

September 28, 2007

University of Wyoming
SCHOOL OF ENERGY RESOURCES
Second Annual Report, 1 October 2007
[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

INTRODUCTION

This document is the second annual report of growth and development of the School of Energy Resources (SER) at the University of Wyoming (UW). The Wyoming State Legislature provided authorization and funding for the SER in its 2006 session, through Senate File 37. W.S. 21-17-117(f) requires a report regarding all revenues to and all expenditures by the school during the preceding fiscal year, accomplishments of the school and its benefits to Wyoming's energy economy.

As outlined in the school's academic and fiscal plan, SER's objectives are 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 industries, companies, community colleges, and government agencies.

Initiatives developed by the School in FY 2006-07 were under the leadership of SER's Energy Resources Council and guidance of SER Interim Director, Prof. Carol D. Frost, and SER Academic Coordinator, Prof. Andrew C. Hansen.

UW Energy Resources Council

Ron Harper – Charman	CEO and GM, Basin Electric
Rep. Tom Lockhart – Vice Chairman	Chairman, Minerals, Business, and Economic Committee
Harold Bergman (ex-officio)	Director Haub School and Ruckelshous Institute of Environment and Natural Resources
Thomas Buchanan (ex-officio)	President, University of Wyoming
Mark Davies	GM of Business Development, Rio Tinto Energy America
Paul Lang	Sr. Vice President of Operations, Arch Coal Inc.
Keith O. Rattie	President, Chairman, and CEO, Questar Corp.
Bobby Shackouls	Retired President, Chairman, and CEO, Burlington Resources, Inc.
Thomas Stroock	Former US Ambassador to Guatemala; President, Alpha Development Corp.
Sen. Charles Townsend	Appropriations and Select Water Committee, Enhanced Oil Recovery Commission
Rob Wallace	Manager, Public Relations, GE Energy

September 28, 2007

This report summarizes progress made in the following areas and is consistent with the original plan for SER presented during consideration of the enabling legislation.

1. Permanent Director for SER
2. Distinguished Faculty Searches
3. Academic Initiatives
 - a. Academic Council
 - b. Energy Summer Institute
 - c. Graduate Assistantship (GA) Allocations
 - d. Course Modification/Development Providing an Energy Emphasis
 - e. Chemistry Research Experiences for Undergraduates (REU) Program
 - f. UW READ
 - g. Curriculum Development
4. Research Initiatives
 - a. Matching Grant Fund Program
 - b. Development of Research Centers
 - c. Clean Coal Initiative
 - d. Wyoming Infrastructure study
5. Outreach Initiatives
 - a. Colloquium Speaker Series
 - b. Stroock Forum
 - c. Public Symposia on Coal Gasification and CO₂ Sequestration
 - d. Wyoming Conservation Corps (WCC)
 - e. SER participation in conferences, exhibitions and trade fairs
6. Development Activities
7. Website

1. PERMANENT DIRECTOR FOR SER

An international search for a permanent director was begun in August 2006. The search committee was composed of the following people:

Dr. Carol Frost (chair)	Interim Director, School of Energy Resources
Rod Debruin	Wyoming State Geological Survey
Paul Heller	College of Arts and Sciences
Norm Morrow	College of Engineering
KJ Reddy	College of Agriculture
Terry Roark	Western Research Institute
Greg Schaefer	Arch Coal
Jim Steidtmann	Enhanced Oil Recovery Institute
Larry Weatherford	College of Business

KornFerry International was engaged to assist the search. Advertisements and a detailed position announcement were published, and more than 220 prospective candidates were identified by members of the search committee and KornFerry. These candidates were from academic (72), industry (129) and government sectors (19).

September 28, 2007

The search committee invited 12 applicants to participate in confidential, off-campus interviews in January through March 2007. Five finalists were announced to the Energy Resources Council and UW Board of Trustees on March 23. These finalists visited UW between April 19 and 30, when they gave a public presentation and met with various groups, including the Energy Resources Council, UW faculty, students and administrators, and a representative of the governor's office.

Based upon the campus visits and with input from constituencies around the state, Vice President for Academic Affairs Myron Allen appointed Dr. Mark Northam of Saudi Aramco to be permanent director of the School of Energy Resources. He took up this post on July 17, 2007. The press release announcing his acceptance is included in Appendix A.

2. DISTINGUISHED FACULTY SEARCHES

Based on proposals submitted by college deans and on the prospects for building rapidly on existing faculty strengths at UW, Vice President for Academic Affairs Myron Allen authorized international searches for four distinguished faculty members in the following areas:

Geology and Geophysics:	Reservoir characterization and rock physics
Chemical and Petroleum Engineering:	Coal conversion technologies
Economics and Finance:	Energy markets and economics
Mathematics:	Numerical modeling of reservoir fluid flows

The position descriptions are presented in Appendix A. Searches for these positions took place beginning in fall 2006 with vigorous efforts to recruit outstanding energy-related teachers and researchers from industry, academia and national laboratories. One or more members of the School of Energy Resources faculty steering committee served on each search committee.

In July 2007, Dr. Felipe Pereira of the State University of Rio De Janeiro accepted the mathematics position. Dr. Pereira has developed an international reputation in the field of computational and applied mathematics, with special focus on multiphase flows in multi-scale porous media. His most recent contributions have been directed toward simulating multiphase flow during enhanced oil recovery.

Due to the outstanding candidate pool uncovered during the mathematics search, it was decided during July to make a second offer to a mathematician that would complement the research of Dr. Pereira and further take advantage of SER's and UW's cooperation with NCAR. That offer is still pending at the time of this submission.

Searches for faculty in Geology and Geophysics, Chemical and Petroleum Engineering, and Economics and Finance are ongoing.

3. ACADEMIC INITIATIVES

The School of Energy Resources is committed to energy education that impacts the broadest possible student cross-section. This section describes academic initiatives for students ranging from high school sophomores to graduate students.

