TEXAS A&M ENERGY INSTITUTE

CONVERGENCE RESEARCH INCUBATOR CO-RE

Convergence Research Incubator
Call for Concept Notes
Summary of Stats

Number of awards	3
Amount per award	USD 15,000
Number of concept notes submitted	17
Total numbers of participants (PIs + Co-PIs)	71
Number of participating faculty and staff	62
Number of non-academic stakeholders	9
Number of international faculty	5 (Qatar , Mexico, Ghana)
Participating TAMU Campuses	College Station (51), TAMU-Galveston (2), TAMU-Q (3), TAMU-Law (2), TAMU-PV (1), TAMU Kingsville (1)

Participating Colleges, Departments, and Centers at TAMU

- **College of Engineering (26)**
  Mechanical (7); BAEN (5); Petroleum (4); Electric & Computer (3); Chemical (2); Chemical and Natural Gas (1); Civil (1); Environmental (1); Industrial and Systems (1); Subsea (1);
- **Agriculture and Life Sciences (8)**
  Agricultural Economics (5); Soil and Crop Sciences (2); Horticulture Sciences (1)
- **Geosciences (5)**
  Geography (2); Geology and geophysics (1); Atmospheric Sciences (1), Berg Hughes Center for Petroleum and Sedimentary Systems (1)
- **College of Education and Human Development (3)**
  Health and Kinesiology (3)
- **Sciences (2)**
  Physics and Astronomy (1); Chemistry (1)
- **Liberal Arts (2)**
  Economics (1); Sociology (1)
- **College of Architecture (2)**
  Landscape Architecture and Urban Planning (2)
- **Veterinary Medicine & Biomedical Sciences (1)**
  Veterinary Physiology & Pharmacology (1)
- **School of Law (2)**
- **Bush School of Government and Public Service (1)**
- **School of Public Health (1)**
- **Centers and Institutes (7)**
  Energy Institute (5), Texas Transportation Institute (1); TEES Gas and Fuels Research Center (1)

Awarded Concept Notes

Concept notes were reviewed by a curated panel from across the university, representing a broad range of disciplines. Selected reviewers were ensured to have no conflict of interest. Any faculty with concept notes under consideration for this call were not eligible to serve as reviewers.

1. SUSTAINABLE GEO-ENERGY SYSTEMS OF THE FUTURE

Marcelo Sanchez *(Civil and Environmental Engineering), Alfredo Garcia (Industrial & System Engineering); Gabriel Eckstein (School of Law); Rodrigo Velez (Economics)*

Sustainable Geo-Energy Systems have emerged as one of the least polluting and environmentally unobtrusive forms of energy, having the lowest lifecycle emissions of any generating technology. A wide array of novel technologies (e.g. energy piles, enhanced energy system, energy walls, compressed air energy storage) facilitated by advances in geo-engineering have the potential to significantly affect the energy industry. The new field of geo-engineering studies the extraction, transfer, storage, and management of energy, energy waste, or energy infrastructure in the subsurface soil or rock. Many fundamental scientific questions pertaining to the behavior of soils and rocks under complex and potentially extreme pressure and temperature regimes, often involving coupled thermo-hydro-mechanical-geochemical (THMG) processes remain unanswered. Furthermore, some renewable geo-energy approaches integrate with geologic CO2 storage to simultaneously isolate this greenhouse gas from the atmosphere and use this emplaced CO2 for energy extraction or energy storage. More broadly, these emerging questions, capabilities, and opportunities suggest the need to coordinate the myriad potential uses of the subsurface in order to maximize the environmental, economic, and social benefits of its use. This development and coordination necessarily involve complex questions of law and policy at both federal and state levels, recognizing the possibility that states could develop complex and competing governance systems. The integration of these geo-energy technologies into existing electricity markets presents novel opportunities and challenges. For example, compressed air energy storage is a technology that can provide additional flexibility for the operation of markets with significant intermittent renewable capacity (e.g. wind, solar). However, the scheduling of compressor and expander units over a given planning horizon (e.g. weekly) must consider the geo-energy system's physical characteristics (e.g. dynamics of the air storage) which are imperfectly known. Thus, a successful integration requires combining expertise from diverse fields such as geomechanics, economics and stochastic optimization. The goal of this project is to develop a comprehensive research agenda on sustainable geo-energy systems encompassing all relevant disciplines. This research agenda would serve as starting point for seeking financial support from research agencies in the federal government and/or industry.

