor, Wyoming Executive Office
- Ron Surdam, Wyoming State Geologist
- Carol Frost, Associate VP for Research and Economic Development
- Mark Northam, Director, UW School of Energy Resources
- William Gern, VP for Research and Economic Development (ex officio)

The steering committee agreed to commit matching funds for grants submissions under the 2009 DOE Recovery Act Solicitations. As a result of the successful submissions, the $8 million appropriation was fully committed. Successful grants were:

1. "Site Characterization of the Highest-Priority Geologic Formation for CO_2 Storage in Wyoming" – $6.3 million of the AML funds used as cost share for a DOE grant that now totals $9.975 million. An additional $2.2 million in of private in-kind match from Baker-Hughes, Inc., Geokinetics, and EMTEK is applied to this project.
   a. This work has been designated as Phase I of the Wyoming Carbon Underground Storage Project (WY-CUSP). It will provide preliminary evaluation of the suitability of formations under the Rock Springs Uplift for CO_2 storage.

b. Project is overseen by Director of the UW Carbon Management Institute, Ron Surdam and his staff
c. The drill site has been selected on Rock Springs Uplift
d. Well design work has been completed
e. Preliminary permitting work with Wyoming Oil and Gas Conservation Commission (WOGCC) has begun
f. Permitting for BLM easement is in process
g. Contracts with Geokinetics and EMTEK have been signed
h. The contract with Baker Hughes in final stages of revision
i. A communication plan has been developed, including a contract hire of Lynn Boomgaarden to serve as communications officer
j. Regulator meetings have been scheduled to maintain lines of communication with all parties.
    i. State agencies
        (a) WOGCC
        (b) DEQ
        (c) State Engineer's Office
        (d) Wyoming Game and Fish
        (e) State Historic Preservation Office
        (f) Wyoming Water Development Office
        (g) BLM
    ii. Conservation/environmental agencies
        (a) Wyoming Associate of Conservation Districts
        (b) Sweetwater County Conservation District
        (c) Wyoming Nature Conservancy
        (d) Wyoming Outdoor Council
        (e) Upper Green River Coalition
j. Anticipate spudding the well by end of October 2010 and reaching total depth in 1Q 2011
k. The successful well will be completed as a monitoring well for the WY-CUSP project (Phase II)

2. "Regional Sequestration Technology Training" – $990,000 of the AML funds used as cost share for a DOE grant totaling $994,910. Dr. James Meyers is using the funding to create the Wyoming CCS Training Institute (WCTI). The WCTI will use an industry-wide model to train a professional workforce, provide pathways for graduates and professionals from allied fields and create a vehicle for communicating regional carbon capture and storage knowledge and technology.
3. "CO2 Sequestration in Depleted Compartmentalized Gas Fields – the Key to Deploying the Clean Coal Technology in the Powder River Basin, Wyoming" – $500,000 if the AML funds used as cost share for a Clean Coal Technology Fund grant of the same amount. The joint UW/WSGS research project is surveying the CO_2 storage capacity of depleted natural gas reservoirs in the Powder River Basin

2010 Wyoming Budget Session Laws, Chapter 39, Section 320 appropriated and additional $45 million in AML funds to SER for development of a sub-commercial scale CO2 sequestration research and demonstration project, subject to the following:

1. *A portion of the funding may expended to complete the stratigraphic test well as a CO2 injection well*
2. *No other funds under this appropriation may be expended until SER, with the approval of the Energy Resources Council, provides the following to the joint minerals, business and economic development interim committee, the joint agricultural, state and public lands and water resources interim committee and the joint appropriations interim committee:*
   a. *An evaluation of the feasibility of proceeding with the project based upon the data derived from the test well*
   b. *A draft plan for the development and operation of the project. The draft plan shall include an explanation of how carbon dioxide for the project will be secured and of how liability issues with regard to injection and storage will be addressed and a plan for the beneficial use and treatment of produced water*
   c. *A draft budget for the development and operation of the project over a period of time that is reasonable for the demonstration of monitoring, verification and accountability (MVA), including the extent to which commitments for non-state resources to support development of the project have been secured.*
   d. *A draft schedule for development*
3. *No appropriations shall be expended for the next phase of the project unless commitments of non-state resources in an amount equal to the state resources to support each of the next phases of the project have been secured*

The total amount of the $45 million has been set aside to conduct the CO_2 injection phase of WY-CUSP. We currently anticipate that the start of that phase will follow the completion of Phase I by about 2 years. Activities under the WY-CUSP, in anticipation of the use of the $45 million appropriation, are reported separately to the Joint Minerals, Business and Economic Development Interim Committee (forthcoming, November 2010).

