

Center for Energy Systems Research
Tennessee Tech University
Annual Report for Fiscal Year 2023-2024

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Annual Report for Fiscal Year

July 1, 2023—June 30, 2024

Satish M. Mahajan, Director



Center for
Energy
Systems
Research

"Where research is put into practice."

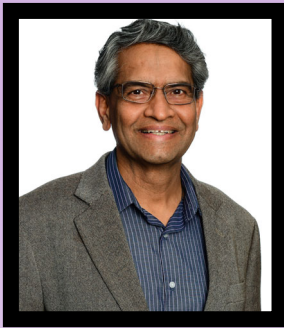


Tennessee
TECH

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YEAR IN REVIEW



Dr. Satish M. Mahajan continued as the Director of the Center for Energy Systems Research (CESR) for fiscal year 2023-2024. The CESR continues to focus on three strategic research areas: Smart Grid, Resilient Infrastructure, and Wireless Power Transfer.

Fiscal Year 2023-2024 was another wonderful year for the CESR. This year, the external funding increased by about 143% over the previous year for a total of **\$7,095,858.18, making 2023-2024 another record-breaking year** in the 39-year history of the CESR. It certainly represents the extra energy put in by the Center faculty associates, and the extra support given to them by the center staff. It is the eighth time since 1985 that the CESR activations have crossed \$2 million, and now six years in a row out of those eight years.

The proposal activity is holding steady at over \$20 million for 2023-2024. This steady value of proposals bodes well for the future impact on generation of external funding. A lot of credit must be given to the support staff within the CESR.

In the 2023-2024 fiscal year, the CESR funded 40 M.S. assistantships (30 on grants only, 9 on CESR only, and 1 on grants plus CESR, plus other University sources combined); and 89 Ph.D. assistantships (62 on grants only, 22 on CESR only, and 5 on grants plus CESR, plus other University sources). The CESR supported a total of 25 graduate students on an hourly basis. The combined headcount of the CESR-supported graduate students is 129. The CESR also supported a total of 33 undergraduate students, a significant number of them funded by grants.

The CESR faculty associates received grants from ARC, USAID, QNRF, EPRI, DOE, TBR, TDOT, LUNA, NSF, NASA, NSA, ORNL, SOCHE, TCA, TVA, ARPA-E, Venturewell, and some industrial sponsors. The variety of funding agencies represents commitment from our senior faculty associates as well as the mid-career ones. It is also wonderful to see the success of the junior faculty, and the investment made by the CESR via start-up commitments paying off. The CESR will be looking for strategic partnerships to collaborate for research in the food, energy, water (FEW) nexus, and the artificial intelligence (AI) areas.

The search for a new Research Assistant Professor in the Transportation Engineering began in Fall 2023 and concluded in the Summer of 2024 resulting in the addition of Dr. Archie Huang. The CESR will continue to invest in new faculty via an additional Research Assistant Professor in the Electric Power area and new start-up packages. This year the CESR is committing to the start-up packages of two new faculty—Dr. Ali Estejab in Chemical Engineering and Dr. Ian Morrell in Civil and Environmental Engineering. We welcome them and look forward to their contributions.

Ms. Barbara Fenlon and Mr. Clay Kelsey have left the CESR as Financial Grants Analysts. Ms. Barbara Fenlon retired after her 12 years of service to TTU, 5 of those being in the CESR. The Center is grateful for her many contributions and the wealth of knowledge she has passed on to the rest of the CESR staff. Ms. Shanae Tyree was promoted to Center Manager and was invited to present at the National Council of University Research Administrators (NCURA) Financial Research Administrators Conference held in Honolulu, Hawaii. Ms. Linda Thurman has taken on a new role as a Financial Grants Analyst and continues to expand her skills and knowledge with post-award grant management while maintaining excellent customer service to CESRs affiliates. Mr. Robert Craven continues to provide excellent support in his role as the Center's research engineer and has played an invaluable role with the Center's largest grant of its history. Many thanks to them all for their tireless efforts in support of students and faculty associated with the CESR!

PROGRAMMATIC REPORT

MISSION

The Center for Energy Systems Research (CESR) was established to advance and apply scientific and engineering knowledge associated with energy systems and in particular with electric power while supporting the instructional program of Tennessee Technological University (TTU) in academic areas associated with energy systems. During the College of Engineering Strategic Planning of 2012-13, two strategic research areas, Smart Grid and Resilient Infrastructure, were assigned to the Center for Energy Systems Research as focus areas of research. Present research efforts, both theoretical and experimental, are focused on solving current and anticipated problems associated with energy and infrastructure systems. Special emphasis is given to the needs of the electric power industry by way of conducting research on Smart Grid.

VISION

The Center will be known and be recognized nationally for its research contributions in Energy Systems and Infrastructure areas.

The Center's vision is to enhance research and education in support of its mission. The Center will conduct advanced and applied research to enhance knowledge in currently needed and emerging technical areas of Energy and Infrastructure Systems. The Center also has major interests in the dissemination of knowledge and enhancing education in energy systems.

The Center draws upon the expertise from the faculty in the College of Engineering as well as from other faculty on campus. Participating faculty and faculty associates represent Basic Engineering, Chemical Engineering, Civil and Environmental Engineering, Computer Science, Electrical and Computer Engineering, Mathematics, Mechanical Engineering, Manufacturing and Engineering Technology, and Physics.

HISTORY

The State of Tennessee established the Center for Electric Power in 1985 in the College of Engineering at Tennessee Technological University. Reflecting the broadening of the activities of the Center, its name was changed to Center for Energy Systems Research. Over the years, research projects have been sponsored by more than 20 major electric utilities, EPRI, NAVY, Air Force, DOD, federal agencies such as DOE, NASA, NSF, ARPA-e, NIST, and ONR, State agencies such as TDOT and Tennessee Department of Education, and industries such as Luna, McHale, Venturewell etc.

In the 2012-2013 academic year, the College of Engineering identified six strategic research areas in which to focus the research efforts of its faculty and students. Of the six areas, the CESR chose two areas, namely, 1) Smart Grid and 2) Resilient Infrastructure to focus its research. In addition, the CESR has started research in the area of 'wireless power transfer' from the year 2019. Development of large collaborative research proposals is encouraged in these areas.

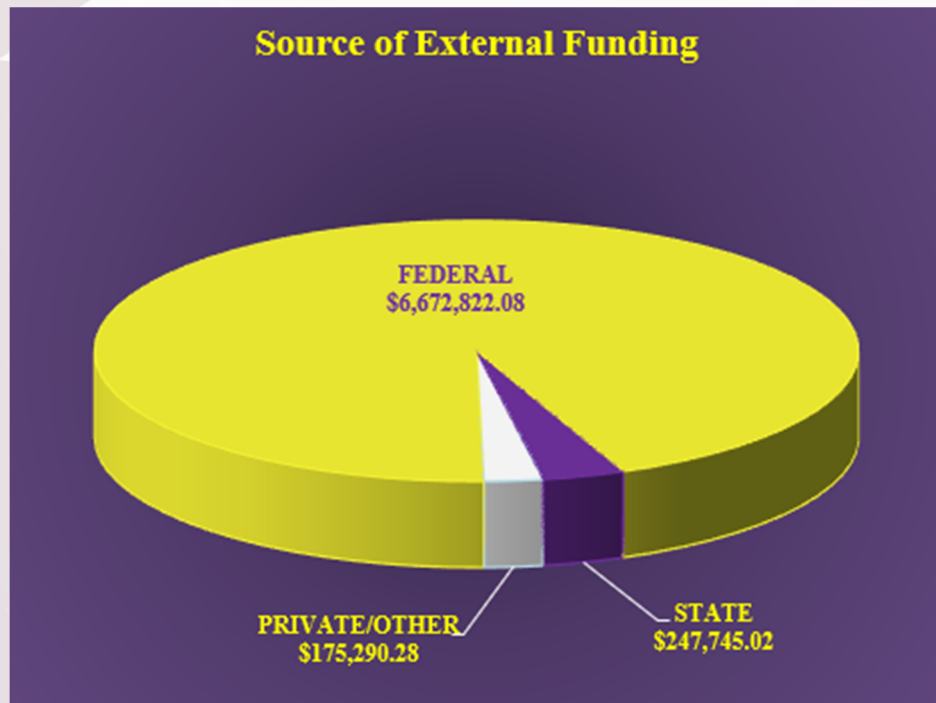
To promote the research and innovation, the CESR provides services of an R&D Engineer, Center Manager, Financial Grants Analyst, and Administrative Associate in support of the various research activities performed by faculty and students. The Center has set up laboratories and computational resources for the benefit of researchers.

The Center promotes international collaboration by hosting visiting scholars, scientists and engineers, and establishing Memoranda of Understanding with international academic institutions and research organizations.

PROGRAMMATIC REPORT

CESR's new matching funds from July 1, 2023 thru June 30, 2024 total \$6,017,910.00. This amount excludes indirect costs of approximately \$1,074,948.04 from this year's funded projects. The result is that the 2023-2024 Matching and Indirect Costs total \$7,092,858.04. The State Appropriation was \$1,138,300.00 for 2023-2024.

