NETL - Penn State

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University Coalition for Fossil Energy Research

2017 NETL Project Review Meeting

University Coalition for Fossil Energy Research

Chunshan Song*

Director of NETL UCFER, Director of EMS Energy Institute

The Pennsylvania State University
C211 CUL, University Park, PA 16802

*E-mail: csong@psu.edu

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Project Goals and Objectives

➢ **Goals:**   To advance the basic and applied energy research and to promote university - NETL collaboration for more efficient and more environmentally friendly utilization of coal, natural gas, and oil in the areas of NETL core competencies.

➢ **Objectives:**   UCFER will identify, select, execute, review and disseminate knowledge from university-based research that will improve the efficiency of production and use of fossil energy resources while minimizing the environmental impacts and reducing greenhouse gas emissions including carbon capture, storage and utilization.

Presentation Outline

- UCFER Organization
- Advisory Committees
  - Technical Advisory Council (TAC)
  - Executive Council (EC)
  - Core Competency Advisory Board (CCAB)
  - Industrial Advisory Board (UAB)
- Management Team
- Tasks
- Budget Overview/Solicitations
- Meetings
- Future Direction

No Silver Bullet in Future Energy?

**Fossil Energy
Coal/Oil/Gas/Shale/Tar
Sands/Hydrates**

**Renewable Energy
Solar/Wind/Biomass/Hydr
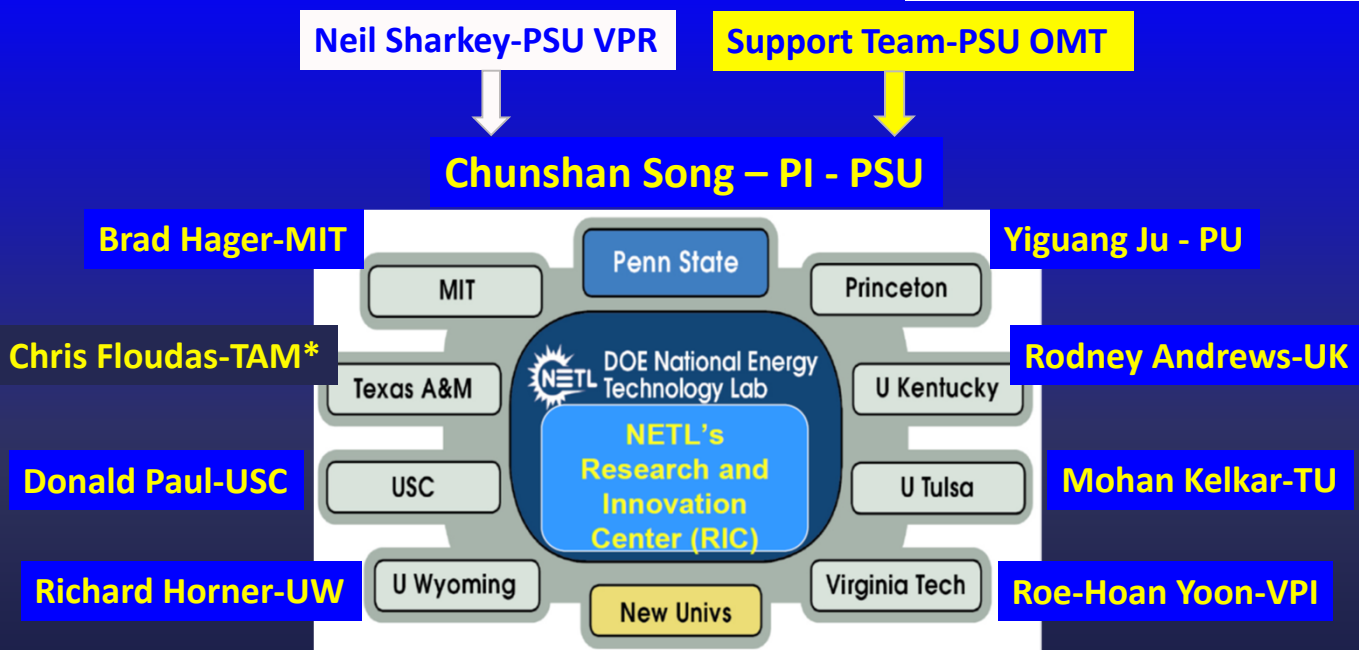o/Geothermal**

Picture source: Mark Jaccard, 2005

Picture Source: Dale Simbeck, SFA Pacific, USA, 2004

A Vision of Clean Carbon Energy

Clean carbon-based secure, reliable and affordable energy future with the more environmentally-friendly and more efficient production and use of fossil fuels including carbon (CO_2) capture, storage and use/re-use.