IV. OUTREACH INITIATIVES

SER's energy outreach mission is to serve as a source of knowledge to energy stakeholders in Wyoming. One of the most effective ways to reach appropriate interest groups is through sponsorships of symposia, conferences, and workshops where experts are invited to deliver lectures on important topics, and then hold discussions with participants in the audience. In FY2010, we were very active in carrying out that mission.

A. Major conferences conducted by SER:

1. **Uranium Research Workshop, Cheyenne WY, September 24, 2009** (please see above in the Uranium Research Fund for details)

2. **Western States Energy & Environment Symposium, October 25-27, 2009 – Jackson**

   2009 General Session House Bill No. 295 authorized the convening of this event**,** appointed a steering committee, and authorized a budget ($450,000; $250,000 to SER for the cost of developing and running the symposium, $200,000 to LSO to pay the costs of

legislators attending) and directed SER to coordinate the activities to plan the symposium. Steering committee members were:

- Representative Tom Lubnau, Chairman
- Senator John Schiffer
- Kyle Davis, Director, Environmental Policy and External Relations, PacifiCorp
- Nancy Ryan, Deputy Executive Director for Policy and External Relations, California Public Utilities Commission
- Bill Schilling, President, Wyoming Heritage Foundation

In June 2009, it was decided by the symposium steering committee to reduce the overall budget by 10%, or $45,000. In total, $320,896 was spent to develop, advertise, and hold the symposium, and to pay the cost of speakers and select legislative attendees. Including the $45,000 original reduction, $129,104 was returned to the state (Table IV-1.).

Table IV- 1. Western State Energy and Environment Symposium Final Accounting

Category	Amount
Appropriation:	
Appropriation from General Session 2009 HB 295 to UW - SER	$ 250,000
Appropriation from General Session 2009 HB 295 to LSO	$ 200,000
Total Appropriation	**$ 450,000**
Expenditures:	
Support - Supplies/AV/Facility/Shuttle	$ 36,406
Travel - Out of State Legislators & Speakers	$ 67,194
Lodging & Food	$ 82,760
Consulting - Communications, Event Mgt , Facilitation	$ 123,061
Mileage to Wyoming Legislators (per LSO)	$ 11,475
Total Expenditures	**$ 320,896**
Reversion to State General Fund:	**$ 129,104**

Note on Revenues: Net revenues receipted by Hip Performance Group for this event totaled $34,767. The company went into foreclosure in early 2010, assets were liquidated, and there was no ability for them to pay these revenues due.

Nearly 250 participants convened for the symposium, including state legislators from fourteen Western states and representatives from local and federal government, private industry, nongovernmental organizations, and academic institutions. The WSEES was designed to accomplish the following objectives in recognition of the importance of the

Western states establishing a cooperative capacity to generate, transport and utilize energy in an economically viable, reliable, and environmentally sensitive manner:

a. Bring together public officials, key stakeholders and notable thought leaders to examine state energy policies from a regional perspective and work toward establishing a common regional vision;
b. Explore opportunities for and impediments to coordinating a Western states energy policies to advance regional and sub-regional economic performance of a Western energy system;
c. Identify state, regional and federal policy challenges and potential solutions for delivering energy resources to consumers;
d. Develop potential regional policy solutions to mitigate the environmental impacts of energy resource development, delivery and consumption in the West; and
e. Work to establish a cooperative agreement among the participants to develop a high level cost/benefit economic analysis assessing the challenges of energy development, production, reliability, marketing, use and environmental protection within these states.