September 28, 2007

Several important academic, research, and outreach programs were initiated in FY2006-07 including

- the allocation of competitively awarded Graduate Assistantships;
- the development of an Energy Summer Institute for high school students, teachers, and counselors; and
- the development of a Matching Grant Fund program to stimulate energy-related research at UW.

Priorities in the year ahead include initiating searches for the next four distinguished faculty positions, selection of faculty members to be awarded temporary half-time positions in the School, and the growth and development of several important research centers.

The four distinguished faculty positions allocated for new searches include the following:

Mathematics:	Reservoir modeling and porous-media flow analysis
Chemical and Petroleum Engineering:	Petroleum engineering
Renewable Resources:	Reclamation and restoration ecology
Chemistry:	Energy storage and renewable energy resources

The first year of the SER was also marked by the first campus discussions regarding future curricular developments for the School. Undergraduate and graduate programs must be developed and numerous options for these programs are under consideration. For instance, will the programs be stand-alone degree offerings, dual degrees, certificates or minors? What is the degree of interdisciplinarity for these programs? What role will the Haub School of Environment and Natural Resources play in an SER curriculum? Is the SER a possible administrative home for UW's Earth Systems Science degree? The decisions to be made in the nascent stages of SER curriculum development will have lasting effects on the School.

a. Academic Council

A substantial number of SER activities require critically important decisions to be made by the Director and Academic Coordinator of the School. As a result, we formed an *Academic Council* for the SER charged with assisting the Director and Academic Coordinator in the operations of the School. The *Academic Council* is intended to represent all facets of the energy teaching and research enterprise at UW. Broad participation across the University ensures the interdisciplinary nature of the School remains strong while faculty engagement across the university is as widespread as possible. In addition to utilizing the *Academic Council* for advice on a variety of important decisions, we expect the *Council* to be an advocate for SER programs while serving as an important conduit for delivering SER messages to the broader campus.

In developing the make-up of the *Council*, we sought breadth both in the number of colleges represented and in the array expertise in energy-related technologies:

- i) Geosciences related to the carbon-energy arena such as reservoir modeling and/or reservoir characterization for enhanced oil recovery, coalbed methane, tight gas, coal conversion, coal gasification, etc.
- ii) Renewable and/or alternative energy including basic energy research.
- iii) Environmental aspects of energy development including reclamation issues and CO₂ storage and capture.

September 28, 2007

- iv) The business of energy including permitting, economic analysis, and law.

The School of Energy Resources is also envisioned to have substantial ongoing interaction with the Haub School of Environment and Natural Resources (ENR). In fact, the Director of ENR is an ex officio member of SER's Energy Resources Council. The Haub School has a tradition of active involvement in a variety of energy-related issues. In an effort to encourage policies and directions that advance both the mission of SER and ENR, it is important to have a stable connection to the School of Environment and Natural Resources.

Based on the above information, we created the following membership profile for the *Academic Council*:

- i) Director of the SER—permanent.
- ii) SER Academic Coordinator—permanent.
- iii) One member from ENR—selected by ENR.
- iv) Five faculty and/or academic professional representatives from colleges across the University. No more than two representatives should come from any one college. Distinguished faculty appointed through the School of Energy Resources are potential candidates for these appointments.

Appointments are for a two-year period although, initially, two of the five college appointments and the ENR appointment were made for a one-year period (AY 2007-08). This approach results in a well-defined rotating membership for the *Council*, thereby increasing exposure of the SER to UW faculty while providing fresh perspectives on the important issues of the day.

Academic Council appointments and their term expiration date are given below.

Mark Northam	Director, SER	Permanent
(Vacant)	Academic Coordinator, SER	Permanent
Harold Bergman	Director, Haub School of Environment and Natural Resources	May 2008
KJ Reddy	Professor, Department of Renewable Resources	May 2009
John Jackson	Chair, Department of Management and Marketing	May 2008
Frederico Furtado	Associate Professor, Department of Mathematics	May 2008
Carrick Eggleston	Professor, Department of Geology and Geophysics	May 2009
Morris Argyle	Assistant Professor, Department of Chemical Engineering	May 2009

b. Energy Summer Institute

A significant component of the academic enterprise of the School of Energy Resources (SER) is to develop strong and lasting links with Wyoming's K-12 teachers, counselors, and students. As part of our efforts to connect with Wyoming's youth, the SER brought 17 high school sophomores (Class of 2010) and 5 teachers/counselors to UW for our first annual SER Energy Summer Institute. The Institute is designed to provide participants with a superb exposure to the challenging energy problems facing the world—and the exciting solutions on the horizon. In addition to the relevant programmatic content, the Institute also affords the youth of our state a terrific opportunity for exposure to higher education and all that UW has to offer.

The 2007 Energy Summer Institute consisted of two courses taught for 2 ½ hours in the morning and afternoon, Monday through Thursday for two weeks beginning 10 June 2007. One of the courses centered on energy conversion technologies and covered topics such as coal-fired power plants for electrical generation, clean coal technologies using coal gasification, and the role of gas turbines in future power generation. In addition to the stimulating course content, participants enjoyed a day-long field trip to the Laramie River Station coal-fired power plant near Wheatland. SER's intent was to get the participants a behind the scenes "engineering tour" of the many interesting facets of these impressive and important facilities.

The second course taught at the 2007 Institute focused on wind energy. Participants learned about the mechanisms and characteristics of wind energy and investigated wind resources for Wyoming. Participants also learned how mechanical motion is converted to electrical power in a wind turbine. The highlight of the course was that each participant constructed model wind turbines along with an axial flux permanent magnet alternator and tested their system for electrical generation capacity in one of UW's wind tunnels.

The SER worked hard to promote the Energy Summer Institute across the state early this year. Informational brochures for students, teachers, and counselors were mailed to all K-12 middle schools, junior high schools, and high schools. A first-hand look at this information is viewable at http://uwadmnweb.uwyo.edu/energy_institute.

c. Graduate Assistantship (GA) Allocations

Essential to UW's research enterprise are the talented graduate students that work with the faculty. Graduate students across the University are generally supported through Graduate Assistantships which pay their tuition and fees as well as a modest stipend. GAs may be funded through a limited state pool or through external research support. A GA is one of the most prized resources for any UW faculty member engaged in research activity.

