Center for Advanced Energy Studies (CAES)
Overview of Activities and Opportunities, Fall 2022

Presented by
Dave Rodgers, ISU Associate Director

Guests:
Phil Reppert, Director
Dave Estrada, BSU Associate Director
John Russell, UI Associate Director

Idaho State University (Pocatello) acknowledges that it is located within the boundaries of the original Fort Hall Reservation on the traditional lands of the Shoshone and Bannock peoples.
What is CAES?

A Consortium of four institutions: INL, BSU, ISU, UI

A Vision of collaborative research/education/innovation in energy fields

A Strategic Plan that is evolving but in recent years has focused on seven energy-related themes:

A Building with access to offices and well-equipped laboratories

A Budget with discretionary funds to support CAES activities
How Can ISU Participate in CAES?

CAES Building (Idaho Falls)
   Six faculty offices plus cubicles for 20+ students

Active Lab Research
   Radiochemistry Lab
   Thermal Hydraulics Lab
   Microscopy and Characterization Suite (MaCS)
   Advanced Manufacturing Lab

Collaborations

INL-supported CAES Activities

ISU-funded CAES Activities
Advanced Reactor Materials Research

- Molten Salt & Molten Sodium
- Structural Materials (Graphite)
- Fuel Materials (Metal, TRISO Compacts)
- Thermal Cycling & Fatigue to Support PWRs
- Advanced Sensors

- All projects either directly funded, or guidance provided, by INL/BEA

Projects include
  - Hands-on experimental work
  - Computational Design studies
  - Data Mining (Historical Efforts)
  - Pre- and Post-Test Analysis (Microscopy, e.g.)
Thermal-Hydraulics Research at CAES

Recent and Active projects:

Scaling study on the heat transfer and fluid flow in FHR pebble bed reactors

Development of highly compact HX technology for non-water advanced reactors (computational & experimental)

Surface wettability and prediction of Critical Heat Flux (CHF) for chrome coated Zirc claddings

Database development for heat pipes in nuclear applications (INL)

Coupled CFD – RELAP5 analysis of in-vessel once-through steam generators
Microscopy and Characterization Suite

- **TEM: FEI Tecnai G² F30 STEM, 300 kV**
  - Analytical Scanning TEM with Field Emission Gun (FEG).
- **New TEM: FEI Spectra STEM, 300 kV**
  - Energy resolution of < 0.2 eV compared to 0.8 eV with older TEM
  - Provides improved spatial resolution at low accelerating voltages, enabling analysis of light elements (Carbon, Nitrogen, and Oxygen for example)
- **LEAP: CAMECA LEAP 4000X HR**
  - 3-dimensional atom probe at near atomic resolution
  - UV laser, energy compensated reflectron, provides excellent mass resolution
- **FIB: FEI Quanta 3D FEG**
  - Dual beam FIB with Field Emission Gun (FEG) (FIB + SEM)
  - Omniprobe/minipulator – for TEM & LEAP samples
  - EDS, EBSD and STEM
- **SEM: JEOL JSM-6610LV**
  - EDS, EBSD and Cathodoluminescence
  - Variable chamber pressures
  - For both inorganic and organic materials

- **Rigaku SmartLab XRD**
  - Focusing and parallel beam geometries
  - Cu-Target, 20-60 kV, 2-60 mA

- **NIAFM: Hysitron TI-950 TribolIndenter**
  - Nanoindenter: nanometer scale indentation
  - Atomic Force Microscope (AFM)
Advanced Manufacturing Lab

- Approximately $1.4M in equipment to support materials development, printed sensors, and structural additive manufacturing for CAES
- Supports existing programs and opens new areas in printed and flexible electronics as well as trusted AI for advanced manufacturing
- Seeds investment in larger AM efforts and infrastructure (R2R, powder feedstock, benchmarking technologies, and custom printers)
CAES – 3D Metal Printer

Open Additive Panda 3D Metal Printer (NSUF)

- Direct Metal Laser Sintering powder bed system
- 6 x 6 x 9 inch build volume
- 1000 W laser
- Custom access door with integrated dual gloves
- Thermal tomography sensor
- 30 gal flammable storage cabinet for powder
- Explosion proof vacuum
- Materials research and technology development
- Stainless steels, Ni-Cr alloy, Ti-Al alloys, Al alloys

Westinghouse

Oak Ridge
• Located in the old ACL, we are installing an electrohydrodynamic inkjet printer, an aerosol jet printer, and suite of instruments to synthesis power feedstocks for ink development and characterization and/or 3D metal printing.