A written report of the symposium was submitted on December 11, 2009 to the legislatures of the western states, all governors and congressional delegations of the participating states, and all conference participants. A copy of the report can be found at the following website: http://legisweb.state.wy.us/2009/Interim/Wsees/FinalReport.pdf. Follow-up from this symposium is with the Council of State Governments – West and will be discussed at the annual meeting in Sun Valley, ID on September 11-14, 2010.

3. **International Advanced Coal Technologies Conference: The Case for Cooperation** – June 23 – 24, 2010.

This symposium was jointly convened by the University of Wyoming and the University of Queensland (Australia). Approximately 200 participants from 6 countries attended. The proceedings from the conference have been published at the following website: http://www.advancedcoalconference.com/sites/default/files/ACC-proceedings.pdf

Following the conference, a working dinner was held for the Australian, UW, DOE and Chinese participants of the conference. The purpose was to move toward commitments for collaboration on low emissions coal technology. Northam and Kelly Thambimuthu (UQ) led a discussion of the areas of common interest generated at the conference in 2008 in Queensland. Progress was made in discussion of faculty and student exchange (agreement between the two universities will be finalized) and funding:

- SER will share future Clean Coal Technology Fund Requests for Proposals with UQ and the Australian National Low Emissions Coal (ANLEC) R&D Program with the goal to coordinate funding that might lead to international collaboration on common issues.
- Mark Davies of ANLEC offered an exchange of project proposals (ours and his) for cross review purposes. Also offered to discuss other ways to collaborate on funding projects.

- Dr. Zhu from Shaanxi Provincial Development and Reform Commission offered (unsolicited) matching funds to support Chinese research in conjunction with either UW, UQ or both up to the full amount of the CCTF.

B. Other Significant Energy Outreach Offerings

The following event benefitted from SER support and coordination in collaboration with other entities:

1. Transmission Forum – Denver, August 11, 2009
2. State of the Dominant Estate – Laramie, November 2009
3. Global Competition for Energy – Casper, October 2009
4. Global Competition for Energy – Cody, October 2009
5. UW Sustainability Conference – Laramie, April 2010
6. Global Competition for Energy – Laramie, May 2010
7. Grand Rounds – Laramie, April 16, 2010
8. Energy and Produced Water Conference – Laramie, April 24-25 , 2010
9. Wyoming State Science Fair – Laramie, March 7-9, 2010
10. Wyoming Reclamation & Restoration Symposium – Laramie, April 6-7, 2010
11. Energy Resources and Produced Water Conference – Laramie, May 25-26, 2010

C. Colloquium Speaker Series

SER also coordinates visits to UW by experts in energy areas to deliver lectures of interest to faculty, students, and the general public on campus. In FY2010, the following lectures were sponsored on campus:

1. Dr. Timothy Carr – January 28, 2010. "Energy in the 21st century – the Promethean Challenge"
2. Dr. Ehlig-Economides – April 12, 2010. Discussion topic was engineering education

D. Participation in Conferences, Exhibitions and Trade Fairs

As part of its outreach mission, SER participated in a number of external conferences, exhibitions and trade fairs in FY2010. These include:

- Global New Energy Summit – Santa Fe, NM, March 21-23, 2010
- WindPower 2010 Conference, Dallas, TX, May, 2010
- Wind Festival – Carbon County, WY, May 2010
- Energy Exposition 2010, Gillette, WY, June, 2010

E. Other Activities:

1. Compressed Natural Gas Vehicle Study

UW, Albany County, and State Officials met with Questar in SLC to review the Utah experience and begin the development of a pilot program with UW, Albany County and

the school district and an economic study of Compressed Natural Gas (CNG) as a transportation fuel. UW is undertaking a study of the long-term economics of the development of a market for CNG as a transportation fuel. Work continues to develop suitable pilot programs among participants.

2. Queensland Trip – March 13 – 20.

Mark Northam was invited to travel with Governor Freudenthal, Rob Hurless, Rob Wallace (Manager, Government Relations, GE Energy and ERC member) and Monty Atwell (General Manager, Gasification Business, GE Energy) to explore collaboration on advanced coal and carbon storage technologies. Twenty five meetings were conducted with high-level delegations from 2 universities, Queensland government, Australian federal government, Australian government research groups, and many industries. The trip established strong foundations upon which future collaborations will be built, and several are in the works.