In March 2007, the School of Energy Resources released a call for proposals for 16 GAs to be distributed across the campus. The complete solicitation is provided in Appendix B of this report. The intent of the GA solicitation was to support a broad range of SER activities that enhanced the academic and research mission of the School. Four areas of interest were emphasized in this call for proposals including:

September 28, 2007

- i) Interdisciplinary research programs,
- ii) Modification of existing courses to increase energy-related content,
- iii) Development of new courses in critical and emerging technology areas, and
- iv) Basic and applied energy research.

The SER received 48 GA proposals (for 16 available GAs) spanning four colleges and the Haub School of Environment and Natural Resources. Proposals were evaluated by SER's *Academic Council* comprised of eight faculty colleagues from across the University and described earlier in this report. The competition was intense and resource constraints prevented us from funding several proposals of significant merit. A listing of faculty receiving GA awards and their proposal titles is provided in Table 1.

Table 1. SER/GA Awards

NAME	TITLE
Alvarado, Vladimir & Mohammad Piri	CO ₂ sequestration in deep saline aquifers
Bagley, David	Sustained biogenic production of coal-bed methane: Microbial production of hydrogen and acetate
Bell, David	Wyoming coal gasification economics, kinetics, and process technology
Bergman, Harold	New Course Development: Applied environmental law for non-lawyers
Chemistry (a) (Dept. Award)	Novel transition metal excited states for solar energy conversion
Chemistry (b) (Dept. Award)	Nanoscale materials for fuel cells and advanced energy storage
Coupal, Roger & Harold Bergman	New Course Development: Sustainable energy futures
Dellenback, Paul	Modeling gas turbine and thermodynamic cycle performance for a novel IGCC plant
Eggleston, Carrick	Synthesis of hematite and albandite photocatalytic films for a tandem fuel cell
Gomelsky, Mark	Sustainable photosynthetic H ₂ production: Genetics and selection of purple nonsulfur bacteria for optimized H ₂ production
Heinz, Stephan	A new concept for the gasification of Wyoming coal
Heller, Paul	A study of shapes, scales, and spacings of channel-belt sand bodies in avulsion-dominated fluvial reservoirs
Johnson, Patrick	Enzyme nanoparticle synthesis and characterization for biofuel cells and cellulose hydrolysis
Mason, Charles	Economic co-optimization of enhanced oil recovery and carbon sequestration
Piri, Mohammad & Z. Karpyn	Multiphase flow in fractured hydrocarbon reservoirs
Urynowicz, Michael & Gus Plumb	Liquid and gas transport in sub-bituminous coals: The effects of bubble nucleation, growth, and competitive adsorption/desorption

d. Course Modification/Development Providing an Energy Emphasis

The University of Wyoming already offers a significant array of energy-related courses at the undergraduate and graduate levels. One of the purposes of SER is to look for synergistic opportunities that may be available through modification of existing courses and to encourage the development of new courses to address pressing scientific, business, or energy-related policy issues.

This past year, SER has supported the development of two new courses through the GA allocation outlined previously. These courses address the following:

- Applied Environmental Law for Non-Lawyers
- Sustainable Energy Futures

In addition to the above courses to be developed with GA assistance, the SER identified and supported three opportunities for course modification/development designed to increase student awareness of critical energy issues while further elevating SER's academic profile across the campus.

Engineering Science 1060: ES 1060 (Introduction to Engineering Computing) is the first exposure to engineering for students in the College of Engineering. The course introduces students to computing tools for data presentation graphics, equation solving, and manipulation of tabular data. The present course suffers from a lack of focus on specific problems, thereby making it difficult to motivate students to continue their pursuit of an engineering career.

September 28, 2007

Recently there has been interest in the College of Engineering to reorganize ES 1060 to give it a thematic base that can provide students with a solid motivation to learn the subject content. Establishment of the SER and the strong focus on energy throughout the University makes energy an ideal theme for the course. The SER has agreed to provide support to modify ES 1060 to introduce engineering students to the broad spectrum of technical, social, and policy issues associated with energy while maintaining the original objectives of the course.

Engineering College Senior Comprehensive Design Experience: Disappearing Roads-Environmentally Friendly Access To Oil And Gas Resources: UW professor and H.T. Person Chair, Charles W. Dolan, teaches an annual engineering college senior design course. The all-college multidisciplinary course for 2007-08 is built on the Texas A&M “Disappearing Roads” competition that explores new and innovative technology to reduce the environmental footprint of energy development in sensitive areas. While the Texas A&M competition is titled “Disappearing Roads,” the work can range from simple improvement in road design to total system analysis and redesign of how energy is extracted. Air and water resources, wildlife considerations, and economics are all critical factors to be considered in any proposed design. Because the designs have to be sensitive to the environmental impacts of extraction, students in the Haub School of Environment and Natural Resources are also encouraged to enroll in the course.

Professor Dolan will lead a class of approximately 20 students to examine the design of the next generation of oil and gas in desert conditions. Dr. Dolan intends to use the Jonah Field and the new Atlantic Ridge site for case studies. The class registration as of 1 June 2007 is:

- 10 Mechanical Engineers
- 4 Civil Engineers
- 1 Chemical Engineer
- 1 Electrical Engineer
- 1 student from the School of Environment and Natural Resources

The myriad of technical, societal, and environmental problems to be resolved provides students with terrific exposure to the energy-related problems at the heart of our great state. The School of Energy Resources is providing support for the course by funding travel of students and faculty to the Jonah Field in the fall of 2007.

GEOL3650: Energy: A Geological Perspective: GEOL 3650 provides students with the skills to formulate successfully informed and reasoned responses to questions about energy exploration, exploitation and use they will face as citizens of an industrialized democracy. To accomplish this, the course:

- Introduces students to the techniques necessary for evaluating the geological aspects of energy resources;
- Assesses energy questions economically,
- Assesses the social impacts of energy extraction and use, and
- Builds an awareness of comparative decision-making processes from the local to the international level.