• A dynamic mechanical analyzer, creep tester, dilatometer, and materials microscope can also support analysis of mechanical properties and microstructure in printed materials.
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  Microscopy and Characterization Suite (MaCS)
  Advanced Manufacturing Lab

Collaborations, such as:
  NSF REU award (led by BSU) – from ISU: Dan LaBrier, Mustafa Mashal
  NSF Engines proposal (led by INL) – from ISU: Donna Delparte
  NSF ERC workshop (led by BSU) – from ISU: Marco Schoen, Dan LaBrier, Amir Ali

INL-supported CAES Activities

ISU-funded CAES Activities
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INL-supported CAES Activities
  Summer Visiting Faculty Program
  Collaboration Fund

ISU-funded CAES Activities
CAES Summer Visiting Faculty Program

Fosters collaboration between university faculty and INL researchers
PIs develop a jointly-funded external research proposal
Includes a $10K stipend for university faculty
Applications due in Winter, selections made in Spring
Over 5 years: 50+ university faculty participants including 17 ISU faculty

Summer 2022 ISU faculty:

<table>
<thead>
<tr>
<th>Project</th>
<th>Principal Investigator(s)</th>
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<tbody>
<tr>
<td>Advanced Multiscale Thermal Properties Prediction in MOOSE via a General Boltzmann Solver</td>
<td>Jackson Harter (INL) Minhaz Zibran (ISU)</td>
</tr>
<tr>
<td>Multiphysics Modeling of Hydrogen Deflagration in the Event of a Severe Nuclear Accident</td>
<td>Ahmed Hamed (INL) Rajiv Mahamud (ISU)</td>
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</tbody>
</table>
CAES Collaboration Awards

Goal: to foster relationships between CAES researchers, leading to extramural funding
Awards of $10-50K funded by INL’s CAES budget
Projects are led by INL researchers and must include faculty from the CAES universities
For 2022: 7 of 13 awards involved ISU researchers:

<table>
<thead>
<tr>
<th>Project</th>
<th>Lead Researchers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net Zero: Utilization of Waste Products from Agricultural and Biomass Industries to Reduce Concrete Emissions</td>
<td>Kunal Mondal (INL) Mustafa Mashal (ISU)</td>
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<tr>
<td>Mobile Robot for Security Applications in Remotely Operated Advanced Reactors</td>
<td>Vaibhav Yadav (INL) Mustafa Mashal (ISU)</td>
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<td>Using Artificial Intelligence to Guide the Run-in of a Pebble Bed Reactor</td>
<td>Ryan Stewart (INL) Leslie Kerby (ISU)</td>
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<td>Improving the electron shuttling efficiency of activated carbon in relation to biological nitrogen removal during water treatment</td>
<td>Asef Redwan (INL) Anirban Chakraborty (ISU)</td>
</tr>
<tr>
<td>Developing Machine Learning based Force Field for Predicting Radiation Resistance of High Entropy Alloys</td>
<td>Md Riaz Kayser (INL) Ahmed Hamed (INL) Mostafa Fouda (INL)</td>
</tr>
</tbody>
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INL-supported CAES Activities
  Collaboration Fund
  Summer Visiting Faculty Program

ISU-funded CAES Activities
  Faculty/staff support
  Seed Grants (Research, MaCS)
  Student Support, Equipment
ISU-CAES Budget, FY23  $996K total funding

- Faculty: 27%
- Staff: 31%
- Students: 5%
- Seed Grant Programs: 28%
- Capital Equipment: 6%
- Operating Expenses: 3%
ISU-CAES Seed Grant Program