Fossil energy R&D will pave the way for the clean carbon-based sustainable energy technologies while mitigating climate change due to GHG.

UCFER Founding Univ Team in 2015

Neil Sharkey-PSU VPR

Support Team-PSU OMT

Chunshan Song – PI - PSU

Brad Hager-MIT

Penn State

Yiguang Ju - PU

MIT

Princeton

Chris Floudas-TAM*

DOE National Energy Technology Lab

Texas A&M

U Kentucky

Rodney Andrews-UK

NETL's Research and Innovation Center (RIC)

Donald Paul-USC

USC

U Tulsa

Mohan Kelkar-TU

Richard Horner-UW

U Wyoming

Virginia Tech

**Roe-Hoan Yoon-VPI**

New Univs

* Dr. Floudas passed away on August 14, 2016 in Greece.

Organization of UCFER

- Member universities (**9 univs** in 2015-2016; **16** univs in 2017) and NETL; Technical Advisory Council Reps from member universities (1 each), Executive Council, Project Officer (Sydni Credle) and Technical Director (Madhava Syamlal) from NETL, and UCFER Director (Chunshan Song).
- Core Competency Advisory Board (CCAB); Industrial Advisory Board (IAB); Operations Management Team (OMT) at PSU.
- By-laws as guiding principle of UCFER, reviewed by all member universities and NETL, approved by DOE and become binding agreement among the member universities and NETL.

UCFER Organization Chart as of Mar 17
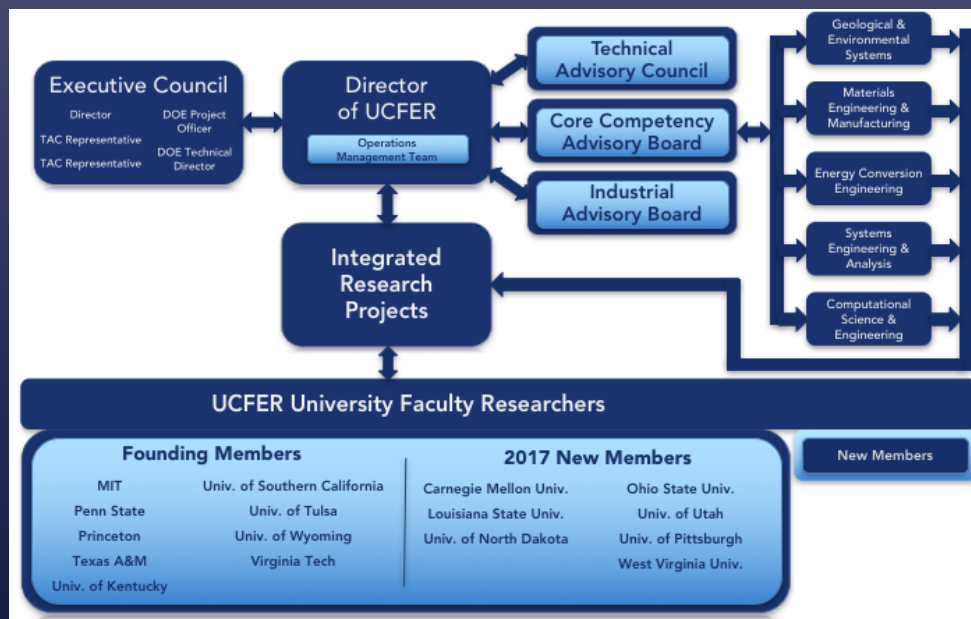
UCFER Inauguration-May 2016

- Inaugural Meeting at Penn State, May 19, 2016. NETL Leaders and Program Officers (Drs. Grace Bochenek, Cindy Powell, Heather Quedenfeld, Paul Detwiler, Denise Riggi, Madhava Syamlal, Sydni S. Credle), Reps from Member Univs, Penn State leaders and faculty members participated.
- Many teleconferences plus emails between Penn State and NETL team on UCFER.
- Many TAC meetings via teleconferencing and group emails periodically with UCFER members.
- Before and after RFP-01 TAC and EC Review Meetings

Technical Advisory Council (TAC)

Consisting of one representative from each member university, the Director, and DOE representatives appointed by NETL

TAC proposes and discusses ideas for the UCFER and connects UCFER to researchers in member universities.