Several of the groups visited during this trip were subsequently represented at the International Advanced Coal Conference discussed above (Section IV. A. 3.). Most notably, the Honorable Hon. Peter Beattie, Queensland's Trade Commissioner in the USA, and former Premier of QLD, Australia attended and was a keynote speaker at the conference.

V. DEVELOPMENT ACTIVITIES

The construction of a state-of-the-art UW Energy Resources Center has been one of the University's highest priorities for private support through the University's academic facilities matching funds program. As of the end of June 2010, $24.7 million has been raised for this building through gifts and state matching funds.

- Encana Oil & Gas USA committed $5 million toward the construction of the Center
- Shell Exploration & Production Company committed $2 million for the Center
- BP also committed $2 million for the Center
- Peabody Energy committed $2 million for an Advanced Coal Technology Laboratory as part of the Center
- Arch Coal, Inc. committed $750 thousand for the Center.
- Marathon Oil Company committed $250 thousand to help construct an Interdisciplinary Fossil Fuel Research Lab as part of the Center.
- Questar Corporation committed $180 thousand to the Center.
- ConocoPhillips committed $170 thousand for the Center.

As the design of the building progressed, it became apparent that an additional effort to provide funds for the technology needed to allow the facility to reach its full potential was warranted. To that end, the UW Foundation worked with SER to create the **"Energy Resources Technology Enterprise Fund"**. The goal of the fund is to raise $2 million in private donations to be matched equally by the state for a total of $4 million. SER plans to leverage the funds to create

partnerships with technology equipment manufacturers and software developers to obtain the technology required to power the state-of-the-art 3D visualization center and collaboration center in the building. This fundraising effort was kicked off on April 29th, 2010 in Denver at the home of UW graduate Peter Mounsey (JD, '84) and his wife, Anne. President Buchanan, Governor Freudenthal, and Senator Al Simpson all spoke at the event that was attended by over 40 representatives of the energy industry. Several gifts were received on the spot and efforts continue to build the fund.

Gifts have also been sought to establish endowments that will supplement annual state support. The University's endowment matching program provided that these gifts could be matched by the State of Wyoming. Through the end of FY2010, these gifts include:

- Jim Nielson, president of the Cody-based energy company Nielson & Associates, has gifted $5 million toward an endowment for the school's general operations. Nielson's gift supports the Director of the School – annual funding from his endowment will be directed to SER programs at the full discretion of the Director.
- Marathon Oil Company pledged $670 thousand to UW to fund student internships and scholarships, symposiums, and field trips.
- Anadarko Petroleum Company pledged $1.5 million to UW to endow the Anadarko Resources Recovery Program. The endowment will be matched by the state. Earnings from the $3 million endowment will be used to fund a number of faculty, graduate student, and undergraduate student fellowships. A request for nominations is currently active.
- Ultra Petroleum pledged $1 million (to be matched by the state) to the UW School of Energy Resources to endow the "Ultra Petroleum Visiting Energy Chair". The first recipient of this visiting chair is currently being sought.

VI. The Energy Resources Center.

A total of $25.4 million was available at the start of the project to design and build the Energy Resources Center (private funds, state match, and interest). The Level 1 plan for the Energy Resources Center was completed in October 2009 by Paulien and Associates, Inc of Denver Colorado. Based on the Level 1 plan, a request for qualifications was issued for the design of the building, and a second request for qualification was issued for a construction manager at risk.

The UW Board of Trustees approved GSG Architecture of Casper, in association with HOK Inc. of St. Louis, to be the architect/engineer for the planned Energy Resource Center (ERC) at their January 2010 meeting. The Board of Trustees approved G. E. Johnson Construction Co. of Jackson as the construction manager at risk for the center during their meeting in March 2010. Work on design and cost of the center is progressing. The total construction cost is estimated to be just over $20 million. Groundbreaking is targeted for November 19th, 2010. Expected completion date of the building is June 2012.

Currently, the building calls for approximately 30,000 square feet of assignable space (50,000 square feet, gross). The building will be located between 10th and 11th Streets on the south side

of Lewis Street. The Energy Resources Center will become the permanent home of the School of Energy Resources and the Enhanced Oil Recovery Institute.