2. ARTIFICIAL INTELLIGENCE PLATFORM TO SUPPORT SUBSURFACE GEOTHERMAL AND CARBON-SEQUESTRATION OPERATIONS

Siddharth Misra*, Petroleum Engineering; Benchun Duan, Geology and Geophysics; Jose Oscar Campos Enriquez, National Autonomous University of Mexico (UNAM)*

Geothermal energy represents a clean, continuous and inexhaustible energy resource. Geo-sequestration of contaminants, such as nuclear waste, CO2, and CH4, will combat climate change and promote environmental security. During subsurface engineering operations for geothermal energy and carbon geo-sequestration, AI technologies are needed to reduce the associated costs, maximize fluid storage and heat-energy transfer, and prevent unintended fracture/fluid-flow pathways that can lead to earthquakes, aquifer contamination, and release of hazardous minerals/gases. AI technologies are needed for real-time monitoring of the dynamic behavior of dominant fluid-flow paths and fracture networks evolving in the opaque subsurface environment thousands of feet below the ground during geothermal/ sequestration operations. Such an AI technology will lead to higher success rate in exploratory drilling, effective stimulation plans, and

greater efficiency in operations that will ultimately lower the costs. The proposed project will deploy methodologies and technologies currently being developed under Department of Energy (DOE) Early Career Award to the PI and those developed under the NSF CAREER Award to the co-PI. The project will leverage datasets generated from DOE and Mexican Government test sites. The proposed project will bring together the College of Geosciences and the College of Engineering in TAMU and UNAM to achieve convergence of engineering, computation, sensor, AI, geoscience, environment and economics. In future, we will also need to incorporate principles from social sciences, governmental regulatory frameworks, sustainability and environmental assessment.

3. THE CONSTRAINTS OF RENEWABLE ENERGY EXPANSION TO ACCOMMODATE WATER SCARCITY, CLIMATE CHANGE AND POPULATION GROWTH: A WATER-ENERGY-FOOD-HEALTH NEXUS ANALYSIS IN SOUTH AND WEST TEXAS

***Bruce A. McCarl**, Department of Agricultural Economics; Yangyang Xu, Department of Atmospheric Sciences; Chengcheng Fei, Department of Agricultural Economics; Yuhong Lei, Department of Agricultural Economics*

San Antonio and surrounding areas plus virtually all of South and West Texas face growing water and energy demands but limited water supplies and a desire to limit climate change via production of low carbon electricity. Simultaneously, conflicts arise in that many water solutions increase energy demand while some energy solutions require more water. Agriculture is one of the large water users in the region. This sets up a Food-Energy-Water Nexus issue. Recently, the City of San Antonio adopted a Plan that strives for carbon neutrality by 2050 with solar and wind electricity expanded to over half of generation sources. This plan would reduce water stress as solar and wind farm does not need cooling water. However, it raises concerns about (a) land use, and (b) electricity grid reliability. (a) In 2018, electricity generation for San Antonio was around 31,000 gigawatt-hours. Without considering demand increases due to population growth, climate change, economic growth, and planned water projects, around 15,500 gigawatt hours of solar and wind-based electricity is needed to achieve these goals. This competes for land: for example, the Blue Wing Solar Project occupies 139 acres land to provide 26.57 gigawatt-hours electricity. If the same land usage rate applies, about a 127 square mile solar area (more than a quarter of the current San Antonio area) would be needed. Wind farms need even more land and are limited in terms of site locations. Demand growth and water projects will only increase renewable energy needs. Land needs will compete with beef and crops. (b) When wind and solar expand to a 50% share, grid reliability is a concern. Some form of storage or back up generation sources would be needed. Meanwhile, a switch to renewable energy would reduce coal and natural gas prices making them desirable to use in other locations – an emissions 'leakage' issue. But, the switch to renewables would also reduce ozone and particulate matter incidence which would positively affect health and crop yields. In this study, we will expand an existing two-stage stochastic equilibrium Nexus model that represents agriculture, water availability, municipal water and energy demands and water projects in the nexus to include further details of: a) agricultural sector and land use competition with renewable energy; b) water project construction and electricity use; c) renewable energy, storage and backup generation construction; d) ozone incidence and effects. We will integrate electrical planning concerns into the nexus model through supporting runs of an hourly electricity demand model. We will do this for South and West Texas including the. We will investigate the impact of renewable energy expansion and water developments plans on the Water-Energy-Food-Health Nexus considering the following aspects: 1) land competition and its effects on food production; 2) reliability of electricity with increases in solar and wind; 3) GHG emission leakage effects of increasing renewable energy; 4) water project power demands and supplies; 5) alterations in water stress in the region due to climate change; and 6) ozone implications on crops and human health.