September 28, 2007

Students are exposed to all of the above through actual case studies that span the globe. As with all real world issues, there are no clear-cut answers to the policy decisions that must be made in each case study. Rather, students must take and defend a position using the geologic, scientific and technical knowledge they have learned and the literacy skills they have mastered.

The case studies for this course were originally developed over a three year period with funding from the Fund for the Improvement of Secondary Education (FIPSE) to the Ellbogen Center for Teaching and Learning. The School of Energy Resources has provided support to expand the number of available case studies for the course. The goal is to have a library of available case studies ranging from the state level (e.g., coalbed natural gas production) to the international level with local consequences, e.g., expanded coal use in China and the issue of CO₂ emissions; nuclear power (and weapons) in Iran, etc.

e. Chemistry REU Program

In the fall of 2006, the Department of Chemistry submitted a proposal to the National Science Foundation to make UW a Research Experience for Undergraduates (REU) site for: "*Chemistry Research Related to Energy Science.*" The proposal outlined a program to bring 10 undergraduate students from neighboring colleges to UW for each of the next three summers to work on outstanding problems related to energy science and energy resource development. Educational activities include hands-on research on projects related to the development of clean and renewable energy sources, energy-related field trips, and scientific seminars and discussions of the chemistry research needed for a sustainable energy plan for the nation.

REU awards are highly competitive nationwide. Although the National Science Foundation declined funding for the Chemistry REU, the School of Energy Resources partnered with the Chemistry Department by committing to fund five undergraduates in the program for the summer of 2007. The Chemistry Department was able to leverage this commitment with additional UW resources to bring a total of 8 students from UW and neighboring colleges to campus for the REU summer program. Not only is the program providing valuable research experience for deserving undergraduates in the summer of 2007, the Chemistry Department intends to use this program as a powerful primer for another run at the NSF/REU program in 2008.

f. UW READ

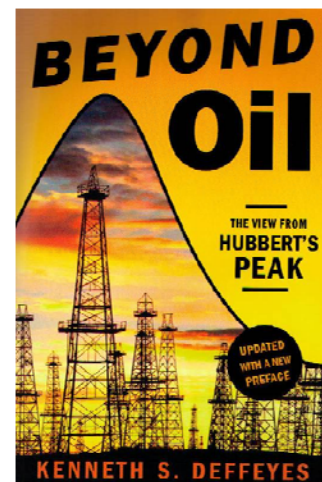
UW READ (Read, Explore, Analyze, Discuss) is a University program designed to introduce incoming freshman to the outstanding intellectual community that is the University of Wyoming. The program asks all incoming freshman to purchase and read a common book in the summer prior to their arrival at UW. The program began in 2004 and is based, in part, upon the premise that students who have a common intellectual experience are more likely to engage in the intellectual life of the campus right from the beginning of their experience at UW.

The book selected for UW READ is intended to be one of broad interest, touching on topics that are both timely and of significant importance to society. The intellectual impact of the book is

September 28, 2007

enhanced by bringing in national speakers in the fall to address the subject. The selected book is also the topic of discussion in a variety of first-year courses.

Beyond Oil by Kenneth S. Deffeyes has been selected as the summer-fall reading project for incoming students. World demand for oil continues to increase unabated—and in a dramatic fashion—as both population and worldwide economic expansion grow. In contrast, oil production is expected to peak in the coming decades and Deffeyes argues that peak production has already occurred. (Production peaked in the United States in 1970.) *Beyond Oil* is an enlightening survey of available world energy sources from a geologic perspective. Natural gas, coal, tar sands, oil shale, and uranium for nuclear power are among the many options discussed as partial replacements for oil. While the development of energy resources relies on science and engineering, the impacts of the development have broad social, economic, and environmental implications. The interdisciplinary nature of energy development, coupled with the impending new-energy era, makes *Beyond Oil* ideal reading for our incoming freshman. The book is especially relevant to our great state as Wyoming's vast and varied energy resources are sure to be explored and developed in unprecedented ways.



Author K.S. Deffeyes, Professor Emeritus at Princeton University, has a long history in the petroleum business with strong connections to Wyoming. His father was a first-generation petroleum engineer while Deffeyes himself received his undergraduate education in petroleum geology from the Colorado School of Mines before graduating from Princeton with a Ph.D. Deffeyes held summer jobs in the oil patch and began working for Shell in 1958 prior to entering academia. Deffeyes spent part of his teenage youth mineral collecting on Casper Mountain and is a graduate of Natrona County High School.

g. Curriculum Development

Arguably the most important mission in the academic enterprise of the School of Energy Resources is the development of outstanding curricular programs for students interested in a career in energy. These programs will not only serve our students, they will form a cornerstone for Wyoming's future energy workforce.

Widespread curriculum discussion among faculty, department heads, and senior administrators has occurred during the past year. While undergraduate and graduate programs must be developed, our original efforts are focused on developing a strong interdisciplinary undergraduate program. The precise nature of the curriculum is yet to be determined although a preliminary proposal is to place the SER undergraduate program under the umbrella of UW's relatively new Earth Systems Science program. In this model, shown in Figure 1, students would take a two-year core of math and science followed by two years in one of three stem areas including:

- i) Modeling and analysis related to basic energy research—there are many topics here including clean coal technology (low CO₂ emissions), enhanced oil recovery (reservoir modeling), fuel cells, biofuels, wind, etc.
- ii) The business and economics of energy including finance and markets, and
- iii) Environmental aspects of energy development including legal aspects, permitting, collaborative management, land fragmentation, etc. This stem would involve close collaboration with the Haub School of Environment and Natural Resources.

The SER undergraduate program would also be marked by a major year-long capstone experience in the senior year. The first semester of the capstone experience would involve a senior project/thesis in the stem area chosen by the student. The second semester would focus on bringing students together in teams from all three discipline areas to work on an energy problem of importance to the state. The SER would work hard to engage state and federal agencies, state government, the state legislature, and private industry to form a meaningful experience that transcends all areas of the SER curriculum.

