DOE/EPSCoR Traineeship Program for Wyoming.

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INTRODUCTION

In the first year of the traineeship program supported by the Department of Energy EPSCoR funding, the University of Wyoming has made outstanding progress toward the objective of increasing the supply of highly trained engineers and scientists with interests in energy related disciplines. The scope of the traineeship program has already broadened to encompass both more departments than originally expected and nearly twice as many graduate students as expected. Further, since the primary emphasis was on new students, most of those recruited have developed ties to the DOE labs that would not have otherwise existed.

This portion of the Progress Report gives an overall summary of the University of Wyoming's approach to the DOE Traineeship Program implementation. It also provides an overview of the results so far and a vision of how this program fits with the broader objectives for development of the University and its academic programs. Subsequent sections describe very briefly the impact of the traineeship students in each department that was successful in obtaining funds through the competitive process that was adopted. Finally, the report ends with a summary of both the academic status of the participants and the budget expenditures to date.

After notification of the funding of our DOE-EPSCoR Traineeship proposal, the DOE-EPSCoR Committee met to make a series of decisions regarding implementation. After some study of the needs for graduate student support, the committee decided to emphasize the recruitment of new domestic graduate students in targeted disciplines with special attention of under-represented minorities wherever possible. To maximize the impact of the DOE funds, a competitive award process was created. This started with a general notification to faculty that traineeships would be

awarded for graduate students working on energy-related research projects. Faculty were invited to submit brief proposals documenting the research project, the name and academic record of the student and a proposed budget. A review committee was established composed of the Project Director, Dean of Engineering and Dean of Arts & Sciences. This committee met to make the decisions of which students would be funded and what the level of funding would be. An important result of this process was that stipends of $1000/month, to include summer months, were found to be adequately competitive at the University of Wyoming. After considering the University's contribution toward tuition and fee costs and the mix of Wyoming resident & nonresident students, we found that the average funding needed for each student was approximately $14,700, allowing us to award 17 DOE traineeships. This is almost double the ten traineeships originally contemplated, and of course this significantly increases the impact of the program.

Seventeen students were selected for DOE Traineeships. These students were distributed among departments as follows:

Department	Number of Students
Electrical Engineering	3
Geology	3
Chemical Engineering	2
Mathematics	2
Environmental Biology	2
Chemistry	1
Civil Engineering	1
Mechanical Engineering	1
Petroleum Engineering	1
Statistics	1

The status of the graduate training and research for each of these students is summarized in this progress report. Taken as a group, these students and the associated faculty have had an important influence on research at the University of Wyoming, improving our focus on energy and the environment, which, considering our State and its economy, is a major emphasis of this institution.

DEPARTMENTAL TRAINEESHIP ACTIVITIES

Since the overall objective of the DOE-EPSCoR Traineeship Program is to increase the number of scientists and engineers who are trained in those areas of importance to DOE, the following sections describe the activities of the students grouped by department. As the research progresses, it is hoped that the influence of the DOE program will spread beyond these individuals. Each department which was successful in the initial competition will be attempting to expand the energy related research with other graduate students supported from other sources. Should the University be successful in obtaining the additional years of support for DOE-EPSCoR Traineeships, future progress reports will document the ancillary energy related research spawned by these departments.

Chemical Engineering

Two graduate students in Chemical Engineering were selected for DOE Traineeships. One of these, Mr. **Mark Welegala** is working on the measurement of the sorption rate of single zeolite crystals. Zeolites are used as catalysts and adsorbents in many energy related processes such as coal liquefaction and oil refining. Detailed knowledge of the mass transport phenomena associated with these materials is critical to further development of the use of zeolites in energy related processes.

The concept behind the rated measurements to be accomplished in Mr. Welegala's research is to suspend a single zeolite crystal in a flowing gas stream by a dynamically adjusted electric field. The control signal necessary to maintain balance in the electro-optical control loop is used to measure sorption rate.

The cell and gas flow system will eventually be used to study rapid diffusion in large pore zeolites. The advantages for this system include a much faster instrument response time than methods incorporating mechanical relays and the ability to study single zeolite crystals which eliminates variation in results associated with distribution of crystal sizes. Thus one can study particle size effects directly. It has been suggested that the major resistance to mass transfer in small crystals of large pore zeolites may lie at the external surface. This new balance will be ideal for investigating the existence of a surface barrier since it can only be studied effectively be varying particle size.