CESR continues to enjoy a broad base of support. The funding categories for 2024 are illustrated in Figure 1. Through June 2024, the cumulative research funding of the Center is \$45,737,092. State appropriations are compared to matching, on an annual, cumulative basis, in Figure 2. \$7.1 M is a huge jump from previous years. It represents a 143% increase over the previous year as well as an increase of more than 800% as compared to the external funding in FY15. Matching is divided into contracts and grants; equipment and all other items such as software, books and reports; and funding for faculty and student exchange programs. The 39-year match of about \$45.7 million represents 128 percent of the state appropriations of \$35.5 million. The cumulative total of indirect costs of approximately \$8.7 million were also received. A list of the projects conducted under the major research areas is given in SM-3 in this report.

CESR Research Funding 2024**Figure 1: Source of FY 2023-2024 External Funding**

Center for Energy Systems Research

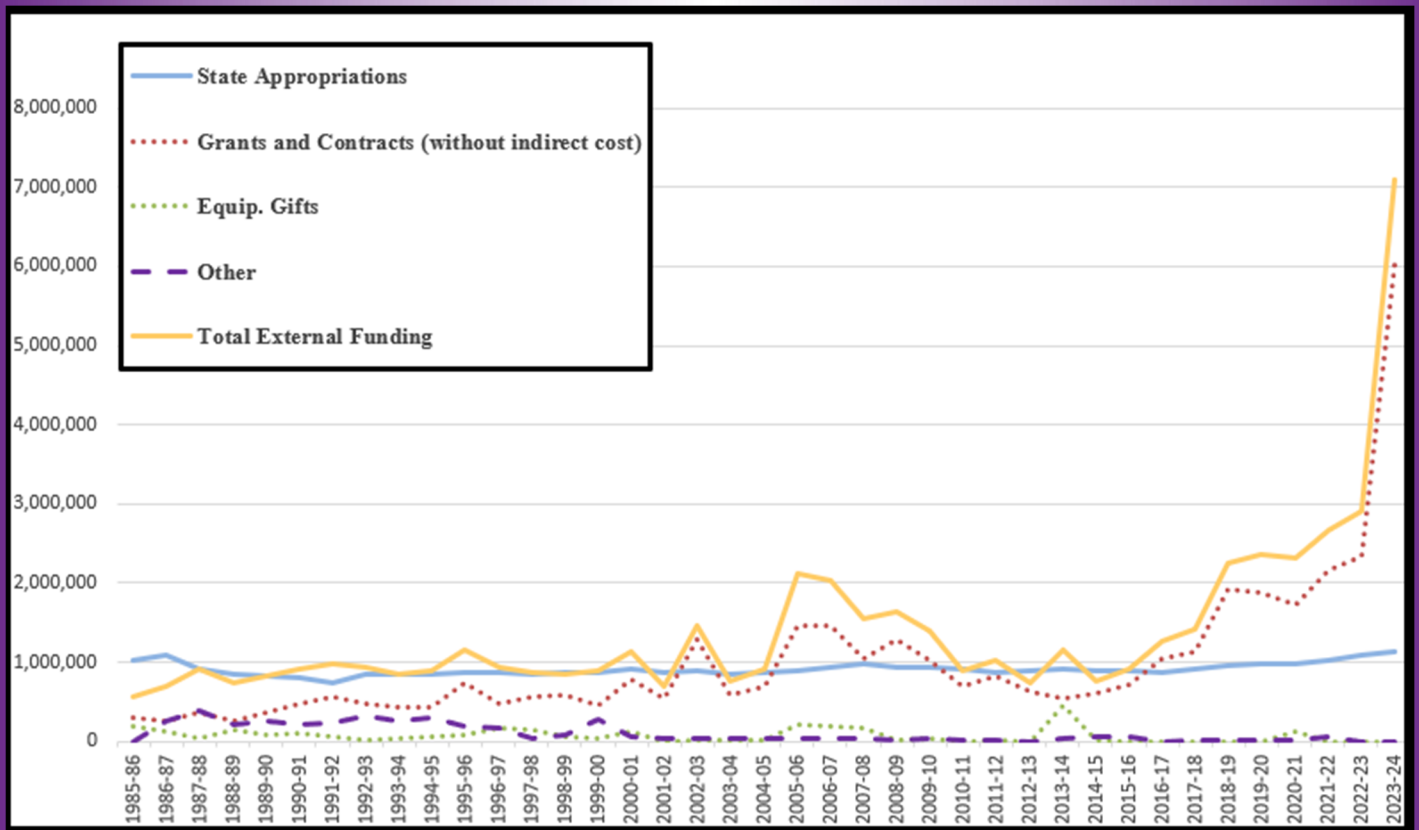


Figure 2: Historical State Appropriations, Matching & Total External Funding 1985-2024

Center for Energy Systems Research

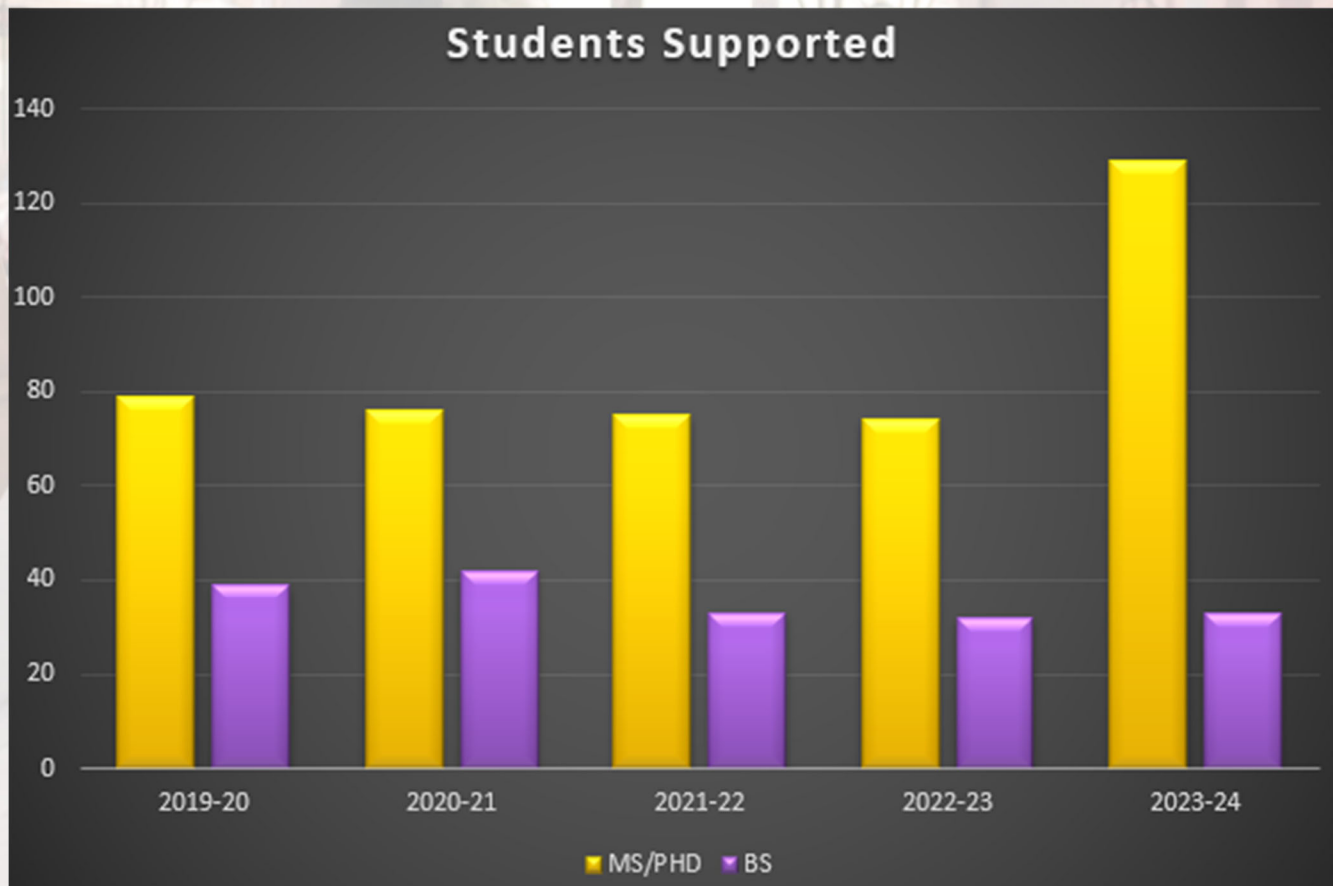


Figure 3: Number of Students Supported Financially

Smart Grid Deployment Consortium and HILLTOP Platform Expansion

Funded by: Appalachian Regional Commission (ARC) under Appalachian Regional Initiatives for Stronger Economies (ARISE)

Engineering researchers to modernize electric grid across Appalachia with \$10M grant

Published Thursday Oct 26, 2023 |



Researchers with the College of Engineering's Center for Energy Systems Research and Tennessee Tech's Center for Rural Innovation will be modernizing the aging electric grid across Appalachia, thanks to a \$10M grant from the Appalachian Regional Commission (ARC)—the largest single grant in Tech's 108-yr history.

ARC Federal Co-Chair, Gayle C. Manchin, announces the \$10M award to TTU.