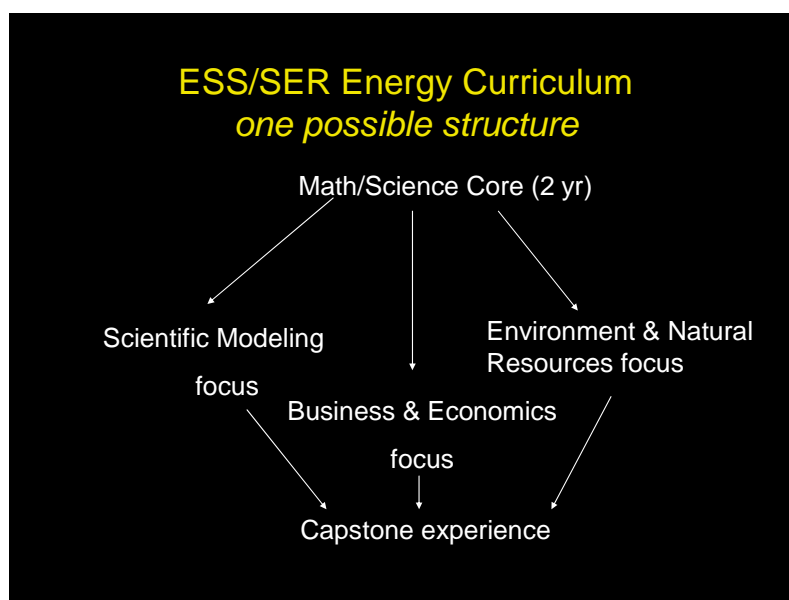


Figure 1. A suggested model for an SER undergraduate program.

4. RESEARCH INITIATIVES

a. Matching Grant Fund

UW faculty and academic professionals are typically engaged in research as part of their job assignments, with the expectation that state-of-the-art research helps maintain professional currency in rapidly changing fields. A successful research program often requires significant external funds — in the form of grants and contracts from federal agencies or corporations — to meet the research objectives. These funds may be used for, among other things, support of undergraduate and graduate students, purchase of critical equipment, and summer salary for the PI.

September 28, 2007

The national landscape for funding is highly competitive. For instance, proposals to national agencies such as DOE or NSF may have success rates of 20-30 percent—sometimes less. As a result, review panels are forced to choose among many excellent proposals and subtle differences, such as an institution's commitment to help support the research, may dictate any proposal's fate. The SER Matching Grant Fund (MGF) program is intended to provide significant additional leverage to already strong UW proposals, thereby improving the chances of acquiring external funding.

A request for proposals (RFP) to the MGF was issued campus-wide on 31 October 2006. The complete RFP is provided in Appendix C. For AY2006-07, the SER committed funds to 17 proposals totaling \$810,200, contingent on the investigators receiving the matching external award. Proposals for 2006-07 covered the entire spectrum of energy research and development. A cursory overview of SER funded topics include:

- Clean coal research
- Geology of fluvial channels for oil field prospects
- Solar energy: Molecular-based photoelectrochemical cells (artificial photosynthesis)
- Enhanced oil recovery—reservoir modeling
- Wyoming oilseed crops for biodiesel production
- Improved nuclear reactor core simulations
- Aerodynamic control of wind turbines
- Coalbed methane co-produced water issues
- Hydrogen production from coal

Funding agencies for the above topics have also been very diverse and include:

- Department of Energy
- American Chemical Society—Petroleum Research Fund
- North Central Sun Grants
- Private Industry
- Idaho National laboratory

As of 1 June 2007, 6 of the 17 SER/MGF proposals have been funded by the external agency receiving the proposal. Moreover, there has been only 1 proposal rejection and the remaining 10 proposals are still pending.

The SER expects to receive a steady stream of funding requests for the MGF program as faculty interest in the program runs high. The MGF program has already provided substantial tangible benefits to UW researchers while significantly elevating the overall campus awareness of the School.

b. Development of Research Centers

The School of Energy Resources (SER) includes three units: academic programs, overseen by an academic coordinator; the Institute for Energy Research, composed of externally funded research centers; and the Center for Energy Outreach, providing energy-related information, workshops and technical consulting.

The research centers in Institute for Energy Research are interdisciplinary groups of faculty and graduate student researchers organized to solve particular research problems. Accordingly, these centers are expected to evolve with time. New groups may form to work on emerging energy-related problems, and some existing groups may disband as their project is completed. The centers that have been organized include:

1. Enhanced Oil Recovery Institute (EORI), Prof. J.R. Steidtmann, Director.

The EORI has funding from the Wyoming State Legislature and partners with Wyoming energy producers to perform the following functions:

- Assist Wyoming operators with their EOR projects by applying existing technologies and creating new knowledge when necessary
- Maximize the economic potential and minimize the risk of EOR projects
- Facilitate the testing, evaluation, and documentation of EOR recommendations in the real world settings
- Transfer the information to Wyoming producers by forming partnerships and conducting workshops and conferences
- Develop technologies for capturing CO₂ from flue gases

Under the SER, scientists and engineers from various disciplines work with oil producers to study the issues of maximizing oil production.

2. Coal Bed Natural Gas Center. Wyoming's coal bed natural gas is an important clean fuel source. This research center has 2 focuses. First, 9 faculty from three different colleges, is engaged in a DOE-funded project on how to cost-effectively extract natural gas while minimizing environmental impacts including co-produced water treatment and management. This group presented their first-year results at the American Society of Mining and Reclamation national meeting in June 2007, and plans to present their final results at a conference in summer 2008 to be held jointly with the Ruckelshaus Institute of Environment and Natural Resources.

Second, a group of faculty from Civil and Architectural Engineering, Chemistry, and the Western Research Institute are working on stimulating additional resource through sustainable biogenic production of coal bed natural gas.