Much of the original development of electrodynamic containment cells for use with solid particles was accomplished at DOE sites such as the Morgantown Energy Technology Center to study combustion properties of single coal properties. This research is very closely related, and for this reason Mr. Welegala is planning on a site visit to Morgantown in the fall of 1992 to work with DOE scientists. He will obtain ideas for installation of the optoelectronic feedback loop needed in his research.

The second DOE Trainee in Chemical Engineering is Mr. **Paul Jacobs**. Mr. Jacobs is chemically modifying commercial coal-liquefaction catalysts and testing the ruggedness of these altered catalysts with a newly designed and built "Catalytic Coal Liquefaction Microreator" or CCLM. The CCLM can determine the effectiveness and longevity of hydrotreating catalysts in the presence of the severe coking environment that exists during direct, single-stage coal liquefaction.

The benchmark catalyst for this study will be Amocat 1A, a cobalt promoted molybdenum catalyst supported on gamma-alumina with a relatively large bimodal pore structure. Alkali and alkaline-earth metals may inhibit the formation of coke by reducing the number of acid sites which adsorb nitrogen containing organics that polycondense on the surface. It may be beneficial to increase the acidity by fluorinating the alumina support in hopes of cracking off coke precursors before the polymerize and polycondense. The addition of phosphorus will also be pursued. It has been claimed that he addition of phosphorus has improved overall catalyst activity and life of petroleum hydrodesulfurization catalysts.

Mr. Jacobs will visit the Process Chemistry Research Institute of the Environmental Research Center at the University of North Dakota in June of 1992. He will work with Dr. Warrack Willson there to learn more about the new coal liquefaction technology being developed by DOE. He is also anxious to learn about other energy related research areas no so directly associated with his research, and the visit to UND will certainly be valuable in this regard.

Chemistry

Mr. **Chris Schnabel** holds the DOE Traineeship in Chemistry. He is working on the development of novel homogeneous transition metal catalysts for selective hydrocarbon cracking (petroleum reforming) and dehydrogentation using fluorocarbon-protected transition metal complexes.

Substantial progress has been made in this research in the six months since DOE support was initiated. Much of the preliminary work has been directed toward the synthesis of potential catalysts for study. Three attractive dimeric complexes have been fully characterized. Current work is focused on making alkane dehydrogentation catalytic in these systems and exploring the generality of C-H bond cleavage reactions.

Research papers based on this work will be presented at an ACS meeting in San Francisco this April. Summer of 1993 is the anticipated graduation date for Mr. Schnabel.

Mr. Schnabel will go to Los Alamos National Laboratory in June where he will be working with the INC-4 research group. This should be an excellent collaborative experience, since INC-4 has some of the top inorganic chemists in the country. The Nuclear Materials Technology group has also expressed interest in developing the use of fluoroalkylphosphine ligand in nuclear materials separation technology.

Civil Engineering

Within Civil Engineering, a student interested in environmental engineering, Mr. **James Oglesby**, was a successful applicant for a DOE Traineeship. James is working on engineering methods for metal removal from landfarm topsoils and from refinery wastewater. His current efforts are directed to the use of heap leaching for metal removal from landfarm topsoils. Since metal migration is limited to shallow depths in landfarm topsoils, the material can be economically excavated for heap leaching processes. The proposed study would quantify design parameters for a metal removing system which would include acid heap leaching followed by metal precipitation from the leachate. This study would emphasize costs and the development of cost estimating relationships for use in estimating of metal removal expenses from limited soil chemical and physical data.

Mr. Oglesby will also investigate several methods for metal removal from refinery wastewater and sludge prior to disposal on landfarm soils. These methods will us suspended or immobilized landfarm bacteria which accumulate high levels of the more toxic metals in refinery wastes such as chromium and lead. In older landfarm soils, the natural selection process should have selected for species and

strains with high tolerance, and in many cases an associated high affinity, for toxic metals. Several of these species wand strains will be isolated, identified and tested in bench-scale metal removal systems.