Smart Grid Deployment Consortium and HILLTOP Platform Expansion

The project envisages developing and demonstrating futuristic applications for active Electric Distribution Networks (EDN). Towards these goals, R&D activities are planned by the Center for Energy Systems Research (CESR), Tennessee Technological University (TTU) and the partners (four-state consortium) including developing algorithms and their testing, analysis and validation of benchmark test systems and real utility systems, training and utility projects. The research activities focus on the following areas:

- **Enhancing DER hosting capacities of the active EDNs:** Modeling of DERs, analyzing the hosting capacities of ADNs and developing methods for enhancing the grid integration of renewables.
- **Grid-scale energy storage & electric vehicle charging impact studies:** Modeling battery energy storage systems, performing BESS-grid integration studies, electric vehicle charging impacts, and developing control strategies for optimal scheduling.
- **Voltage control and optimization:** The project focuses on analyzing the effect of voltage and reactive power control in ADNs and finding methods to utilize them to improve the efficiency and reliability of electric grids.
- **Cybersecurity of ADNs:** One of the goals of the project is to develop schemes for electric grids to be resilient towards cyber-attacks.
- **Demand side management:** The project will feature studies on flexibility in power consumption to improve operational benefits to the utilities, and financial advantages to the participants.
- **Optimal topology identification and network reconfiguration:** Reconfigurable networks will be included in the analysis to understand the impact of network topology on various control schemes.
- **Economic impact assessment of various control strategies:** The project will develop economic models for control devices to bring out cost-efficient grid operational strategies.

Training & utility projects: Development of tools, software training on OpenDSS, real-time simulators and HILLTOP+, collaborative engagements with partners, learning curriculum development, utility projects.

PARTNERS:

West Virginia University, Penn State University, Massachusetts Institute of Technology Lincoln Lab (MIT-LL), Massachusetts Institute of Technology (MIT), The Biz Foundry, Knoxville Entrepreneur Center, BRITE Energy Innovators

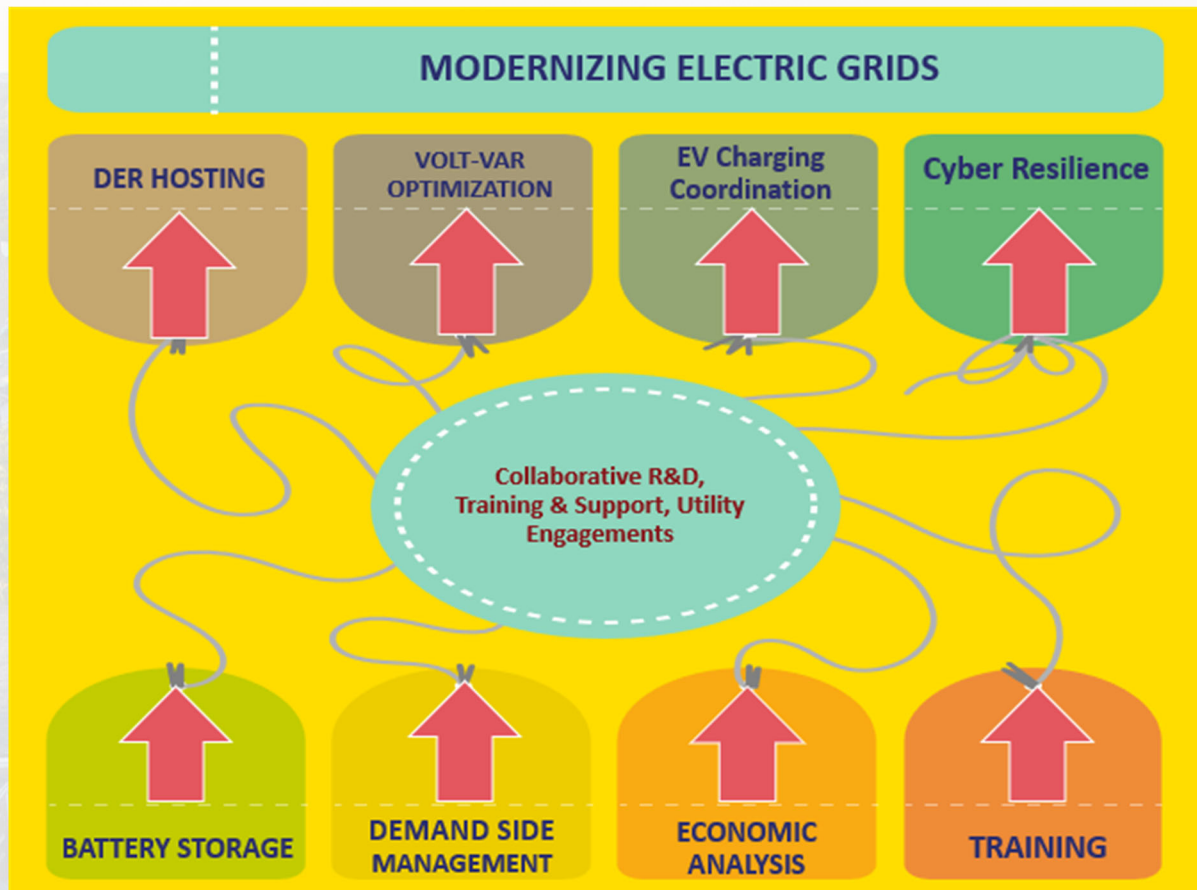


Fig. 1 Project initiatives and research activities

HILLTOP Hardware & Software

- Microgrid Development & Deployment Platform originally developed by MIT-LL
- Two Commercial Inverter Controllers for PV and BESS
- RTAC as the microgrid controller
 - [AcSElerator Software](#)
- Typhoon HIL

Users planning to utilize the HILLTOP, should coordinate with their IT department to have the hardware specific software be approved for installation to enable HILLTOP operation

OpenDSS for Distribution Planning Studies with DERs

- Spatio-temporal DER integration and planning studies in **real utility distribution systems with 1000's nodes** require industry-proven software that can effectively perform yearly time-series simulations, and without the limitations of EMT software
- **OpenDSS** (open-source distribution system simulator) can perform dynamic power flow, suitable for studying challenges associated with the integration of DERs in utility systems, i.e., operation constraint violations

IEEE 8500 Node System
Source: EPRI OpenDSS

Fig. 2 Training and utility engagements



Fig. 3 ARC SGDC-HILLTOP+ training sessions led by Dr. Ali Arzani.

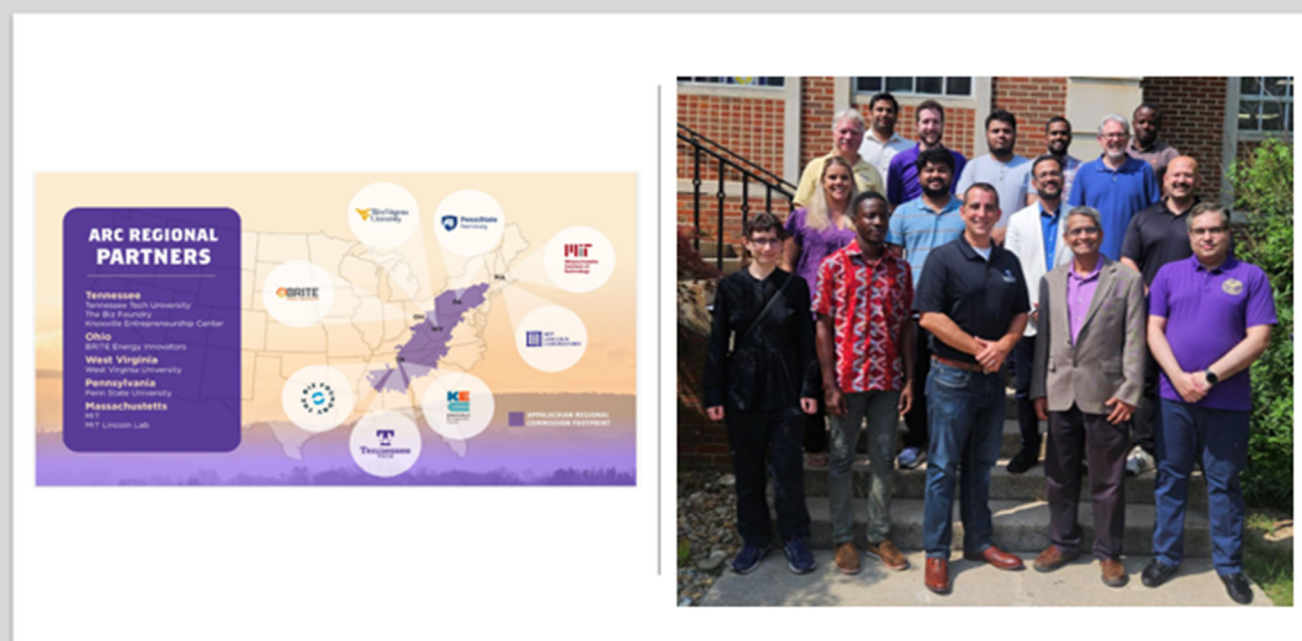


Fig. 4 Project consortium members and Team TTU



Academic Review and Rewrite of NAVFAC DM 7.3

In Fall 2023, Dr. Daniel VandenBerge (Associate Professor, Civil and Environmental Engineering) was awarded a grant from the US Naval Facilities Command (NAVFAC) via the National Institute of Building Sciences to rewrite NAVFAC's *Design Manual 7.3* on earthquake engineering. The three-year project has a total budget of over \$600,000. Dr. VandenBerge will be leading a team that includes authors from Virginia Tech, University of Arkansas, University of Utah, and University of California – Davis. The project follows a successful revision of NAVFAC's *Design Manuals 7.1* and *7.2*, completed March 2021 and August 2023, respectively.