3. Renewable Energy Resources Center. This center has two initial areas of emphasis. First, faculty from the colleges of Arts and Sciences and from Engineering propose fundamental research in energy nanoscience, in particular solar cells, fuel cells and energy storage. Development of solar fuels may be an important way to supplement fossil fuel energy production, and is a research area where UW and SER could be national leaders. Initial work in this group will:

- Develop and characterize nanocrystalline semiconductor films, and functionalize them with dyes/catalysts for photocatalytic solar fuels generation and possibly for photovoltaic applications.
- Synthesize and characterize nanoparticulate metal oxides as energy storage media.
- Construct a prototype microbial fuel cell based on existing expertise with the metal-reducing species *Shewanella oneidensis* MR-1 and *Geobacter sulfurreducens*.
- Quantify protein adsorption and catalytic activity on semiconductor electrode surfaces as part of a functioning biofuel cell.

September 28, 2007

- Construct a microfluidic cell capable of utilizing formate (such as from a solar photocatalytic cell) in the production of electrical current.

Second, faculty members in Electrical Engineering, Mechanical Engineering, Atmospheric Science and Mathematics have identified key aspects of wind energy research and development that UW researchers are well-poised to pursue. The wind energy research group aims 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. They have an ongoing effort to model the wind inflow to these turbines, a collaborative effort between researchers with expertise in turbulence, geophysical flows, and large-scale weather forecasting.

(Groups working on other aspects of renewable energy research may be organized in the future.)

4. Arid Lands Restoration Ecology (Wyoming Reclamation and Restoration Center). Many energy-related activities involve disturbance of the land surface, including mining, oil and gas development, pipelines and power transmission lines. UW has had an active reclamation and restoration program for many years; much of their research has been supported by the Abandoned Mine Lands Research Program. This group is developing a project to demonstrate their abilities in restoration ecology related to surface impacts of natural gas in the upper Green River Basin of Wyoming.

5. Coal Conversion Technologies Center. Wyoming coal provides the majority of the fuel for generation of our nation's electricity; it also may be processed to provide synthetic gases, diesel, other hydrocarbons such as alcohols, and even hydrogen fuels. Existing expertise at UW and the Western Research Institute will be expanded with the hire in 2007 of a distinguished professor in coal technologies. The School of Energy Resources will be positioned to develop a strong research center in coal conversion technologies, particularly those that are optimized for Wyoming's low sulfur, sub-bituminous coal and for Wyoming's relatively high elevation.

6. Research Center for Fundamentals of Subsurface Flow. The mission of this center is to fill the knowledge gaps in the current state-of-the-art experimentation and modeling of multiphase flow in porous media to ensure present and future access to subsurface energy resources. The Wyoming and national energy matrix is comprised of a significant component of fossil fuels (hydrocarbons and coal). Optimum access to hydrocarbon energy resources from conventional oil and gas reservoirs, coal seams (coalbed methane), low permeability (tight) gas reservoirs and oil shale relies on deep understanding of complex multiphase and multicomponent transport phenomena in porous media. This center will be at the forefront of porous media transport phenomena experimentation and modeling, with a unique ability to bridge between fundamentals of multiphase flow in porous media and applications in subsurface hydrocarbon resource production and geological storage of CO₂. State-of-the-art Enhanced Oil Recovery (EOR) techniques potentially have many viable applications in Wyoming oil and gas reservoirs. Limited success in the application of EOR schemes to subsurface hydrocarbon resources to a great extent is due to incomplete understanding of complex multiphase and multicomponent transport phenomena in porous media. Progress in this area would definitely lead to sound design of reservoir exploitation plans and reduction in uncertainties associated with these attempts.

September 28, 2007

A potential additional research center that could be developed is a Carbon Separation and Sequestration Research Center. Carbon separation and sequestration is poised to become a necessary aspect of fossil-fuel use, especially coal use, and is thus becoming an area of paramount interest to the state of Wyoming. CO₂ injection is also an important part of enhanced oil recovery in the state. It is crucial to have technical expertise at UW to monitor and assess the state of CO₂ at the surface and in the subsurface as well as to predict its movements and chemical behavior over time. Carbon separation and sequestration on the surface is particularly important to coal-fired plants as they manage the exhaust produced during combustion. Sequestration Geoscience involves the quantitative evaluation of geologic reservoirs for carbon sequestration. Researchers in this group may use geophysical approaches to monitoring and verification of carbon storage, including 3-D seismic reservoir characterization and monitoring of CO₂ migration as well as characterization of the fracture mechanics of a reservoir including the formation and fracturing of seals.

“Seed” research grants for developing SER research centers

In 2007, the School of Energy Resources granted several small ‘seed money’ grants to interdisciplinary groups of researchers who were working to develop SER research centers. The groups receiving this support are:

Sustained Biogenic Production of Coal-Bed Methane SER Coal Bed Natural Gas Center	\$77,000
Energy Nanoscience: solar cells, fuel cells, and energy storage SER Renewable Energy Resources Center	\$71,000
Energy Development Mitigation in upper Green River Basin, Wyoming SER Arid Lands Restoration Ecology Center	\$50,000

c. Clean Coal Technologies Research Program

Original House Bill No. 301, Enrolled Act No. 121, enacted by the Legislature of the State of Wyoming during the 2007 General Session created a Clean Coal Research Account. The legislature appropriated \$2.5 million dollars to this account to fund the Clean Coal Technologies Research Program. The purpose of this program is to stimulate research to enhance and improve clean coal technologies, with an emphasis on use of sub-bituminous coal at high altitudes. The legislation also created the Clean Coal Research Task Force, composed of the members of the Wyoming Energy Resources Council to the University of Wyoming School of Energy Resources. The task force was charged with soliciting research proposals for research into clean coal technologies.