TAC members will participate in the peer review of proposals in the areas of their expertise, except when there is a conflict of interest. They are excluded for reviewing proposals submitted from their own univs; for proposals to a given topic when they submitted or participated in a proposal to that topic.

TAC discusses the results of proposal peer review by experts (anonymous to TAC) and provides recommendations to the Executive Council, and in developing and implementing technology transfer plans.

Technical Advisory Council (TAC) Members

Organizations	TAC Rep	Close to NETL CC Areas
MIT	Dr. Bradford H. Hager	Geological & Environmental Systems
Penn State	Dr. Chunshan Song	Energy Conversion Engineering
Princeton	Dr. Yiguang Ju	Energy Conversion Engineering
Texas A&M	Dr. Stratos Pistikopoulos	Systems Engineering & Analysis
University of Kentucky	Dr. Rodney Andrews	Materials Engineering & Manufacturing
University of Southern California	Dr. Kristian Jessen	Geological & Environmental Systems
University of Tulsa	Dr. Mohan Kelkar	Geological & Environmental Systems
University of Wyoming	Dr. Richard A. Horner	Energy Conversion Engineering
Virginia Tech	Dr. Roe-Hoan Yoon	Materials Engineering & Manufacturing
NETL, DOE	Dr. Madhava Syamlal	Computational Science & Engineering
NETL, DOE	Dr. Sydni Credle	Materials Engineering & Manufacturing

TAC 2017 New Members – 3/20/2017

Universities	TAC Rep	Close to NETL CC Areas
Carnegie Mellon University	Dr. Andrew Gellman	Materials Engineering & Manufacturing
Louisiana State University	Dr. James Spivey	Energy Conversion Engineering
Ohio State University	Dr. Kate Bartter?	
University of North Dakota	Dr. Michael Mann	Energy Conversion Engineering
University of Pittsburgh	Dr. Götz Veser	Energy Conversion Engineering
University of Utah	Dr. Arnis Judzis	Materials Engineering & Manufacturing
West Virginia University	Dr. Brian Anderson?	

Executive Council (EC)

- A DOE Project Officer appointed by NETL (**Dr. Sydni Credle**);
- A DOE Technical Director appointed by NETL (**Dr. Madhava Syamlal**);
- UCFER Director (**Dr. Chunshan Song**), who shall preside over the Council; and
- Two representatives from the Technical Advisory Council (TAC) elected annually – current representatives are **Drs. Roe-Hoan Yoon (VPI)** and **Mohan Kelkar (TU)**.

The EC shall establish an overall research and development plan for the UCFER; issue requests for proposals in research areas identified by DOE; establish review procedures for research proposals; and make selection recommendations to DOE regarding such proposals based on technical merit and alignment with the goals and objectives of the UCFER as set forth in the Statement of Project Objectives.

Core Competence Advisory Board (CCAB)

- CCAB shall consist of representatives from the UCFER members and NETL with expertise in the five core competencies that are the focus of the Coalition's collaborative research on coal, natural gas, and oil.
- CCAB will participate in the peer review of proposals in the areas of their expertise, except when there is a conflict, and advise the UCFER Director and principal investigators on projects selected for awards.
- CCAB shall participate in Coalition meetings, and make recommendations to the Director as to future research related to the core competency areas.
- CCAB shall host technical webinars as a means to update Coalition members on the current status of core competency areas, and CCAB shall analyze the R&D portfolio of active projects conducted by the Coalition and communicate deficiencies or opportunities to reinforce collaboration among Coalition members and NETL.