James will be doing his internship at the Western Research Institute (WRI), a DOE contract laboratory in Laramie. He will work with Florence Barker for several weeks in early summer on projects related to biotreatment of oil and gas industry wastes. This activity is closely related to his research and should be very valuable in moving his project forward. If WRI can obtain the necessary funding, a cooperative biotreatment project on landfarming will be initiated.

Electrical Engineering

Three students in EE were successful in obtaining DOE Traineeships. Two of these are new students who were attracted to graduate study by the DOE opportunity. The continuing student was **Wayne Austad.** Wayne's research work was associated with speech processing applications in power system smart relaying. A few weeks ago, Mr. Austad completed all of his degree requirements except for the oral examination and he went to work for EG&G Idaho in their Artificial Intelligence Group. EG&G operates the DOE Idaho National Laboratory and Wayne's DOE Traineeship activity was instrumental in both developing his energy interests and his eventual placement with EG&G. A new graduate student, **Mr. Thomas Nichols,** will replace Mr. Austad as a DOE Traineeship holder. Mr. Nichols is from Cheyenne, Wyoming and will be added to the growing cadre of graduate students in Electrical Engineering interested in electric power generation and distribution problems. He is a Cum Laude graduate of the University of Tennessee and is being attracted to full time graduate study by the DOE Traineeship.

Electrical Engineering was particularly successful in recruiting female students for DOE Traineeships. One of these students, Ms. **Gena Moser**, is studying the health effects of low-level electromagnetic fields such as those associated with power transmission lines. In recent years, many such studies have been performed and the consensus of scientists is that if there are health effects, they are minor and rare. Even so, uncertainties persist. The purpose of the current study is to measure the EM fields for a variety of communication and electric utility sources and compare them with the EM fields from other common sources such as electric blankets, microwave ovens, and video terminals. The work is being done in cooperation with DOE's Western Area Power Administration.

Ms. Moser has made contact with the Power System Technology Group at Oak Ridge National Laboratories. Ms. Moser is planning to spend a portion of the summer at this facility working with DOE scientists on the health effects of EM fields. The DOE Traineeship was instrumental in encouraging Ms. Moser to pursue a graduate degree.

Ms. **Kathleen Newtson** is studying the effect of the growing number of adjustable speed drives (ASDs) on the harmonic problems for the power distribution system. The increased power capability and decreased cost of silicon controlled rectifiers (SCRs) and gate turn-off transistors (GTOs) are causing many users to adopt the use of more efficient ASDs. These and other non-linear loads contribute to the degradation of the quality of the power supplied to all users. As such, they pose a substantial problem for the electric utilities. Ms. Newtson will study the harmonic generation of a variety of these devices and make measurement to quantify their effects on the power quality.

The DOE internship is somewhat complicated for Ms. Newtson because she is expecting a child this summer. However, initial contacts have been made with the

Power Technology Group at Oak Ridge National Laboratories regarding this project. The specific timing of Ms. Newtson's visit to Oak Ridge or another DOE laboratory will depend on when her child arrives and how soon she is ready to resume her Traineeship activities. A temporary leave from the Traineeship has been approved. As with Ms. Moser, the DOE Traineeship was an important factor in Kathy's decision to continue in graduate school. Her course work and initial stages of her research are continuing through the Spring semester. It is anticipated that the leave this summer will be only a minimal disruption in her graduate program and that she will still finish the M.S. degree in August of 1993.

Geology

The Geology Department currently has three students with DOE-EPSCoR Traineeships. One of these, Mr. **Chris Faucette**, is working on modeling reservoir heterogeneity in storm-dominated sandstone deposits. Data on variation in thicknesses of a storm-dominated sandstone environment has been collected south of Rock Springs, Wyoming. The distribution of small, intermediate and large scale barriers to fluid flow through the sandstones was of primary interest. This data set will be used to determine the geostatistical properties needed for stochastic simulation of the reservoir facies and flow barriers within the facies. Two primary scales of flow compartmentalization have been found. One scale is the variation of the grouped units over scales of 0.5-2 kilometers. This scale of variation will be simulated first using frequency-domain conditional simulation. The second scale of heterogeneity involves compartmentalization of individual sandstones by clay barriers which occur on the scale of 0.5-2 meters. This variation will be simulated after the larger scale heterogeneity using three dimensional techniques. Porosity and permeability of the facies and barriers will also be measured and stochastically simulated. These

stochastically simulated properties will then be used as input for a finite-element reservoir flow model.