Funding for research projects led by ISU with collaborators from BSU, UI, INL

Research theme should correspond to CAES Strategic Plan

Prioritize projects that will lead to External Grant Proposals

At least $200K available annually, Individual awards of $20-30K

Successful Projects include the following.....
<table>
<thead>
<tr>
<th>ISU PI</th>
<th>ISU Department</th>
<th>ISU co-PIs</th>
<th>University co-PIs</th>
<th>INL co-PI</th>
<th>Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ali, Amir</td>
<td>NE</td>
<td>David Arcilesi (UI)</td>
<td>Piyush Sagharwall</td>
<td></td>
<td>Small-Scale Heat Exchanger Thermal Performance Facility</td>
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<tr>
<td>Jenkins, Cori</td>
<td>Chemistry</td>
<td>Josh Pak</td>
<td></td>
<td>Chris Zarzana</td>
<td>Urethane degradation analysis for upcycling and designing sustainable</td>
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<td>Brittany Hodges</td>
<td>plastics</td>
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<td>Leung Solomon</td>
<td>CE</td>
<td>Yaqiao Wu (BSU MaCS)</td>
<td></td>
<td>Don Wood</td>
<td>Sorption Removal of Gaseous Fission Products in Nuclear Fuel Reprocessing by MCM-41, TiO2, and their Functionalized Derivatives</td>
</tr>
<tr>
<td>Mashal, Mustafa</td>
<td>CE</td>
<td>Bruce Savage</td>
<td>Rajiv Khadka</td>
<td></td>
<td>The Use of Emerging Technologies for Training of Emergency Responders</td>
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<td></td>
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<td>Jared Cantrell</td>
<td>Xingue Yang</td>
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<td>Roy Dunker</td>
<td>John Koudelka</td>
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<td>Maya Redden</td>
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<td>Bryon Marsh</td>
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<td>Shad Keele</td>
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<td>Michael Shurtliff</td>
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<tr>
<td>Murray, Kendra</td>
<td>Geosciences</td>
<td>Nick Bulloss (BSU MaCS)</td>
<td></td>
<td>Xiaofei Pu</td>
<td>Olivine phenocrystal evolution in the Snake River Plain basalt flows that underlie the INL</td>
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<tr>
<td>Pashikanti, Srinath</td>
<td>Pharmacy/Chemistry</td>
<td>Rene Rodriguez</td>
<td>Robert Fox</td>
<td></td>
<td>Synthesis of Conformationally-Rigid Tetralkyl phosphonium based Ionic Liquids for extraction of critical element Cobalt</td>
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<td>van Woerden, Irene</td>
<td>Community &amp; Public Health</td>
<td></td>
<td>Donna Baek</td>
<td></td>
<td>Perceptions of INL and Nuclear Energy in the local community</td>
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<tr>
<td>Ali, Amir</td>
<td>Nuclear Engineering</td>
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<td>Yasir Arafat</td>
<td>Performance optimization of MARVEL Microreactor power conversion system</td>
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<td>Bodily, Paul</td>
<td>Computer Science</td>
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<td>Rajiv Khadka</td>
<td>Application of Advanced Computational Theory to Facilitate Efficient Solutions to Real-World Combinatorial Problems</td>
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<td>Forest, Tony</td>
<td>Physics</td>
<td></td>
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<td>Chutiing Tan</td>
<td>A Neutron Generator for Materials Testing</td>
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<td>Fouda, Mostafa</td>
<td>ECE</td>
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<td>Ahmed Hamed</td>
<td>Smart Analytics of Biomass Images</td>
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<td>Kalivas, John</td>
<td>Chemistry</td>
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<td>John Koudelka</td>
<td>Virtual Reality for Dynamic Data Visualization of Analytical Chemical Data</td>
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<tr>
<td>Mashal, Mustafa</td>
<td>Civil Engineering</td>
<td>Dan LaBrier Jared Cantrell</td>
<td></td>
<td>Som Duhlipala Amit Jain</td>
<td>Machine Learning-Aided Validation of a Sustainable and Highly Durable Construction Technology for the Containment Facility of Advanced Reactors</td>
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<td>Pashikanti, Sr</td>
<td>Biomedical and</td>
<td>Rene Rodriguez</td>
<td></td>
<td>Robert Fox Donna Baek</td>
<td>Incorporation of Sterics in novel Phosphonium Ionic Liquid (PIL) and their Effect on Ligand Intermolecular Interactions and Chelation Properties</td>
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<td>Pharmaceutical</td>
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<td>Sciences</td>
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<tr>
<td>Savage, Bruce</td>
<td>Civil Engineering</td>
<td>Chikashi Sato Jim Mahar Mustafa Mashal</td>
<td>Karen Humes, UI Dakota Roberson, UI</td>
<td></td>
<td>Water Storage Infrastructure Viability using Repurposed Tires for Pumped Hydro</td>
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<tr>
<td>Xu, Danny</td>
<td>Biomedical and</td>
<td>Kenneth Cornell, BSU</td>
<td></td>
<td>Eric Whiting</td>
<td>Hearing Loss Prevention through Integrative High Performance Computing, Data Science, and Experimental Biology</td>
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<td></td>
<td>Pharmaceutical</td>
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MaCS Seed Grant Program

Funding for research projects that use instrumentation in the MaCS lab

$25K available annually, Individual awards of $5K

Three applications received and funded:

Dan LaBrier, Nuclear Engineering:  
*Requisite Training for Characterization of Magnetic Powder*

Dave Pearson, Geosciences:  
*Microstructural investigation of a shear zone in the northern Rocky Mountains*

Dan LaBrier, Nuclear Engineering:  
*Integration of Experiential Training with Traditional Classroom Instruction for an Introductory Material Science Course*
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  Others: Fluids, Visualization, Electronics

Collaborative Proposals
  NSF REU, Engines, ERC, and others

INL-supported CAES Activities
  Collaboration Fund – Winter application, $10-50K
  Summer Visiting Faculty Program – Winter application, $10K

ISU-funded CAES Activities
  ISU CAES Seed Grant – November application, $20-30K
  MaCS Seed Grant – rolling application deadline, $5K
  Discretionary funds – rolling deadline: Student Support, Equipment
New Initiatives & Ideas

INL Net Zero by 2031 – reduce greenhouse gas emissions

Modified CAES Strategic Plan

Increased Coordination of CAES – C3 -- Cybercore

High Performance Computing
  Falcon Supercomputer donated by INL to BSU/ISU/UI
  New ISU staff position in HPC – Michael Ennis
Center for Advanced Energy Studies (CAES)
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More info:
https://www.isu.edu/research/centers-and-institutes/
https://caes.org/
davidrodgers@isu.edu