The DM 7 manuals are some of the most broadly used reference documents by geotechnical engineers across the globe. They provide quick, accurate, and concise information and design guidance on a broad range of topics. The new DM 7.3 many is especially exciting because it will include substantial new material to the series. It's completion will make the series a truly comprehensive set to aid the practice of geotechnical engineering in the 21st century.

The project kicked off with the submission of an Academic Review of the existing manual (submitted Jan. 29, 2024). In March 2024, a group of national experts in geotechnical earthquake engineering convened at Tennessee Tech for a workshop to discuss the contents of the new manual. The government attendees were from the US Navy, US Army Corps of Engineers, and US Air Force. Academic and industry representatives attended from Geosyntec, Greenfield Geotechnical, Iowa State, Merrimack College, Pacific Gas & Electric, University of Arkansas, University of California Los Angeles, University of Utah, and Virginia Tech. TTU faculty member, Tim Huff, participated, and undergraduate students Abbie Ferguson and Gracie Gore provided support to the event.



TDOT RES2013-13 - Chemical Subgrade Stabilization of Tennessee Soils – Recommended Practices

In July 2024, Dr. Daniel VandenBerge (Associate Professor, Civil and Environmental Engineering) completed a two-year project for the Tennessee Department of Transportation (TDOT). The project supported the work of two M.S. students as well as multiple undergraduates.



TN TDOT
Department of Transportation

Chemical Stabilization of A-7-6 Soils
(USCS Classification: CL and CH with LL > 40)

Untreated Soil Properties

A-7-6 soils are clayey soils with high plasticity. The liquid limits of these soils are greater than 40. They shrink and swell substantially because of changes in water content.

As a compacted pavement subgrade, A-7-6 soil will have the following properties:

- Poor drainage
- Fair fill stability
- Subject to softening, cracking, expansion, etc.
- Poor to very poor support

A-7-6 soils compacted to about 100% of Standard Proctor maximum dry unit weight typically have the following strength properties:

- Unconfined compressive strength: UCS = 55 psi ± 30 psi
- California bearing ratio: CBR = 3 to 10

Typical Chemical Admixtures

Clay soils are most often stabilized using lime. The clay minerals react with the lime, exchanging cations. The clay particles flocculate into larger aggregates. The grain size distribution becomes coarser and the plasticity index reduces, both of which result in improved workability. These lime-soil reactions require a mellowing period to occur. The pozzolanic strength gain with lime-soil depends on the soil mineralogy. Lime reactions occur when the pH exceeds about 12.4. The minimum lime percentage (MLP) required to reach this pH is found by the Eades and Grim test.

Portland cement can be used to stabilize some A-7-6 soils, especially those with relatively low liquid limits and plasticity indices. However, it may be less economical in many cases. Cement hydration occurs quickly, and final compaction is often completed within 2 hours after mixing. Cement hydration produces lime, which produces additional benefit through lime-soil reaction. Adequate mixing for cement stabilization may be difficult in A-7-6 soils.

Fly ash is sometimes used to stabilize clayey soils; however, Class F fly ash requires activation using lime or portland cement. Fly ash stabilization typically produces slower reactions and compaction occurs within about 6 hours after mixing.

Other materials that have been explored for the stabilization of A-7-6 soils include by-product materials such as cement kiln dust (CKD), lime kiln dust (LKD), and waste lime. Less common options include volcanic ash, xanthan gum, and copper slag.

Common Admixture Percentages and Strengths

The typical ranges of admixture required to stabilize A-7-6 soils are summarized to the right. A mix design should be used to select the particular requirements for a specific soil.

| Admixture | Percentage (by weight) | Typical 28-day UCS (psi) |
|-----------------|------------------------|--------------------------|
| Lime | MLP up to MLP + 4% | 140 (average), 30 to 230 |
| Portland cement | 10 to 16% | 250 to 600 |
| Fly ash | 8 to 16% [2] | 50 to 150 (only fly ash) |

Percentage of Surficial Soil Types in Each County Containing A-7-6 Soil

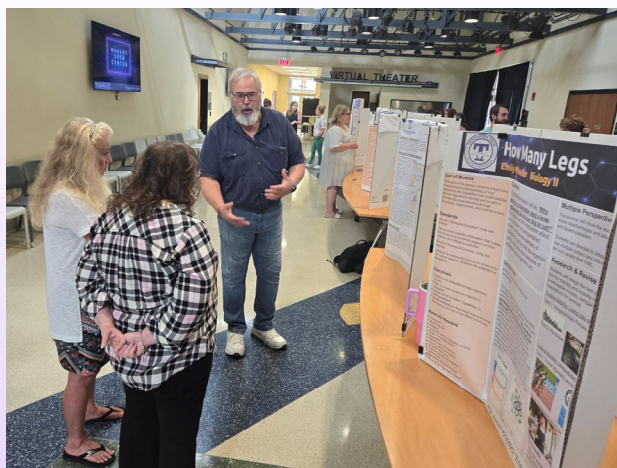
Legend: >85%, 70-85%, 55-70%, 40-55%, 25-40%, 10-25%, <10%

This distribution was prepared as part of TDOT Research Project RES2013-13 and does not necessarily reflect the policies or priorities of TDOT.

The successful project provided TDOT with a shelf-ready plan for implementing chemical soil stabilization on Tennessee highway projects. The project produced a manual for laboratory and field testing of chemically stabilized soils along with four mix design examples. Innovative fact sheets were created to give engineers a quick-reference for soil stabilization projects. Finally, suggested revisions to TDOT's standard specifications were proposed.



Dr. VandenBerge (center) with graduate students Shushanta Chakraborty (left) and Henry Asamany (right)



NSF RET Summer Workshop



PLANS FOR 2024-2025

Increase Research Activity in the Areas of the Center

Generate external funding that will contribute to the long-term growth and sustainability of the Center. As a minimum, the external funding generated per year by the center should match the state funding. Efforts will be made to sustain a \$3 million level.

Center faculty and the R&D Engineer will produce at least five publications in total. This year we had a total of six publications. A new research assistant professor in the area of Transportation Engineering has joined the CESR. He will also contribute to the CESR publications.

The Center focus areas also intersect the University Flight Plan focus areas to Create Distinctive Programs and Invigorate Faculty. This activity will continue.

Increase Student Research Activity

Continue pursuing support to the MS and Ph.D. graduate students in the strategic research areas of the Center consistent with the level of external funding.

Support at least two undergraduate research projects per year in the areas related to energy systems.

This goal intersects the University Flight Plan's New Graduate Programs sub goal.

Increase Collaborative Research

Continue pursuing the development and submission of two collaborative proposals with interdisciplinary focus. The number of collaborative proposals submitted should be at least two per year.

This goal intersects the University Flight Plan's Multidisciplinary Research Innovation sub goal.

Add Laboratory Facilities

The CESR will support expansion of the smart grid laboratory in the inductive wireless power transfer area. Support for heat transfer experiment for transformer will also be given.

This goal intersects the University Flight Plan's Physical Infrastructure Priorities sub goal and the Technology Service to Students sub goal, and the Technology in Teaching sub goal. Better facilities in areas of national importance like the Smart Grid benefit research, education, and hire-ability of our graduates.

Increase Outreach Activities

We will organize a minimum of two seminars by external speakers.

This goal intersects the University Flight Plan's Co-Curricular Undergraduate Program sub goal and the Multidisciplinary Research Innovation sub goal. By having research area experts from outside the university come and teach seminars, workshops or short courses, the students will be exposed to a broader base of information and hopefully promote collaborative efforts from TTU researchers with those at other institutions.

SUPPORTING MATERIALS



CESR tours the Ashraf Islam Engineering Building.



TVA Engineers tour CESRs Smart Grid Lab!



Dr. Joseph Biernacki and colleagues with participants from NSF:RET project.



Dr. Charles Van Neste lamps powered by sensors in the soil.