Mr. Faucette already made a site visit to British Petroleum's research group in Anchorage, Alaska. The applicability of this model to the Prudhoe Bay field was discussed, since BP is planning a water flood of that field. It was determined that the Prudhoe Bay sandstone was deposited by different geologic processes and therefore while the technique could be applied the data was not applicable. Another site visit may still occur as the research progresses.

Another Geology student, Ms. **Beverly Burns**, is studying the relationships (if any) between changes in relative sea level and the deposition of nonmarine sediments. Cyclic changes in relative sea level or base level may punctuate the geologic record with distinctive stratigraphic signatures. Learning to identify these stratigraphic responses will enable us to better predict the stratigraphic distribution of sediments in subsurface basins. Predictive stratigraphy is an extremely powerful tool in both petroleum and mineral exploration.

Ms. Burns plans to visit the Los Alamos National Laboratory in New Mexico in July, 1992. Since her dissertation involves the sedimentary development of fluvial reservoirs in response to sea-level changes, this is the appropriate DOE facility for investigation of mutual research interests. Her advisor, Dr. Paul Heller, plans to accompanying Beverly for a part of her visit where they will spend time with Dr. Scott Baldridge and Dr. Chuck Harrington. Field trips to the Rio Grande Rift alluvial systems may also be included. The visit to Los Alamos Labs is intended to develop collaborative projects.

The third Geology student, Ms. **Debi Maucione**, is doing research on the delineation of abnormally pressured compartments using surface seismic methods. This work is applicable to reservoirs in the Powder River Basin of eastern Wyoming

and will use seismic data preliminary to well drilling. A velocity study of this area using sonic logs has already been completed. Current efforts center on techniques for processing surface seismic data. This work is being done with Dr. Scott Smithson, and due to his absence from campus at this time, specific plans have not been made for a DOE site visit. This will be done in cooperation with Dr. Smithson in the near future.

Mathematics

Mr. **John Spitler** is working with Dr. Ewing in the Mathematics Department on modeling techniques important in seismic prospecting. Forward solving routines for two and three dimensional finite difference models have been developed in recent years. Linearized versions of these equations have been implemented and work well away from the sources and interfaces. The focus of this research work is the development and analysis of schemes that include the nonlinear terms at the sources and interfaces. A second part of the work will be full three dimensional implementation of the model, a problem that is machine size dependent but is increasingly practical as computer technology advances.

Arrangements have been made for Mr. Spitler to visit the Oak Ridge National Lab in May. He will meet with Dr. Robert Ward, Director of the Oak Ridge Lab, to discuss the possibility of incorporating the techniques used for handling nonlinearities that are being developed at Oak Ridge into his research work. The Oak Ridge work in modeling of contaminate flow in both porous media and the atmosphere have potential application in the seismic code being written by Mr. Spitler and others at the University of Wyoming. There are also overlapping interests in grid refinement projects at both laboratories.

The second mathematics student, Mr. **Robert Simon**, is working on methods for visualization of large quantities of oil and gas well data. He has been working with the extraction of pressure and geologic formation data from large databases purchases from Petroleum Information Corporation in Denver, Colorado. The oil and gas well databases encompass the Powder River Basis of Wyoming and Montana (over 15,000 wells), the Green River Basin of Wyoming (over 4,000 wells), and the Washakie Basin of Wyoming and Colorado (over 4,000 wells).

Robert has analyzed various contouring algorithms to construct geologic formation specific maps of these areas which display such parameters as pressure from oil and gas well drill stem tests, potentiometric surface, structure contour and ground elevation. He has also constructed X-Y plots of the same data showing the functional relationship between measured pressures and depth, and between temperature and depth. Mr. Simon's work in visualization of oil field data is of particular interest to scientists at Western Research Institute in Laramie, particularly Mr. Fran Micknis. Consequently, plans for the summer internship currently center around projects at WRI, although there is also a possibility the Mr. Simon will visit other DOE laboratories as well.