The School of Energy Resources issued a request for proposals for the Clean Coal Technologies Research Program on May 15, 2007. Areas of research eligible for consideration include:

- Pre-combustion/pre-gasification technologies
- Combustion and gasification design technologies
- Post-combustion/post-gasification gas clean-up technologies
- Advanced cycle technologies

September 28, 2007

- Air separation technologies
- Carbon capture and sequestration technologies
- In situ gasification technologies
- Coal to liquids/coal to hydrogen technologies
- Economic analysis

Proposals were solicited from academic institutions and private industry. The program requires a dollar-for-dollar match from non-state funds. Proposals were due August 31, 2007; 10 were received. The proposals include 3 from universities, 4 from research institutes, and , 3 from industry. They have been evaluated competitively based upon their probable benefits to the State of Wyoming through improved use of Wyoming's coal resource. The results of the research will be available for public dissemination. These funds will become available upon 1) approval of the research projects recommended by the task force to the Governor and Joint Minerals, Business and Economic Development Interim Committee, and 2) appropriation of the funds from this account by the Legislature in March 2008. Funds are to be expended by June 30, 2009.

The Call for Proposals document is appended in Appendix C.

d. Wyoming Infrastructure Authority study

SER commissioned a study entitled "An Economic Impact Analysis of Proposed Tax Incentives to Attract Integrated Gasification Combined Cycle Power Generation Facilities to Wyoming" by University of Wyoming faculty and students Roger Coupal, Robert Godby, David Bell, David Taylor, Jamison Pike, and Thomas Foulke. This report, which may be found in Appendix C, was prepared for the Wyoming Infrastructure Authority, and provided information for the legislature for their 2007 session.

5. OUTREACH INITIATIVES

a. School of Energy Resources Lecture Series

To enhance the SER's visibility and to facilitate the recruitment of outstanding candidates for the directorship and for the first four distinguished faculty position, the SER sponsored a year-long colloquium series in energy-related science, engineering and economics. The series brings to UW a set of internationally recognized experts in these fields to give lectures, to stimulate interdisciplinary research and to help identify potential candidates for the open positions. The following are the speakers who presented lectures during 2006-2007:

- | | |
|-------------------|---|
| 18 September 2006 | Dr. Zhangxin (John) Chen, Southern Methodist University
"Modeling Heavy Oil Reservoirs" |
| 23 October 2006 | Dr. Richard D. Boardman, Idaho National Laboratory
"Gasification: Implications for the Future" |
| 29 January 2007 | Baron Prof. E. Ron Oxburgh, past chairman, Royal Dutch Shell
"Energy in a Changing Climate" |

September 28, 2007

30 April 2007

Judi Johansen, former president and CEO, PacifiCorp
“New Developments in Energy Policy and Technology”

The fliers for their talks are found in Appendix D.

b. Energy Futures: Global Changes that Challenge Wyoming

The School of Energy Resources teamed with the Haub School of Environment and Natural Resources, UW Outreach School, UW/Casper College Center and UW Stroock Forum on Wyoming Lands and People to co-sponsor a series of public lectures on the future of energy and what it may mean for Wyoming. Six lectures were presented in Casper between September 14 and November 16, 2006. These were followed by a day-long forum at UW in Laramie, “Energy: Ultimate Brew for the Future.” Interim Director Carol Frost was among the speakers at the Laramie forum. The fliers for these events are found in Appendix D.

The speakers ranged from oil company executives to energy technology engineers to investment advisors. They discussed topics including oil and gas, coal, uranium, alternative energy resources, climate change and trends in energy investment. The series is designed to provide the people of Wyoming with information to help them make informed decisions about their energy resources and their future.

These presentations were recorded and edited for broadcast on Wyoming Public Television, where they will be shown as six half-hour segments in fall 2007. SER provided the funding for these productions and the interim director taped the introductory and transition segments. The DVD of these programs will be distributed free of charge to schools, libraries and interested parties throughout the state.

c. Public Symposia on Coal Gasification and CO₂ Sequestration

The School of Energy Resources contracted with the Western Research Institute to organize and conduct two symposia during 2006-2007. The symposia agendas are found in Appendix D.

The first symposium, entitled “**Coal Gasification: What does it mean for Wyoming?**” was held on 28 February 2007 at the Holiday Inn in Casper, Wyoming. The symposium featured speakers from academia, industry, law and Wyoming government. The keynote speaker was attorney Eric Redman of Heller and Ehrman, LLP, an expert in Energy Law. The 1-day free symposium drew over 80 participants.

The second symposium, entitled, “**CO₂ sequestration: opportunities for Wyoming,**” was held on 4 April 2007 at the Holiday Inn in Cheyenne, Wyoming. This symposium also featured speakers from academia, industry, law and government. The introductory talk was given by SER Interim Director Carol Frost and the keynote by Carl Bauer, Director of the National Energy Technology Laboratory of the U.S. Department of Energy. This free, day-long symposium drew over 110 participants.

d. SER Sponsorship of the Wyoming Conservation Corps

In 2006 the Wyoming Conservation Corps was organized by UW student Nick Agopian. The program is affiliated with Wyoming and provides students with opportunities to obtain experience and skills in natural resource and environmental career fields through projects focusing on improving Wyoming's public lands. SER provided \$10,000 to cover student tuition and support for an energy related project in northeastern Wyoming. A team of 8 students and 2 supervisors will map and catalog weeds in and adjacent to oilfields located in Weston County. Support is provided by SER, the BLM Newcastle Field Office and Rockwell Petroleum.