CESR FACULTY & STAFF – 2023-2024

| | | |
|---|-----------------------|--|
| Center Director: | Dr. Satish M. Mahajan | Director; ECE Professor |
| Center Faculty: | Dr. Ali Arzani | Research Assistant Professor |
| Center Staff: | Mr. Robert Craven | Research Engineer |
| | Ms. Barbara Fenlon | Administrative Associate 4/Financial Analyst |
| | Mr. Clay Kelsey | Financial Analyst |
| | Ms. Linda Thurman | Administrative Associate 4 |
| | Ms. Shanae Tyree | Financial Analyst/Center Manager |
| | Dr. Vineeth Vijayan | Post-Doctoral Researcher |
| CESR Staff (Part Time, Temporary): | | |
| | Dr. Sabrina Buer | Project Manager |
| | Terry Hendrixson | Administrative Associate |
| | Dr. Md Shariful Islam | Post-Doctoral Researcher |
| | Kinwa Leung | IT Specialist |
| | Allison McDaniel | Administrative Associate |
| | Aleka Rice | Financial Analyst |

Faculty Groups in the Strategic Research of the Center

| Smart Grid | Resilient Infrastructure | Wireless Power Transfer & Wireless Charging |
|----------------------------|---------------------------|---|
| Michael Aikens, TCRI | Pedro Arce, CHE | Indranil Bhattacharya, ECE |
| Ali Alouani, ECE | Daniel Badoe, CEE | Satish M. Mahajan, CESR |
| Ali Arzani, CESR | Joe Biernacki, CHE | Charles Van Neste, ECE |
| Indranil Bhattacharya, ECE | J.W. Bruce, CEC | |
| Nan Chen, ECE | Steven Click, CEE | |
| Robert Craven, CESR | Ali Estejab, CHE | |
| Tarek Elfouly, ECE | Gerald Gannod, CSC | |
| Sheikh Ghafoor, CSC | Bahman Ghorashi, CHE | |
| Maanak Gupta, CSC | Craig Henderson, CEE | |
| Syed Rafay Hasan, ECE | Tim Huff, CEE | |
| Muhammad Ismail, CSC | Mazen Hussein, GIE | |
| Satish M. Mahajan, CESR | Alfred Kalyanapu, CEE | |
| Mohamed Mahmoud, ECE | Ethan Languri, ME | |
| Joseph Ojo, ECE | Jane Liu, CEE | |
| Ghadir Radman, ECE | Ben Mohr, CEE | |
| Syed Rizvi, ECE | Ian Morrell, CEE | |
| Rory Roberts, ME | MD Zulkar Nine, CSC | |
| Michael Rogers, CSC | Mustafa Rajabali, Physics | |
| Anthony Skjellum, CSC | Mohan Rao, ME | |
| Charles Van Neste, ECE | Robby Sanders, CHE | |
| | Holly Stretz, CHE | |
| | Daniel VandenBerge, CEE | |
| | Kumar Yelamarthi, COE | |
| | Hyung Yoon, ME | |
| | Peng Zhang, ME | |

CONTRACT AND GRANT AWARDS Activated Between July 1, 2023 and June 30, 2024

| Index | Title | P.I. | Source | Project Dates | Amount |
|--------|---|-------------|---|-----------------------|--------------|
| 539399 | Best Practices for Bridges with Pipe Piles | Huff | Federal Highway Administration - State | 8/1/2022 to 7/31/2024 | \$16,440.00 |
| 539400 | Best Practices for Bridges with Pipe Piles | Huff | Federal Highway Administration - Federal | 8/1/2022 to 7/31/2024 | \$62,330.00 |
| 535286 | Machine Learning-Based Design and Operation of Next Generation Software-Defined Heterogeneous Networks | Ismail | Qatar National Research Fund, TAMU Engineering Experiment Section | 5/15/21 to 5/14/2024 | \$49,875.60 |
| 531338 | NRT-FW-HTF: Engendering the Spirt (sic) of Gadugi at the Food-Energy-Water Nexus | Arce | National Science Foundation | 7/1/2022 to 6/30/2027 | \$516,605.00 |
| 535311 | Reduction in Compressive Strength Test Results due to Above Specification Initial Concrete Cylinder Curing Temperatures | Crouch | Tennessee Concrete Association | 8/1/2023 to 7/31/2024 | \$7,192.00 |
| 539492 | Guidance for Chemical Stabilization of Pavement Subgrade Soils in Tennessee | VandenBerge | Tennessee Department of Transportation - State | 8/1/2022 to 7/31/2024 | \$17,169.60 |
| 539493 | Guidance for Chemical Stabilization of Pavement Subgrade Soils in Tennessee | VandenBerge | Tennessee Department of Transportation - Federal | 8/1/2022 to 7/31/2024 | \$68,681.40 |
| 533266 | Early Age Concrete Acceptance | Mohr | Tennessee Department of Transportation - State | 8/1/2023 to 7/31/2024 | \$25,887.00 |
| 533267 | Early Age Concrete Acceptance | Mohr | Tennessee Department of Transportation - Federal | 8/1/2023 to 7/31/2024 | \$103,548.00 |
| 533264 | Development of Tennessee UHPC for Bridge Applications | Mohr | Tennessee Department of Transportation - State | 8/1/2023 to 7/31/2025 | \$22,483.42 |
| 533265 | Development of Tennessee UHPC for Bridge Applications | Mohr | Tennessee Department of Transportation - Federal | 8/1/2023 to 7/31/2025 | \$89,933.68 |

CONTRACT & GRANT AWARDS, Continued

SM-3

| | | | | | |
|--------|---|-------------|--|-------------------------|----------------|
| 533269 | Review of State Vehicle Classification Programs | Badoe | Tennessee Department of Transportation - UTAP | 9/1/2023 to 11/30/2024 | \$84,198.00 |
| 531342 | Collaborative Research: SitS: Collaborative: Long Range Wirelessly Powered Multi-Variable Sensor Network for Continuous Monitoring of the Soil Health | Van Neste | National Science Foundation | 10/1/2022 to 9/30/2025 | \$121,829.00 |
| 535313 | Development of A Software Application for 'DER Systems of Record' Database | Ghafoor | Electric Power Research Institute (EPRI) | 9/12/2023 to 12/31/2023 | \$9,345.00 |
| 539216 | Smart Grid Development Consortium and HILLTOP Platform Expansion | Mahajan | Appalachian Regional Commission | 8/15/2023 to 8/14/2026 | \$3,902,891.00 |
| 531353 | Collaborative Research: Cybertraining: Implementation: Medium: Introductory Computing Course Sequence Exemplars Infused with Parallel and Distributed Computing | Gannod | National Science Foundation | 9/15/2023 to 8/31/2026 | \$67,964.00 |
| 535296 | Privacy-Preserving Health Monitoring System Using AI and Non-Intrusive Smart Sensors | Mahmoud | Qatar National Research Fund | 2/19/2022 to 10/11/2023 | \$2,178.28 |
| 531341 | Collaborative Research: SHIELD: Strategic Holistic Framework for Intrusion Prevention Using Multi-modal Data in Power Systems | Ismail | National Science Foundation | 9/1/2022 to 8/31/2025 | \$111,819.00 |
| 531340 | Collaborative Research: NeTS: JUN03: SWIFT: Softwarization of Intelligence for Efficient 6G Mobile Networks | Ismail | National Science Foundation | 9/1/2022 to 8/31/2025 | \$75,000.00 |
| 539216 | Smart Grid Development Consortium and HILLTOP Platform Expansion (additional) | Mahajan | Appalachian Regional Commission | 8/15/2023 to 8/14/2026 | \$3,547.00 |
| 532446 | National Cybersecurity Teaching Academy: Southeast Consortium | Mahmoud | University of Louisville Research Foundation, Inc. via NSA | 8/6/2021 to 8/2/2024 | \$30,000.00 |
| 532820 | NIBS Academic Review and Rewrite of NAVFAC DM 7.03 | VandenBerge | United States Naval Facilities Command via National Institute of Building Sciences | 9/21/2023 to 12/14/2023 | \$601,782.00 |
| 539502 | Site-Specific Ground Motion for Bridge Design in Tennessee | Huff | Tennessee Department of Transportation - State | 1/15/2024 to 12/31/2026 | \$61,672.20 |

CONTRACT & GRANT AWARDS, Continued

SM-3

| | | | | | |
|--------|---|-------------|--|--------------------------|--------------|
| 535295 | Impact of DER Performance on Bulk Power System Inverter Behavior | Arzani | Electric Power Research Institute | 3/14/2022 to 2/29/2024 | \$1,700.00 |
| 535320 | Sustainable Transportation Electrification in the Appalachian Region | Chen | VentureWell | 2/1/2024 to 8/31/2027 | \$12,279.00 |
| 531344 | IPA Assignment | Ghafoor | National Science Foundation | 2/13/2024 to 2/12/2026 | \$196,583.00 |
| 531337 | CAREER: CAS-Climate: Understanding Thermal Transport Processes in Atmospheric Boundary Layer with Utility-Scale Solar Photovoltaic Plants | Vaselbehagh | National Science Foundation- | 7/1/2022 to 6/30/2027 | \$109,840.00 |
| 532469 | Design Optimization and Validation of a Machine-Learning Based Integrated JB/AMB supported Rotor for Energy System Application | Rizvi | U.S. Agency for International Development (USAID) | 10/1/2023 to 8/31/2025 | \$54,059.00 |
| 532461 | Lake Observation from Citizen Scientists and Satellites | Ghafoor | University of North Carolina via National Aeronautics & Space Administration | 12/25/2022 to 12/24/2025 | \$84,567.00 |
| 535313 | Development of A Software Application for 'DER Systems of Record' Database | Ghafoor | Electric Power Research Institute (EPRI) | 9/12/2023 to 5/31/2024 | \$9,913.00 |
| 532069 | Virtual Reality Simulation and Testbed Development for Advanced Air Mobility | Yoon | National Aeronautics & Space Administration via University of Nevada Reno | 1/1/2024 to 6/30/2024 | \$15,000.00 |
| 531345 | RET Site: Energize Teachers | Biernacki | National Science Foundation | 5/1/2024 to 4/30/2025 | \$193,560.00 |
| 531358 | ERI:Data-Driven Expansion of Electrified Transportation Network | Chen | National Science Foundation | 6/1/2024 to 5/31/2026 | \$97,428.00 |
| 532459 | Phase II Option (#1) LUNA | Zhang | Luna Innovations Incorporated | 12/1/2022 to 2/1/2025 | \$90,000.00 |
| 532279 | The Structure of Neutron-Rich Deformed Nuclei Studied via Beta Decay | Rajabali | Department of Energy | 5/1/2024 to 4/30/2027 | \$119,855.00 |
| 539238 | Atmosphere Independent Bipropellant Consuming Additively Manufactured Solid Oxide Fuel Cells (SOFCs) for Assured On-Orbit Space Power | Roberts | Southwestern Ohio Council for Higher Education (SOCHE) via DOD funds | 8/1/2020 to 4/30/2024 | \$46,000.00 |
| 533285 | Second-Life Battery in Mobile EV Charging Application for Rural Transportation (SMART) | Chen | TDEC | 10/1/2023 to 9/30/2026 | \$12,703.00 |