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List of submitted concept notes

#	PI	Co-Pis	Affiliations	Title
1	**Maria A. Barrufet**	Elena Castell-Perez, Rosana G. Moreira	**Petroleum/Chemical Engineering**, Biological and Agricultural Engineering	Capture of CO2 and Water while Driving for Use in the Food and Agricultural Systems
2	**Samuel Ma**	Hongcai Zhou, Virender K. Sharma	**Environmental Engineering**, Chemistry, Public Health	Developing biomimetic catalysts powered by solar energy for the degradation of per- and polyfluroalkyl substances (PFASs) in the water-energy-food-health nexus
3	**Brian McCullough**	Chrissie Segars, Bassel Daher, Meg Patterson, Chase Straw	Extension Turfgrass Specialist, Soil & Crop Sciences; Biological & Agricultural Engineering; **Health & Kinesiology**	Stakeholder convergence in the decision-making processes of public spaces of the future and the resulting sustainable management goals
4	**Luis San Andrés**	Adolfo Delgado, Hamid Toliyat, Jing Yang	**Mech Eng**, Electric and Computer Science Eng	Oil-Free Electrical Turbo Chargers for Hybrid Vehicles and Unmanned Aerial Systems
5	**Siddharth Misra**	Benchun Duan, Jose Oscar Campos Enriquez	**Petroleum Engineering**, College of Engineering, TAMU; Geology and Geophysics, College of Geosciences, TAMU; National Autonomous University of Mexico	Artificial intelligence platform to support subsurface geothermal and carbon-sequestration operations
6	**Bruce A. McCarl**	Yangyang Xu, Chengcheng Fei, Yuhong Lei	**Department of Agricultural Economics;** Department of Atmospheric Sciences	The Constraints of Renewable Energy Expansion to Accommodate Water Scarcity, Climate Change and Population Growth: a Water-Energy-Food-Health Nexus Analysis in South and West Texas
7	**Paul Mario Koola**	Anna Armitage, Debalina Sengupta, Mark Holtzapple, Bassel Daher; Astrid Layton, Orla Punch, Nancy Zakhour	**Ocean Systems & Technologies, Ocean Energy Conversion;** Department of Marine Biology,TEES Gas & Fuels Research Center; Department of Chemical Engineering; Texas A&M Energy Institute,Mechanical Engineering; Independent Architect Consultant, Energy Industry Lead	Dynamic Resilient Interconnected Floating Technologies for Sustained Living on Water [DRIFT SLOW]
8	**Mohammad Rahman**	Ibrahim Hassan; Rashid Hasan; Nazmul Rahmani; Saadat Mirza	**Petroleum Engineering, TAMUQ, Qatar**; Mechanical Engineering, TAMUQ, Qatar; Petroleum Engineering, TAMU, USA; Chemical and Natural Gas Engineering, Texas A&M University, Kingsville, USA; Subsea Engineering, TAMU, USA	Development of a Multiphase Flow Metering Tool for Complex Conditions