CCAB Founding Univ Members

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University	CCAB Rep	CC Areas
MIT	Dr. Ruben Juanes	Geological & Environmental Systems
Penn State	Dr. Adri van Duin	Computational Science & Engineering
Princeton	Dr. Eric D. Larson	Systems Engineering & Analysis
Texas A&M	Dr. Akhil Datta-Gupta	Computational Science & Engineering
University of Kentucky	Dr. Rick Honaker	Materials Engineering & Manufacturing
University of Southern California	Dr. Theo Tsotsis	Energy Conversion Engineering
University of Tulsa	Dr. Cem Sarica	Geological & Environmental Systems
University of Wyoming	Dr. Paul A. Dellenback	Energy Conversion Engineering
Virginia Tech	Dr. Srinath Ekkad	Energy Conversion Engineering

CCAB 2017 New Univ Members – 3/20/2017

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University Coalition for Fossil Energy Research

University	CCAB Rep	CC Areas
Carnegie Mellon University	Dr. Jay F. Whitacre	Materials Science and Engineering
Louisiana State University	Dr. Konstantin 'Gus' Kousoulas	Energy Conversion Engineering
Ohio State University	TBD	
University of North Dakota	Dr. James A. Sorensen	Geological & Environmental Systems
University of Pittsburgh	Dr. J. Karl Johnson	Computational Science & Engineering
University of Utah	Dr. Raymond Levey	Geological & Environmental Systems
West Virginia University	TBD	

Industrial Advisory Board (IAB)

- UCFER will recruit industry representatives to the IAB, who will participate in the UCFER's Annual Review Meeting, interim reviews, and other activities of the UCFER.
- IAB will provide advice to the Director of the UCFER on strategies and areas of research on coal, natural gas, and oil and energy industries.
- The IAB will seek to identify opportunities for industry to collaborate with universities in the UCFER's research areas.
- The IAB will provide advice and guidance on the industrial relevance of research projects and the outreach and technology transfer to industry.

UCFER Operations Management Team at PSU

- **Jennifer Lear**, Director of Grants and Contracts, College of Earth and Mineral Sciences
- **Bruce Miller**, Manager of OMT for UCFER, Associate Director of EMS Energy Institute
- **Joel Morrison**, Coordinator for UCFER OMT, Director of Sustainable Energy Program, EMS Energy Institute
- **Elizabeth Wood**, Website Manager and Graphic Designer for UCFER OMT, EMS Energy Institute
- **Kelly Rhoades**, Budget and Administrative Coordinator for UCFER OMT, EMS Energy Institute

UCFER Tasks

- Task 1.0 - Project Management and Planning

PHASE 1 –COALITION ADMINISTRATIVE PLANNING:

- Task 2.0 – Organization
  - completed by-laws and organizational structure
- Task 3.0 – Operation Plan
  - submitted to and approved by NETL
- Task 4.0 – Membership Plan
  - submitted to and approved by NETL

UCFER Budget Overview

- **DOE Award** with **$20 M DOE funds for 6 yrs**; Final (modified) contract (DE-FE0026825_0003) completed 4/8/2016
- **$4.865 M Authorized by DOE in Total Yr. 1**
- 1st RFP: 4 Topics with $1.925 M, released 4/22/2016
  - ❖ **Carbon Use and Reuse ($814,000)**
  - ❖ **Carbon Storage ($814,000)**
  - ❖ **Rare Earth Elements from Coal ($163,000)**
  - ❖ **Crosscutting Research & Analysis ($134,000)**
- 2nd RFP: 3 Topics with $2.08 M, released 7/22/2016
  - ❖ **Carbon Capture ($814,000)**
  - ❖ **Advanced Combustion ($859,000)**
  - ❖ **Oil & Gas – Natural Gas Infrastructure ($407,000)**

UCFER Tasks (cont.)

PHASE 2 –EXECUTION:

- Task 5.0 – Solicitation
  - Subtask 5.1 Solicit Research
    - RFP 2016-01 with 4 research topics (Carbon Use and Reuse, Carbon Sequestration, Rare Earth Elements, Crosscutting Research Analysis) released on 4/22/2016, with proposal due date 6/17/2016
    - RFP 2016-02 with 3 research topics (Carbon Capture, Oil and Gas, and Advanced Combustion) released on 7/22/2016, with proposal due date 9/16/2016
  - Subtask 5.2 Technical Evaluation of Proposals
    - Conflict of Interest Policy set after review and discussion by TAC and approval by NETL on 3/16/2016
    - RFP 2016-01 evaluation by peer reviewers and by TAC completed 8/10/2016
    - RFP 2016-02 evaluation by peer reviewers and by TAC completed 1/11/2017

UCFER Tasks (for RFP-01)

- Task 5.0 – Solicitation cont.
  - **Subtask 5.3 Selection Recommendation**
    - RFP 2016-01 recommendation by EC completed 8/16/2016, NETL review and approval 9/13/2016

  - **Subtask 5.4 Award Projects**
    - RFP 2016-01 award selection notices sent 9/27/2016; award contract processing began 10/3/2016; projects start date 10/1/2016; 4 of 6 contracts completed in Jan 2017; 2 of the 6 contracts finalized as of 3/20/2017.