TOTAL CONTRACTS AND GRANTS

\$7,095,858.18

**CENTER FOR ENERGY SYSTEMS RESEARCH
STATUS OF PROPOSALS**

Submitted Between July 1, 2023 through June 30, 2024

| TITLE | INVESTIGATORS | SOURCE | AMOUNT |
|--|---|---|-----------------|
| Seismic Design of Bridges Based on Site-Specific Ground Motion Analysis in West Tennessee | Timothy Huff | Tennessee Department of Transportation - State | \$166,725.00 |
| Review of State Vehicle Classification Programs | Daniel Badoe, Steven Click | Tennessee Department of Transportation - State | \$84,198.00 |
| Development of a Software Application for 'DER Systems of Record' Database | Sheikh Ghafoor | Energy Power Research Institute EPRI - Federal | \$9,345.00 |
| NRT-GCR, AI: Fostering an Immersive Research Traineeship in the Convergence of Artificial Intelligence, Energy and Cyber Security | Indranil Bhattacharya, Doug Talbert, Maanak Gupta, Yelamarthi | National Science Foundation | \$3,000,000.00 |
| Investigation of Synchronous Response in Nonlinear Rotor dynamic Systems and Control by Distributed Smart Magnetic Bearings | Syed Ali Asad Rizvi | Multidisciplinary University Research Initiatives | \$1,250,000.00 |
| Multi-State Smart Grid Deployment Consortium (SGDC) using Hardware-In-the-Loop, Laboratory Testbeds, and Open Platforms (HILLTOP+) | Satish M. Mahajan, Michael Aikens, Ali Arzani | Appalachian Regional Commission | \$10,000,000.00 |
| ERI: Morphing Vehicles and Vehicle Platoons with Superior Efficiency | Peng Zhang | National Science Foundation-Federal | \$200,000.00 |
| ERI: Inverter-Based Resources Operation Enhancement in Weak Transmission-Distribution Networks | Ali Arzani | National Science Foundation | \$199,722.00 |

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| ERI:Data Exploration Strategy using Adversarial Machine Learning for Computer Vision assisted Manufacturing Processes | Hyung-Jin Yoon | National Science Foundation - ERI | \$200,000.00 |
| Academic Review and Rewrite of NAVFAC DM 7.03 | Daniel Vandenberg | US Naval Facilities Command via National Institute of Building Sciences | \$601,782.00 |
| ERI: Evolutionary Data-Driven Expansion of Electrified Transportation Network | Nan Chen | National Science Foundation | \$195,769.00 |
| Design Optimization and Validation of a Machine-Learning Based Integrated JB/AMB supported Rotor for Energy System Applications | Syed Ali Asad Rizvi | US-Egypt Joint Board on Scientific and Technological Cooperation | \$100,000.00 |
| REU Site: Vision-Based Attach Detection for Autonomous Vehicles | Hyung-Jin Yoon | National Science Foundation - REU | \$16,645.00 |
| Through the Soil Long Range Wireless Power Transfer for Rapid Electrification of Lunar Infrastructure | Charles Van Neste | Defense Advanced Research Projects Agency | \$100,000.00 |
| Excellence in Research: AI-Driven Malware Analysis for Container-Based Cloud Microservices | Gupta | National Science Foundation | \$180,000.00 |
| Zero Emission Railroad, Oceanic & Aviation Demonstration (ZEROAD) | Rory Roberts | Department of Energy | \$465,000.00 |
| Through the Soil Long Range Wireless Power Transfer for Rapid Electrification of Defense Operations | Charles Van Neste | Department of Defense - US Army | \$37,500.00 |
| Sustainable Transportation Electrification in the Appalachian Region | Nan Chen, Michael Aikens, Yi Peng, Hyewon Park | Venturewell | \$27,637.00 |

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| A Novel Crystallization Process to Produce Lithium for Battery Production | Bahman Ghorashi | Department of Energy | \$1,046,325.00 |
| RAISE: CET: Understanding Moisture and Turbulence in Offshore Wind Turbine Wakes via Wind Tunnel Experiments and High-Fidelity Numerical Simulations | Ahmad Vasselbehagh | National Science Foundation - Research Advanced by Interdisciplinary Science and Engineering | \$261,414.00 |
| "Equipment: MRI: Track 1 Acquisition of a Three-Dimensional Particle Image Velocimetry and Digital Image Correlation System for Research and Education" | Peng Zhang, Ahmad Vasselbehagh | National Science Foundation MRI | \$1,087,176.00 |
| The Structure of Neutron-Rich Deformed Nuclei Studied via Beta Decay | Mustafa Rajabali | Department of Energy Office of Science | \$544,459.00 |
| Virtual Reality Simulation and Testbed Development for Advanced Air Mobility | Hyong Yoon | University of Nevada, Reno | \$15,000.00 |
| Flexible Neutron Source for Research and Education Access | Rao | Department of Energy via University of Tennessee - Knoxville | \$70,000.00 |
| A New Educational Model for Enhancing Visual Communication Skills of Engineering Students Using Generative AI | Tarek Elfouly, Kumar Yelamarthi, Indranil Bhattacharya | Engineering Information Foundation | \$25,000.00 |
| Smart and Cascaded Solid-State Transformer for Low Cost and Efficient PV Systems | Indranil Bhattacharya | Department of Energy | \$250,000.00 |
| Thermal Energy Storage System based on Enhanced Phase Change Material | Ethan Languri, Rory Roberts | Department of Energy - Federal | \$115,000.00 |

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|--|--|---|--------------|
| An Assessment-Centric Approach to Increase the Reach of PDC Training | Mike Rogers, Ada Haynes | National Science Foundation | \$219,633.00 |
| Reverse Logistics for Electric Vehicle Batteries | Mazen Hussein | Environmental Research & Education Foundation | \$100,000.00 |
| Career: Exploring Electromagnetic Coupling Phenomena Over and Through the Soil for Long-Range Wireless Power Transfer, Climate Monitoring, and Energy Harvesting | Charles Van Neste | National Science Foundation | \$534,825.00 |
| High Power Density Solid-Oxide Fuel Cell Through Advanced Manufacturing | Rory Roberts | NASA Small Business Innovation Research | \$45,000.00 |
| Solid-Oxide Thermo-Electrochemical Heat Engine (SoTech) for Efficient Thermal-to-Fuel Conversion | Rory Roberts | NASA Small Business Technology Transfer | \$48,000.00 |
| Real-time Data Driven Estimation of Aircraft Performance for Maneuver Predictions during Test and Evaluation. (T&E) | Hyung Yoon | Air Force Office of Scientific Research (AFOSR) | \$25,000.00 |
| Multiscale Modeling of Forest Mechanics and Growth to Mitigate Wind-Induced Damages | Peng Zhang | National Science Foundation | \$307,625.00 |
| ENG-NEZERO: Repurposing Second Life Batteries as Cloud-Edge Energy Storages | Nan Chen, Ping Chen, Indranil Bhattacharya | National Science Foundation | \$314,635.00 |
| Regionally Available Supplementary Cementitious Materials for Concrete | Benjamin Mohr, Md Shariful Islam | Illinois Tollway | \$99,809.00 |
| Modification No. 2 to Subcontract No. 374802TTU Phase II Option | Peng Zhang | Luna Innovations Incorporated | \$90,000.00 |
| Performance-Based Seismic Design of Bridges in Tennessee | Timothy Huff | Tennessee Department of Transportation-State | \$455,167.39 |

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|---|-------------------|---|------------------------|
| Secure Diabetic non-invasive Monitoring and Personalized Recommendations powered by Explainable Artificial Intelligence and IoT | Mohamed Mahmoud | Qatar University | \$125,457.94 |
| *NASA addition* Wire Free Quasi-wireless Energy Transfer for Modular and Adaptable Robotic Systems | Charles Van Neste | National Aeronautics and Space Administration | \$81,999.99 |
| TOTAL, PROPOSALS FOR 2023-2024 | | | \$22,695,849.32 |

Journal Papers

1. C.M. Emeghara, S.M. Mahajan, A. Arzani, “Direct Power Control of a Surface-Mounted Permanent Magnet Synchronous Generator Wind Turbine for Offshore Applications”, **IEEE Access J.**, **11**, pp. 62409-62423, 2023.