The overall theme of the building is to provide energy research and collaboration assets to the campus. It will provide 12,000 square feet of rapidly reconfigurable lab space for advance coal technology research, reservoir characterization research, alternative energy research, and instrumentation development. There will also be a state-of-the-art 3D Visualization research facility, a fully capable classroom/auditorium for up to 60 participants, and a 3,000 square foot reconfigurable "collaboratorium" for fully interactive distance collaboration.

VII. Financial Report

The Wyoming State Legislature provided funding for SER over the 2009-10 Biennium in the 2008 Legislative Budget Session. This funding was comprised of two parts. First, the legislature appropriated $17,420,565 to derive from the Abandoned Mine Lands Fund. Second, the Legislature approved the carryover of up to $2,020,177 of unspent monies appropriated for the support of SER in the 2006 budget session. Combined, these two sources of funds provide $19,440,742 to operate SER for the 2009-10 Biennium.

Expenditures for the 2009-2010 Biennium totaled $17,575,059. Of that total, SER spent:

- $5.8 million for salaries and benefits for SER staff, 11 faculty, 3 visiting faculty.
- $2.8 million to cover start-up commitments made to SER faculty
- $1.2 million for 54 graduate assistantships
- $2.6 million for the Matching Grants Fund
- $3 million to establish new and support existing Centers of Excellence.
- $455 thousand for Outreach events and the Energy Summer Institute
- $1.7 million for remaining expenses that include recruiting, travel, publications, office support, etc.

See Table VII-1 for more details on expenditure.

During the 2010 Legislative Budget session, the legislature appropriated $17,400,000 derived from the Abandoned Mine Lands Fund, and again approved for up to $2,000,000 to be carried over from unspent monies appropriated in the preceding biennium. The actual amount carried over at the end of FY2010 was $1,865,683.

Table VII-1. School of Energy Resources 2009-2010 Biennium Expenditures

	Fiscal Year 2009	Fiscal Year 2010
Academics		
Salary & Benefits	$235,133.00	$385,971.12
Office support expenses	$22,388.00	$55,431.10
Distinguished Faculty Salary & Benefits	$1,531,263.00	$1,947,828.37
Distinguished Faculty Startup	$1,120,720.00	$1,675,680.56
Recruiting	$22,807.00	$13,433.79
Undergrad research fellowship stipends	$11,635.00	$0.00
Graduate Assistantships	$402,841.00	$815,052.82
Visiting Professorships	$59,060.00	$231,158.52
Other Support (Course Dev, Faculty Searches, A&S startup)	$177.00	$812,287.55
Research Experiences for Undergraduates (REU)	$2,505.00	$31,900.00
Equipment requests funded	$2,976.00	$121,165.92
Energy Summer Institute	$96,240.00	$74,920.36
Subtotal Academics	$3,507,745.00	$6,164,830.11
Research		
Carbon Management Institute	$50,000.00	$615,021.22
Enhanced Oil Recovery Institute		$277,671.82
Matching Grant Funds	$102,450.00	$2,545,305.00
Equipment requests funded		$20,000.00
Research Centers	$174,580.00	$2,188,358.96
Subtotal Research	$327,030.00	$5,646,357.00
Outreach		
Salary & Benefits	$81,703.00	$224,607.14
General Office support	$7,759.00	$82,527.66
Travel	$16,813.00	$14,577.52
Sponsorships	$10,425.00	$147,561.81
Publications	$42,000.00	$25,606.66
Lectures	$3,065.00	$13,840.96
Workshops	$55,740.00	$69,563.71
Subtotal Outreach	$217,505.00	$578,285.46
Administration		
Salary & Benefits	$400,901.00	$442,272.19
General Office support	$89,272.00	$200,861.20
Subtotal Administration	$490,173.00	$643,133.39
Total Expenditures for Fiscal Year	**$4,542,453.00**	**$13,032,605.96**
Carryover into FY 2011/2012		**$1,865,683.00**

Appendix A. Matching Grants Fund Details

Attached as a Separate File

Appendix B. Matching Grants Fund Details

Attached as a PDF File