The final report on the project prepared by Nick Agopian is presented in Appendix D.

e. SER participation in conferences, exhibitions and trade fairs

As part of its outreach effort, SER participated in a number of conferences, exhibitions and trade fairs in 2006-2007, and is preparing for additional events in 2007-2008. These include:

- Coal Gasification: what does it mean for Wyoming? 28 February 2007, Casper. Interim Director Dr. Carol Frost gave the introductory welcome and introduction to the School of Energy Resources, which sponsored this symposium.
- CO₂ Sequestration: opportunities for Wyoming, 4 April 2007, Cheyenne. Interim Director Dr. Carol Frost gave the introductory welcome and summarized the 2006-2007 academic, research and outreach activities of the School of Energy Resources, which sponsored this symposium.
- Consortium for North American Higher Education Collaboration conference, 25-27 April 2007, Quebec City, Canada. Director of UW's International Programs, Dr. Anne Alexander, attended to establish contacts with partners in Mexico, Canada, and elsewhere in the U.S. for collaborative energy-related research in geosciences, engineering and policy areas. (Her report is found in Appendix D).
- CBM Fair, 31 May-1 June 2007, Gillette. SER had an exhibition booth at this education fair at the Cam-Plex. Most frequent comments from visitors were that they enjoyed the public symposia and looked forward to more in the coming year; they were happy that the undergraduate degree in petroleum engineering was reestablished, and they wanted to know about the SER undergraduate curriculum and looked forward to enrolling.
- American Society for Mining and Reclamation Annual Meeting, 3-6 June 2007, Gillette. SER was a gold sponsor of this conference, and shared an exhibition booth with UW's School of Environment and Natural Resources.
- Wyoming Mining Association Annual Meeting, 21 June 2007, Sheridan. Interim Director Dr. Carol Frost is the keynote speaker.
- Rocky Mountain Mathematics Consortium/UW summer conference "Flow in Porous Media with Emphasis on Modeling Oil Reservoirs", 18-29 June 2007, Laramie. Academic Coordinator Dr. Andy Hansen will speak to the meeting about SER and opportunities for participation in the Research Center for Fundamentals of Subsurface Flow.
- Western Region Joint Summer Meeting, 15-18 July 2007, Jackson. This meeting brings together Deans of Colleges of Agriculture and Natural Resources, directors of Experiment Stations, directors of Extension Agencies and others interested in agriculture,

September 28, 2007

rural energy production and efficiency, ecology and restoration. Interim Director Carol Frost is the lead speaker for the session on “Energy and Natural Resources in Wyoming.”

SER is a co-sponsor with EORI and ENR of a summit on “Finding the Balance: Energy and Climate” to be held in Teton Village 8-10 October 2007. Speakers include Governor Freudenthal, Lord Ron Oxburgh, UW President Buchanan, Dr. Stephen Schneider, Dr. Geoff Heal, Dr. Michael Economides, Greg Boyce, Ralph Cavanagh, David Siever, Kipp Coddington and others. The preliminary agenda is found in Appendix D.

6. DEVELOPMENT ACTIVITIES

The construction of a state-of-the-art UW School of Energy Resources Center is the University’s highest priority for private support through the University’s academic facilities matching funds program. The Wyoming Legislature appropriated, and the Governor approved \$20 million in state matching funds for construction of the Center. As of the end of June, \$14 million had been raised through gifts and state matching funds to build the SER Center, envisioned as a \$40 million project.

- EnCana Oil & Gas USA has pledged \$5 million toward the construction of the SER Center facility. EnCana's gift is in addition to a prior gift of \$2 million toward the university's petroleum engineering program. Combined, they represent the largest industry gift to UW.
- Shell Exploration & Production Company gave \$2 million for the SER Center (full payment on commitment was paid in December, 2006).
- In August, ConocoPhillips pledged \$580 thousand to help construct the School of Energy Resources center.
- In September 2007, BP also pledged a total gift of \$5 million to the University. Of that total, \$2 million will support the construction of the SER center building; \$2 million was pledged to the College of Engineering and Applied Sciences establish a Wind Energy Research Center; and \$1 million will support the development of a first-class rock and fluid properties lab.

These gifts, when matched, will bring the total raised for the Center to \$18.6 million.

Gifts are also sought to establish endowments that will supplement annual state support. The University’s endowment matching program provides that these gifts can be matched by the State of Wyoming. 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. Other priorities for endowment include support for centers of excellence focused on research areas important to Wyoming’s energy industry, supplemental support of professors associated with the SER, and additional funds for graduate students in order to attract the best.

Significant conversations with several other companies have also occurred.

September 28, 2007

On October 5, 2006, Governor Freudenthal hosted representatives of EnCana, Shell, Questar, BP America, Nerd Gas, as well as UW President Tom Buchanan, UW Vice President for Academic Affairs Myron Allen, Interim SER Director Carol Frost and UW Foundation President Ben Blalock. EnCana and Shell representatives shared their intent to support the School. Follow up conversations have occurred at various levels with the others. A proposal has been submitted to BP America following a campus visit and subsequent conversations and a decision is anticipated before the end of the year.

Two trips to Houston have been made:

- In December 2006, senior representatives of ConocoPhillips were visited by President Tom Buchanan, Myron Allen, and Ben Blalock, as well as State of Wyoming Energy & Telecommunications Advisor Rob Hurless, UW Department Chair of Geology and Geophysics Art Snoke, and ConocoPhillips director and Energy Resources Council member Bobby Shackouls. A proposal has been shared and a decision is anticipated before the end of the year.
- In May 2007, senior representatives of Marathon, Anadarko and Ultra were visited by Governor Freudenthal, President Tom Buchanan, Senator Alan K. Simpson, Rob Hurless, and Ben Blalock. Follow up conversations, leading to submission of proposals, are planned over the next few months.

In April 2007, representatives of the Wyoming Mining Association (WMA) were hosted on the University of Wyoming campus by President Tom and Jacque Buchanan. Before a reception at their home, a roundtable discussion about the SER's teaching, research and outreach mission involved coal representatives of the WMA, interim SER director Carol Frost and key UW faculty associated with the SER. Follow up discussions with senior coal company representatives are expected before the end of the year.

Many other meetings with energy companies associated with Wyoming and the University of Wyoming are planned before the end of the year. All should have an opportunity to assist with making the University of Wyoming's SER a world-class facility and operation.

7. WEBSITE

UW has established a web site (<http://www.uwyo.edu/SER>) containing information about SER, including SER structure and the Energy Resources Council, advertised faculty positions, events, funding opportunities, and forms and documents. We are currently in the process of updating the content of our web site to reflect recent changes in personnel, research and outreach activities.