Conference Papers

1. Manicavasagam, R., Rogers, M. D., Mahajan, S., Craven, R., Emeghara, C.; “Relating Network Behavior to Demand-Response during dDOS Attack in the Smart Grid”; **Future Technologists Conference**; (Vol. 816). San Francisco, CA: Springer, November 2023.
2. A. Arzani, D. Ramasubramanian, D., P. Mitra, “Inverter-Based Resource Plants Operation in Combined Transmission-Distribution Weak Grids: A Case Study”, IEEE Power & Energy Society Innovative Smart Grid Technologies Conference (**ISGT**), Washington DC, USA, 2024
3. C.M. Emeghara, S.M. Mahajan, A. Arzani, E. Amako, “Evaluating Grid Support Features of Voltage Source Inverter: An Analysis of Direct Power Control”, IEEE North American Power Symposium (**NAPS**), Ashville, USA, 2023.
4. Q. Le, R. P. M. Craven and S. Mahajan, "Smart Agents for Academic Studies on Scale Model Grid," 2023; IEEE North American Power Symposium (**NAPS**), Asheville, NC, USA, 2023, pp. 1-6, doi: 10.1109/NAPS58826.2023.10318689.
5. Abigail C. Farris, William A. Stump, Christopher S. Johnson, Robert (P.M.) Craven, C.W. Van Neste, “Grid-Induced Telluric Currents for Non-Contact Load Monitoring and Fault Detection”, IEEE Energy Conversion Congress & Expo (**ECCE**)Oct 29, 2023.
6. Shanae Tyree, Clay Kelsey, “Smooth Sailing through the Post-Award”, **NCURA FRA Conference**, Honolulu, HI, USA, 2024.

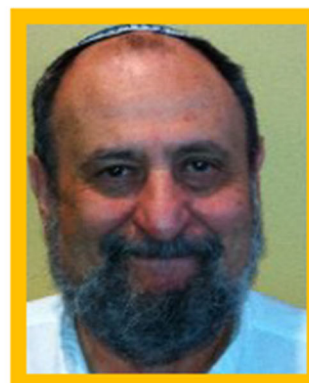


CENTER FOR ENERGY SYSTEMS RESEARCH SEMINAR ANNOUNCEMENT

“Quasi-Resonance in Solid State Power Storage Systems for Advanced Control System for Electric Vehicles”

Presented by:
Wolf Kohn Ph.D.
Chief Scientist of CrowdPoint Technologies

Date: Thursday, October 12, 2023
Time: 11:00 a.m. to 12:00 p.m.
Location: Brown Hall 208



Abstract:

This presentation gives an overview of an advanced distributed real time control and synchronization system for the electric drive system of an electric motorcycle. The presentation will illustrate the unique features of our approach that are responsible for the expected efficiency, long term between charges, and driver response quality. The features that we will discuss are: *Functional Modelling*, *Quasi-Resonance*, *Chattering Optimization*, and *Pareto Synchronization*. These features combine to make the control system produce a quality response to rider commands, battery longevity and short charging time. The presentation will focus on the control aspects, and not on the material aspects of the storage system units.

Speaker Bio:

Wolf Kohn is the Chief Scientist of CrowdPoint Technologies. He received his Ph.D. from MIT in Electrical Engineering and Computer Science. He co-founded ClearSight Systems, Inc., a company that developed decision and control systems in applications to financial and enterprise resource planning and scheduling. He co-founded Kohn-Nerode LLC, which is doing groundbreaking research and development in quantum hybrid control. Dr. Kohn has published over 100 refereed papers and book chapters, and two books on intelligent control. He has been awarded 25 patents in the US and abroad and has been a keynote speaker at several Control conferences. Dr. Kohn received Engineer of the Year awards from Boeing, Lockheed, NASA, and a teaching award from MIT. He has taught at CUNY Graduate Center, New York; Courant Institute of Mathematical Sciences (about nano-control systems), University of Houston, Wayne State University, and Rice University Department of EE. Dr Kohn recently retired from University of Washington ISE, where he was a professor for 20 years. He is the recipient of Lockheed's Robert E. Gross Award for technical excellence, and the Boeing Achievement Award from Boeing computer systems. Over the last ten years, he has been involved in the development of intelligent control and synchronization of microgrids—in particular, solid state battery control, advanced solar panel control, and IOT nanodevices.



CENTER FOR ENERGY SYSTEMS RESEARCH SEMINAR ANNOUNCEMENT

“Electrolyte Design for Li-ion and Li Metal Batteries”

Presented by:

Chunsheng Wang Ph.D.

Robert Franklin & Frances Riggs Wright
Distinguished Chair Professor
At the University of Maryland

Date: Thursday, October 19, 2023
Time: 11:00 a.m. to 12:00 p.m.
Location: Prescott Hall 225



Abstract:

The energy density, safety, and cycle life of rechargeable batteries are critical for electric vehicles (EV), electric aviation, and renewable energy storage. However, current Li-ion batteries still cannot simultaneously meet all these requirements. We developed non-flammable fluorinated organic electrolytes, water-in-salt electrolytes, and solid-state electrolytes to enhance the energy density, safety, and cycle life of the Li batteries. The electrolyte design principle for high-capacity anodes and high-voltage cathodes will be discussed.

Speaker Bio:

Dr. Chunsheng Wang is a Robert Franklin and Frances Riggs Wright Distinguished Chair Professor in Chemical and Biomolecular Engineering at the University of Maryland. He is an associate editor of ACS Applied Energy Materials, UMD Director of the UMD-ARL Center for Research in Extreme Battery, and a Fellow of the Electrochemical Society. His research focuses on rechargeable batteries and fuel cells. He has published more than 350 papers including Science, Nature, Nature Energy, Nature Materials, and Nature Chemistry. His work has been cited more than 63,000 times with an H-index of 134. He has been listed as a Highly Cited Researcher since 2018 by Clarivate and received the 2021 Battery Division Research Award from The Electrochemical Society.



CENTER FOR ENERGY SYSTEMS RESEARCH SEMINAR ANNOUNCEMENT

“Electrifying Large Scale Transport”

Presented by:

Matthew Pearce Ph.D.

Research Fellow with the University of
Auckland, NZ

Date: Thursday, October 26, 2023

Time: 4:00 p.m. to 5:00 p.m.

Location: Prescott Hall 225



Abstract:

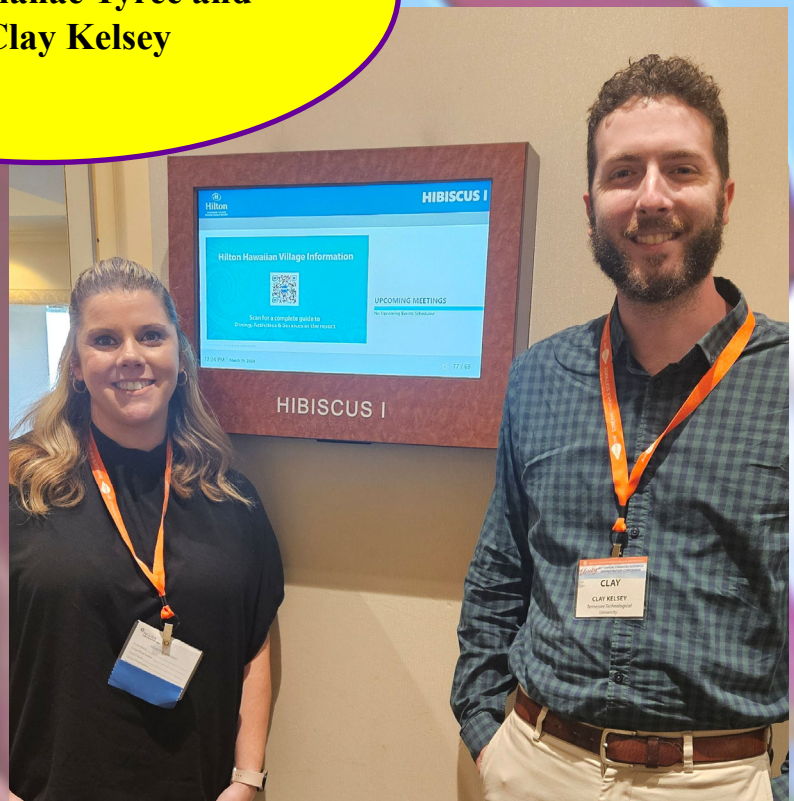
Long range electric aircraft require a substantial increase in motor power density. This is possible with superconducting electric motors in a cryogenic environment. This talk will cover our recent progress in producing fully cryogenic electric motor drives for superconducting aviation applications. Cryogenic characterization of switching transistors, integrated circuits and magnetic materials will be presented. Of particular interest is the device physics of GaN HEMT switching transistors which exhibit a significantly lower $R_{ds(on)}$ at cryogenic temperatures vs room temperatures. Converters constructed with these components achieve efficiencies greater than 99% and are immersion cooled in liquid nitrogen (-196 C) and can be conduction cooled to achieve even lower temperatures. In addition, the Inductive Power Transfer heavy transport electrification research ongoing at the University of Auckland and in wider New Zealand will be discussed.