UCFER RFP 2016-01 Projects

Area	PI	Title
Carbon Use & Reuse	Dr. Bruce E. Koel **Princeton Univ**	Converting CO_2 and Methane to Fuels by Enhanced Plasmonic Effects in a Nanotemplated Catalyst Plasma Reactor
Carbon Use & Reuse	Dr. Michael A. Hickner **Penn State Univ**	Efficient Reduction of CO_2 in a Bipolar Electrochemical Cell
Carbon Storage	Dr. Shunde Yin **Univ Wyoming**	A Low-cost Technique for In-situ Stresses and Geomechanical Properties Measurement Based on Leak-off Tests and Caliper Logs
Carbon Storage	Dr. Behnam Jafarpour **Univ Southern Ca**	A Novel Point Process Filtering Paradigm for Modeling and Inversion of Microseismic Monitoring Data During CO_2 Storage
Carbon Storage	Dr. Fred Aminzadeh **Univ Southern Ca**	Integration of Geophysical and Geomechanical Modeling to Monitor Integrity of Carbon Storage
Crosscutting Research & Analysis	Dr. Ahmed F. Ghoniem **MIT**	Grid Independence and Uncertainty Quantification in Gas-Solid Flow Simulations

UCFER Tasks (for RFP-02)

- **Task 5.0 – Solicitation cont.**
  - **Subtask 5.3 Selection Recommendation**
    - RFP 2016-02 EC Selection Recommendation completed 1/18/2017 following the TAC Panel Review completed 1/11/2017; submitted to NETL for review and approval 1/22/2017

  - **Subtask 5.4 Award Projects**
    - RFP 2016-02 award selection pending with NETL's review and approval; Final NETL decision notice anticipated by 3/31/2017; this will be followed by award notices and then contract processing with projects start date thereafter.

UCFER Tasks 6 ~ 7

- Task 6.0 – Research Projects
  - Projects based on selected proposals conducted at member universities
- Task 7.0 – Manage Coalition Projects
  - Subtask 7.1 Monitor Projects
    - Technical reports, schedule, budget
  - Subtask 7.2 Review Projects
    - Conduct Technical Review Meetings of funded projects including TAC, IAB, and CCAB.
  - Subtask 7.3 Disseminate Knowledge from Research Projects
    - Newsletter, website, publications, and webinars
  - Subtask 7.4 Development of Online System for Coalition Research Portfolio Management
    - Website including both public access and controlled access
    - Web portal for proposal submission and projects management

UCFER Introduction at UK CCS Conf 2016 in Edinburgh, and at 5th US-China CO2 Conf in Hangzhou, 2016

第五届中美CO₂排放控制技术研讨会
5th U.S.-China Symposium on CO₂ Emission Control Science & Technology

UCFER Meetings in 2017

- Many teleconferences and emails between Penn State and NETL team on UCFER.
- Many TAC meetings via teleconferencing and group emails periodically with UCFER members.
- TAC review meeting for RFP 2016-02 on January 11, 2017
- EC selection meeting for RFP 2016-02 on January 18, 2017
- New UCFER member meeting via teleconferencing March 6, 2017
- 2017 NETL Crosscutting Research Project Review March 20-23, 2017
- 1st TAC-CCAB meeting onsite NETL-Pittsburgh/Morgantown May 16-17, 2017
- TAC and CCAB meetings associated with RFP-03 after NETL onsite meeting
- Invited plenary lecture (C. Song) at 15th ICCDU, July 2017 (paid by conf host)
- Invited keynote (C. Song) at 9th Sino-US Chem Eng Conf Oct 2017 (paid by host)

Future Directions for UCFER

- ➢ New approaches in basic and applied research for cleaner and more efficient production, conversion and utilization of fossil energy (coal, oil, gas) including related areas such as CCUS, (co)gasification, advanced combustion, rare earth elements, advanced materials, unconventional resources, and crosscutting research, etc.

- ➢ R&D complimentary to NETL in CC areas incl. comput. sci and eng, energy conversion eng, geological and environ systems, materials eng and manufacturing, and systems analysis and eng.