Mechanical Engineering

Mechanical Engineering was also successful in recruiting a new female graduate student with the DOE Traineeship. Ms. **Susanna Barney's** research work involves studying the dynamics of sucker rod driven pumping systems. This is a major part of a project aimed at designing an improved sucker rod using composite materials. Since such materials exhibit strength/weight ratios far superior to the steel now used for sucker rods, they offer the potential for substantial efficiency improvement and concomitant energy savings.

While the prospect of a composite sucker rod system is very attractive, several technical problems will have to be resolved. In addition to the obvious design task associated with obtaining appropriate mechanical strength properties in the composite rod, dynamic characteristics and manufacturing issues must be considered. Ms. Barney is developing the necessary understanding of the dynamics of the complete system so that this can be included in the design considerations. Other faculty and graduate students are working on the associated manufacturing systems and composite materials problems.

The DOE facility that is currently doing research in this area is the Bartlesville Project Office. Initial contacts with Ms. Nancy Comstock at BPO have resulted in plans for Ms. Barney to spend some time this summer working in Bartlesville. The interaction is expected to be very beneficial for both groups.

Petroleum Engineering

Mr. **Bernard Indart** is a student in Petroleum Engineering who was selected for one of the DOE-EPSCoR Traineeships. His research is associated with the North Tisdale Mine, which is currently producing oil from a series of horizontal wells drilled from a mine adit dug into the side of the anticline. The only production mechanism is by gravity drainage. Bernard is mapping the reservoir and has conducted a screening for various enhanced oil recovery techniques. As a result of his investigation, the array of possibilities has been reduced to water flooding and steam flooding. Following the recommendations from this research, water flooding has commenced in the field. Mr. Indart will now attempt to model these selected processes to match the production history and forecast the potential increase in oil flow rates as well as total oil recovery.

Mr. Indart is already very involved in field studies, so specific plans for any DOE site activities have not been formulated. Mr. Indart plans to work with scientists at the Bartlesville Project Office to broaden his appreciation of reservoir characterization methods. Initial contacts have been made to arrange for the visit to Bartlesville.

Statistics

One of the students supported by the DOE Traineeships is Mr. **Ying Yan**, a student in the Department of Statistics. Ms. Yan is working on a correlation model for the spatial characteristics of the storm/wave dominated shallow marine environment in the Rock Springs sandstone formation. She has collected data from the field and is now using that data to construct the model. Estimates will be made of the thickness of certain sandstone bodies in areas for which no data was obtained. The model uses a new method based on a finite element approach. A FORTRAN-77 computer program for the simulation is nearing completion.

Ms. Yan's site visit was made to the British Petroleum research lab in Anchorage, Alaska in March. BP is interested in these modeling methods for possible use in planning the water flooding strategy of the Prudhoe Bay field. She made a presentation about her correlation model at BP research, as well as studying their core samples. The possible use of SAS as a tool for this modeling was also discussed. The activity was successful in both providing guidance for Ms. Yan's research as well as giving BP some new modeling methods that they can investigate.

Environmental Biology

Mr. **John Baldwin** is one of the Environmental Biology students supported on DOE-EPSCoR Traineeships. He is working to characterize and quantify the

dependence of dabbling ducks on intertidal areas threatened by oil spills. His field work is being done in northwest Washington where major terminals at Cherry Point and Port Angeles receive heavy tanker traffic from Valdez, Alaska. There have been recent and important oil spills on the Washington coast, notably the Nestucca spill in 1988 and a spill in Fidalgo Bay in spring 1991.

John's work is the first to describe waterbird use of eelgrass foliage and invertebrates in intertidal areas threatened by such spills. He has found that many of the birds share their prey base with commercially important fish using these habitats as nursery areas, notably English sole, starry flounder, Pacific herring, dungeness crabs, and salmon smolts. The data from this study will be valuable in setting standards for restoration and mitigation in the likely event of an oil spill in this area. Mr. Baldwin is providing information to U.S., state, Canadian and provincial governments as they formulate international plans and regulations for oil tanker traffic.