9	**Marcelo Sanchez**	Alfredo Garcia; Gabriel Eckstein ; Rodrigo Velez	**Civil and Environmental Engineering**; Industrial & System Engineering; School of Law; Economics	Sustainable Geo-Energy Systems of the Future
10	**Sarhan Musa**	Christian Brannstrom	**Electrical and Computer Engineering, Prairie View A&M University**; Geography, Texas A&M University	Emerging Energy Decarbonization for Justice in Growth of Electrochemistry and Hydrogen Energy in the United States
11	**Nancy Zakhour**	Bassel Daher;Ying Li; Sarhan Mahmoud Musa; Paul Mario Koola; Debalina Sengupta; Mukul R. Bhatia; Joseph Gallegos	**Occidental Petroleum**; Department of Biological and Agricultural Engineering; Department of Mechanical Engineering, Texas A&M University; , Electrical and Computer Engineering Department, Prairie View A&M University; Ocean Engineering, Texas A&M University, Galveston; TEES Gas and Fuels Research Center; Berg Hughes Center for Petroleum & Sedimentary Systems; Umida AG	Revolutionizing the O&G Business Model through Cross-Industry Collaboration for a More Sustainable and Profitable Future
12	**Burak Güneralp**	Yangyang Xu, Styliani Avraamidou, Bassel Daher, Joseph Gallegos, Dongying Li, Valentini Pappa, Anastasia Shcherbakova	**Geography**; Atmospheric Sciences; Energy Institute; Biological and Ag. Engineering; Drought Diet Products; Agriculture Economics, Landscape Architecture	Integrated assessment of urban cooling in a changing world: A case study of the City of San Antonio
13	**C. Silva Hamie**	Bassel Daher; Jonas Ecke; Sonya Panjwani; Valentini Pappa,; Konstantinos Pappas; Debalina Sengupta; Stakeholders: Joseph Gallegos; MacGregor Stephenson; Mary Ellen Ternes; Nilanjana Bhowmick	**Bush School of Government & Public Service**;Energy Institute & Biological and Ag. Engineering; Department of Humanities and Social Sciences, Ashesi University, Accra, Ghana; Department of Health and Kinesiology, TAMU; TEES Gas and Fuels Research Center; Drought Diet Products; TDEM- the Texas Division of Emergency Management; Earth and Water Law LLC; Independent Journalist	Enhancement of resilience to disasters and emergencies through integrating technical and response infrastructure systems using a social capital framework

14	**Trevor Vaughn**	Styliani Avraamidou; Sergio Capareda; Bassel Daher; Pliny Fisk III; Jim S. Kamas; Ying Li; Felix Mormann; Valentini Pappa; Dana Porter; Lubinda Walubita; Joseph Cerecedes, Joseph Gallegos	**Terry County stakeholder, Founder of Sawyer Carbon**;A&M Energy Institute; Bio and Ag Engineering; Center for Maximum Potential Building Systems; Texas A&M AgriLife Extension Viticulture; A&M Mechanical Engineering; School of Law; BAEN AgriLife Extension; A&M Texas Transportation Institute; CSO Liquid Phi; Drought Diet Products	Circular Farming: Demonstrating Regional Circular Economies through Waste to Energy and Industries Models with Carbon Sequestering Materials
15	**Sarah N. Gatson**	Sarah N. Gatson; Robert Brown; Yu Zhang; Jacqueline Aitkenhead-Peterson; Marissa Cisneros	**Sociology**; Landscape Architecture & Urban Planning; Agricultural Economics; Soil & Crop Science; Veterinary Physiology & Pharmacology	Urban Networks, Micro Agriculture, and Community Food Security
16	**Peter McIntyre**	Mehrdad Ehsani	**Physics & Astronomy**; Electrical and Computer Engineering	Superconducting Magnetic Energy Storage: Green Energy on Demand
17	**Mehrdad Ehsani**	Peter McIntyre	**Electrical and Computer Engineering**; Physics & Astronomy	Selectable Interconnection of Diverse Renewable Power Sources