- ➢ Facilitate collaborative research between existing and new member universities with NETL; facilitate outreach and tech transfer to industry.

- ➢ Propose to designate a small part of funds in DOE NETL's specific research areas/sub-areas, but keep the RFP description more open in terms of ideas and approaches towards desired outcomes, if possible, in order to identify and develop novel or high-risk high pay-off ideas.

Acknowledgments

- DOE NETL Director **Dr. Grace Bochenek**, other NETL leaders, NETL's UCFER management team including **Drs. Sydni Credle**, **Madhava Syamlal**, **Amanda Lopez**, and **Lisa A. Kuzniar**.

- TAC Reps, Faculty participants, CCAB Reps, IAB members, and Leaders of the 9 founding members and 7 new member universities.

- Penn State VPR Neil Sharkey, EMS Dean Bill Easterling, PSIEE Director Tom Richard, EMS ADGER John Hellmann, Tim Stodart of OSP, and Ron Huss of OTM.

- Operations Management Team at PSU includes Jennifer Lear, Bruce Miller, Joel Morrison, Elizabeth Wood, and Kelly Rhoades.

Questions?

General Info: http://www.energy.psu.edu/ucfer/

The UCFER Website contains both public and member-only info

Contact: Chunshan Song, ucfer-director@ems.psu.edu

Tel: 814-863-4466

Appendix:

UCFER Selects Six Projects for Funding from RFP-01 – Proj 1

Converting CO_2 and Methane to Fuels by Enhanced Plasmonic Effects in a Nanotemplated Catalyst Plasma Project Reactor - *(Princeton University, 18-month project, $199,631)*

Rising atmospheric concentration of CO2 is forecasted to have potentially disastrous effects on the climate from its role in global warming and ocean acidification. To alleviate atmospheric CO2 levels, significant cuts in emissions and active removal of CO2 from the atmosphere are necessary. Princeton will develop a novel nanodischarge reactor with enhanced plasmonic effects from a nanotemplated catalyst structure to achieve highly efficient plasma-enhanced low temperature conversion of CO2 and methane (from natural gas) to chemicals or fuels. Primary objectives are to: 1) demonstrate low temperature operation of a novel nanoplasma catalysis reactor to enable a large volume and uniform discharge, 2) understand and optimize the energy transfer and kinetic interactions between the plasma and catalyst, and 3) increase the selectivity for coupling reactions. The research is being led by Dr. Bruce Koel at Princeton University.

UCFER Selects Six Projects for Funding - 2

Efficient Reduction of CO_2 in a Bipolar Electrochemical Cell - *(Penn State University, 18 –month project, $200,000)*

An electrochemical CO2 reduction cell using a unique bipolar membrane and novel catalysts will be employed to produce scalable, efficient conversion of CO2 to syngas. The bipolar membrane electrochemical reduction of CO2 to carbon monoxide and hydrogen is meant to circumvent limitations in purely acidic or basic electrochemical systems. This novel concept will be validated at NETL in terms of products produced and efficiency calculations at both Penn State and NETL will ultimately allow this new process to be compared to conventional CO2 conversion technologies and other emerging electrochemical reduction work. The developed membrane and catalyst materials will be integrated into a membrane electrode assembly and tested for the current density and product distribution. This early-stage product will produce the data necessary to assess electrochemical processes for their potential as CO2 conversion devices. Electrochemical devices are scalable and continuing to push into emerging markets, such as industrial hydrogen generation. This project will assess the economic case of electrochemical CO2 conversion using a novel bipolar electrochemical cell that incorporates inexpensive materials. Dr. Michael A. Hickner will serve as Principal Investigator for Penn State.

UCFER Selects Six Projects for Funding - 3

A Low-Cost Technique for In-Situ Stresses and Geomechanical Properties Measurement Based on Leak-Off Tests and Caliper Logs – (University of Wyoming, 18-month project, $325,600)

Knowledge of state of in-situ stress and geomechanical properties is essential to understand the potential wellbore instability and induced fracturing in the injection zone and confining zone as a result of CO2 injection in a carbon storage site. Traditional in-situ measurement of stress field is at high cost, and traditional laboratory measurement of geomechanical properties affected by the disturbed core samples. It's therefore desirable to develop a method that can keep the measurement "in-situ" while in the meantime reducing the cost and enhancing the accuracy. The objectives of this project are to: Develop an in-situ technique for state of in-situ stress and geomechanical properties measurement at low cost and with enhanced accuracy, and to demonstrate the feasibility of such a technique for in-situ stress measurement by comparing with different field data from oil fields. The project is being led by Dr. Shunde Yin at the University of Wyoming.