The DOE Traineeship has greatly increased the depth and extent of Mr. Baldwin's research. He should complete his degree by the end of summer, 1992. John has organized a field trip to Battelle Pacific-Northwest Lab in Sequim, Washington. His research is similar to that of Mr. Ron Thom at Battelle and the two will collaborate and compare results. John considers this a great opportunity and looks forward to the experience as well as the chance to see the BNW Laboratory facilities. He will make the visit in April, 1992.

A second Environmental Biology student, Ms. **Aida Farag**, is studying the biochemical and physiological responses of rainbow trout following an exposure to metals via the food chain. This work involves the experimental assessment of effects of metals on fish, as opposed to more traditional methods of studying population statistics or ambient concentrations of toxic chemicals in water and sediment from the field. The drawbacks of the traditional methods are well documented, and this study

will provide a valuable additional dimension to our knowledge of these toxic effects.

The research is investigating the mechanisms of toxicity of Cd, Cu, Pb and Zn transferred through the food chain to fish. Six biochemical and physiological responses which may explain metal toxicity are being considered. These include autopsy assessments, tissue metal concentrations, ionoregulatory failure, histology, stress protein induction and lipid peroxidation. The experimental procedure uses 4-month-old and 11-month-old rainbow trout exposed to three dietary treatments (one containing elevated amounts of metals) and two water treatments (one containing elevated amounts of metals). The data will be studied for correlation with survival, length, weight and autopsy information at the conclusion of the experiment.

Ms. Farag has made plans for a visit to the Oak Ridge National Laboratory in Tennessee. She will made that visit this summer and intends to make presentation of her research as well as discuss further collaborative efforts with DOE scientists.

SUMMARY

The brief descriptions of individual research projects demonstrate the wide scope of energy-related research that the DOE-EPSCoR Traineeships have initiated in Wyoming. The availability of this funding has encouraged many talented students to continue their education in fields of interest to DOE. There are additional "synergistic" benefits from this program in Wyoming. One is that our graduate classes are typically quite small, and the additional bright, energetic graduate students improve the educational atmosphere for everyone. Another is that the visibility of the DOE program has sharpened the focus of the science and engineering departments on the energy-related research of importance to Wyoming and DOE.

The competitive process used to select DOE Trainees worked well and it is our

intent, if renewal funding is obtained, to repeat it. A general announcement of the program will go to all faculty and will request brief proposals detailing the research project and the qualifications of prospective graduate students. Faculty are particularly encouraged to identify undergraduate students at UW and other institutions who are highly qualified and could be encouraged to pursue graduate study through use of this funding. Underrepresented minorities are given preference in the final awards, and since this is known to the faculty, they make particular efforts at recruiting such students.

Now that the Wyoming DOE-EPSCoR Committee has been formed, it will be the committee that will make the final selection of Trainees from the proposals submitted. This differs from the process used in the first year, when a committee composed of the Project Director and two Deans made the selections. The pressure of making selections in time for the students to make plans for graduate school dictated using the Deans last year. However, having the Committee make selections will give a broader base to the selection process as well as increasing the involvement of the state government and industry representatives on the state committee.

The original proposal indicated that any increases in tuition and fees for graduate students would be absorbed by the University. The projected increases for the next two years will make these costs go from $4826 this year to $5260 next year and to $6000 in the second year of this proposal. As promised, UW will make up this difference an consider it as a contribution to the DOE-EPSCoR Traineeship program.

Finally, all of the DOE-EPSCoR program is being coordinated with a university-wide effort to develop undergraduate curricula, graduate programs and a research center in a broad program called Environment and Natural Resources. A major committee was appointed by the Provost several months ago to develop plans for these programs. The committee is to provide a report including implementation

alternatives for the Provost this spring. The Chair of the Wyoming DOE-EPSCoR Committee, Dr. Hodgson, also chairs the University committee charged by the Provost with developing these programs. The Project Director, Dr. John Steadman, is also a member of that committee.

The impact of the DOE Traineeships in Wyoming has been substantial and very positive. It has not only increased the number of students studying in energy-related disciplines but also increased the quality of their graduate research. The program has also increased the visibility of DOE in Wyoming and has helped us focus our attention on the energy and environmental graduate education which is so essential to our University and our State.

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