UCFER Selects Six Projects for Funding – 4

A Novel Point Process Filtering Paradigm for Modeling and Inversion of Microseismic Monitoring Data During CO_2 Storage - *(University of Southern California, 18-month project, $244,300.00)*

This project will develop a novel geomechanically-driven point process modeling approach for accurate representation and inversion of microseismic monitoring data, as a key monitoring technology, during bulk CO2 injection into geologic formations. Accurate representation of the distribution and attributes of discrete microseismic monitoring events is critical for characterization of rock flow and mechanical properties. These properties determine the changes in the subsurface stress and strain distributions due to CO2 injection. The proposed method establishes physical correlations among rock mechanical properties and discrete microseismic events, a fundamental requirement for formulating and solving inverse problems to estimate rock physical properties from observed microseismic monitoring data. Point process modeling techniques are discrete stochastic methods that are suitable for describing binary random processes (such as microseismic events) and their associated uncertainty with very high accuracy and resolution. While point processes represent discrete observations, which are challenging to incorporate into inverse problems, their underlying parameters are continuous and more amenable estimation with well-established inverse formulations. The proposed point process model constitutes a measurement operator for coupled flow and geomechanic state-space models. This observation model, in turn, enables the development of theoretically rigorous filtering methods to infer rock mechanical properties from discrete microseismic data. Dr. Behnam Jafarpour will serve as Principal Investigator for USC.

UCFER Selects Six Projects for Funding - 5

Integration of Geophysical and Geomechanical Modeling to Monitor Integrity of Carbon Storage - *(University of Southern California, 12-month project, $244,100).*

The geological storage of CO_2 in saline aquifers is considered to be an important technology to address greenhouse gas emissions in the short-term. The safe, long-lasting storage of CO_2 requires a combination of structural trap with intact integrity, and a suitable monitoring system to image the movement of the injected CO_2 and determine any potential breach or leakage points. The focus of the research is the use of different types of geophysical data (seismic and EM) with different resolutions for CO_2 monitoring. The work will involve rock physics and geotechnical based modeling to conduct sensitivity analyses to determine the feasibility of seismic monitoring under different geologic settings. Proposed techniques are intermediate scale (1-100's m) geophysical surveys providing information in between the large scale of surface seismic (km's) and the smaller scale of well logs and core measurements (mm to m). The time-lapse seismic signature extracted from cross-well, VSP, Seismic, and EM, in certain geological settings, can be extremely useful for the monitoring of CO_2 injection and storage. The core objective of the project is to conduct research to develop appropriate techniques for an effective, low-cost, and geohazard risk free CO_2 capture, storage and monitoring. The work will complement several current projects within the USC Reservoir Monitoring Consortium (RMC). The size and the stand-alone nature of this project is comparable to some other initiatives that are either in the planning stage or ongoing. Collaboration with the NETL will provide the opportunity for an exchange of data and ideas with the industry partners of RMC. The project will be led by Dr. Fred Aminzadeh at USC.

UCFER Selects Six Projects for Funding - 6

Grid Independence and Uncertainty Quantification in Gas-Solid Flow Simulations - *(*Massachusetts Institute of Technology, *12-month project*, $134,000).

Grid independence studies for modeling gas-solid flows are challenging because of the particularly prohibitive computational cost of high-resolution simulations. The proposed work, will employ large-scale 3D simulations (periodic and/or large reactor sizes) for a systematically sampled range of operating conditions (particle properties, solids concentration, gas velocity) and domain sizes, determined using statistical methods developed at NETL and in-house. Grid independence will be realized based on the convergence of cluster dynamics with decreasing grid size, in addition to global metrics such as the pressure drop and/or bed height. Subsequently, using the response surface for the corresponding grid resolution and cluster statistics generated from these sampled cases, a robust criterion for grid independence will be proposed and its sensitivity to operating conditions will be evaluated. The project will provide essential guidelines for high-fidelity simulations for the conversion of fossil energy and other chemical processes using fluidized beds. The project will be directed by Dr. Ahmed Goniem at MIT.