Speaker Bio:

Matthew Pearce received a B.E. (Hons.) and Ph.D. degrees (on Inductive Power Transfer for Roads) in electrical and electronic engineering from The University of Auckland, Auckland, New Zealand, in 2014 and 2020, respectively. From 2021 to 2022, he was with Tennessee Tech as a Post Doctoral Researcher investigating capacitive and through the soil power transfer techniques with Dr. Van Neste. He has worked in health-care electronics, consulted on bioelectronics and instrumentation and inductive heating and power transfer systems. Continuing with a transportation theme, he is currently a Research Fellow with The University of Auckland, NZ, investigating high power electric motor drivers for transportation applications.



Photos from Seminar given at the NCURA FRA Conference by Mrs. Shanae Tyree and Mr. Clay Kelsey



**GRADUATE THESIS/DISSERTATIONS AND OTHER STUDENT PUBLICATIONS
MASTERS****WILLIAM STUMP**

“Directional Step Potential Sensor Using Horizontal Surface Electrodes”

Fall 2023

Dr. Charles Van Neste

Electrical and Computer Engineering

ABIGAIL FARRIS

“Grid Induced Telluric Currents for Non-Contact Load Monitoring and Fault Detection”

Fall 2023

Dr. Charles Van Neste

Electrical and Computer Engineering

MICHAEL MINER

“Lithium Ion Cell Temperature and Pressure Monitoring for Potential Failure Prediction”

Fall 2023

Dr. Ali Alouani

Electrical and Computer Engineering

CHIJOKE EKECHI

“Intelligent Control of a Swarm of Unmanned Aerial Vehicles in Turbulent Environments Using Clustering -PPO Algorithm”

Fall 2023

Dr. Tarek Elfouly

Electrical and Computer Engineering

ZACK BIKAKIS

“An Argument for the Dynamic Ether of Cosmic Space”

Fall 2023

Dr. Indranil Bhattacharya

Electrical and Computer Engineering

SAMUEL FISHER

“Experimental and Analytical Evaluation and Installation of Spatially Distributed Smart Building Sensors”

Spring 2024

Dr. Craig Henderson

Civil Engineering

NABIL B.S. SHUVA

“Performance Analysis of Smart Agent Based Distribution System”

Spring 2024

Dr. Satish M. Mahajan

Electrical and Computer Engineering

DEVIN ROLAND

“10.6 Micrometer CO₂ Infrared Laser Beam Behavior Within Turbulent Humid Flow”

Spring 2024

Dr. Ahmad Vasselbehagh

Mechanical Engineering

WARREN SIMS

“Selection of MET Tower and Instrumentation for the Future Analysis of Thermal Transport Processes in the Atmospheric Boundary Layer in Presence of Utility-Scale Photovoltaic Plants

Spring 2024

Dr. Ethan Languri

Mechanical Engineering

NOAH SIMPSON

“Analytical Design, Experimental Testing, and Simulation of an Ejector for Anode Off-Gas Recirculation in a 1 kW Solid Oxide Fuel Cell”

Spring 2024

Dr. Rory Roberts

Mechanical Engineering

Number of MS Students: 10

**GRADUATE THESIS/DISSERTATIONS AND OTHER STUDENT PUBLICATIONS
PHD****MD SHARIFUL ISLAM**

“Properties and Optimization of Zeolite Modified Cementitious Materials”

Summer 2023

Dr. Benjamin Mohr

Engineering

M. RAYHAN AHMED MITHU

“Incorporating a Knowledge Base into Machine Learning Techniques for Forensic Analysis of Control Systems”

Summer 2023

Dr. Michael Rogers

Engineering

ADEWALE ADEYEMO

“Towards Securing Edge Intelligence for Inference in Horizontal Collaborative Environments”

Summer 2023

Dr. Syed Hasan

Engineering

VINIT PRABHU

“Enhanced Thermal Energy Storage and Transfer for Industry”

Summer 2023

Dr. Ethan Languri and Dr. Sally Pardue

Engineering

SAANYOL IGBAX

“Optimization of Biodiesel Production Using Ultrasound and Electrostatic Separation”

Summer 2023

Dr. Stephen Idem & Dr. Dan Swartling

Engineering

REZA NOURI

“The Need to Go Deeper: The Employment of a Convolutional Neural Network to Analyze Turbulent Flows Frequency Content”

Summer 2023

Dr. Ahmad Vasselbehagh

Engineering

SUSHIL POUDEL

“Securing Front-End Vehicle-to-Grid Communications: Malware Attacks and Defense Strategies in Public EV Charging Stations”

Fall 2023

Dr. Muhammad Ismail

Engineering

RAJESH MANICAVASAGAM

“Identifying and Detecting Network Indicators of Compromise (IoCs) for Demand Response Programs”

Fall 2023

Dr. Michael Rogers

Engineering

CHIKEZIE EMEGHARA

“Modeling and Control of Inverter-Based Resources for Grid Applications”

Fall 2023

Dr. Satish M. Mahajan

Engineering

OLUWASEYI AYENI

“Two Phase Modeling of Fluid Transport in Massively Arrayed Fibrous Channels Using Computational Fluid Mechanics (CFD)”

Spring 2024

Dr. Holly Stretz

Engineering

DANIEL CANNON

“Understanding the Impact of Photovoltaic Solar Panels on The Near-Ground Atmosphere: A Pilot Study”

Spring 2024

Dr. Sally Pardue

Engineering

Number of Ph.D. Students: 11

M.S. STUDENTS

| Name | Dept. | Source of Support | Advisor |
|-----------------------|--------------|--------------------------|---------------------------|
| Henry Asamany | CEE | TDOT | Dr. Daniel VandenBerge |
| Samuel Asare-Duah | CEE | CESR | Dr. Daniel Badoe |
| Shushanta Chakraborty | CEE | TDOT | Dr. Daniel VandenBerge |
| Grace Dadzie | ECE | CESR/Water Center | Dr. Albert Kalyanapu |
| Md Saeid Ebna Maleque | CEE | TDOT Early Age Concrete | Dr. Benjamin Mohr |
| Abbie Ferguson | CEE | TDOT UTAP | Dr. Timothy Huff |
| Brett Harden | ECE | TVA Endowment | Dr. Charles Van Neste |
| S M Mostaq Hossain | CSC | NSF & CESR | Dr. Sheikh Ghafoor |
| Pramashis Kar | CEE | TDOT Early Age Concrete | Dr. Benjamin Mohr |
| Michael Miner | ECE | CESR | Dr. Ali Alouani |
| Conor Orr | ECE | SitS | Dr. Charles Van Neste |
| Taiye Owu | ECE | CESR | Dr. Satish M. Mahajan |
| Carson Pope | ECE | NASA & SitS | Dr. Charles Van Neste |
| Devin Roland | ME | TVA | Dr. Ahmed Vasselbehagh |
| Nabil Shuva | ECE | CESR | Dr. Satish M. Mahajan |
| Noah Simpson | ME | CESR | Dr. Arman Sargolzaei |
| Babatunde Dami Soyoye | ECE | IUSE | Dr. Indranil Bhattacharya |
| William Stump | ECE | NSF & CESR | Dr. Charles Van Neste |
| Gabriel Tardy | CEE | CESR | Dr. Jane Liu |
| Michael Tidwell | ECE | NSF & CESR | Dr. Charles Van Neste |
| Yang Zheng | ECE | CESR | Dr. Nan Chen |

Ph.D. STUDENTS

| Name | Dept. | Source of Support | Advisor |
|------------------------------|--------------|----------------------------|---------------------------|
| A. Isaac Adeleke | CHE | CESR | Dr. Pedro Arce |
| Ejikeme Amako | ECE | ARISE & CESR | Dr. Satish M. Mahajan |
| Mary Vinolisha Antony Dhason | ECE | CESR | Dr. Indranil Bhattacharya |
| Junaid Anwar | ECE | NIST | Dr. Syed Rizvi |
| Brendan Atarigiya | CEE | CESR | Dr. Daniel VandenBerge |
| Shampa Banik | CSC | ARISE | Dr. Michael Rogers |
| Trapa Banik | ECE | TVA Endowment & NSF RET | Dr. Indranil Bhattacharya |
| Rajat Bhattarai | CSC | NASA via UNC | Dr. Sheikh Ghafoor |
| Atef Bondok | ECE | QNRF & HBKU | Dr. Mohamed Mahmoud |
| D. Trevor Cannon | ME | TVA & NSF | Dr. Ahmed Vasselbehagh |
| Nathan Duran-Ledezma | CHE | IUSE & NSF RET | Dr. Joseph Biernacki |
| Islam Elgarhy | ECE | QNRF & HBKU | Dr. Mohamed Mahmoud |
| Chikezie Emeghara | ECE | CESR | Dr. Satish M. Mahajan |
| Mariam Gado | CSC | NSF | Dr. Muhammad Ismail |
| Ty Hagan | ME | TVA Sequoyah Nuclear | Dr. Ahmed Vasselbehagh |
| Eslam Hasan | CSC | NSF & TEES | Dr. Muhammad Ismail |
| Md Shariful Islam | CEE | CESR | Dr. Arman Sargolzaei |
| Shafieh Karami | CHE | CESR | Dr. Pedro Arce |
| Sina Kazemipour | ME | CESR | Dr. Peng Zhang |
| Trevor Kramer | ME | ARPA-E | Dr. Rory Roberts |
| W. Luke Lambert | CSC | ORNL | Dr. Sheikh Ghafoor |
| Priyanka Mahajan | CHE | CESR | Dr. Pedro Arce |
| Elmahedi Mahalal | CSC | NSF | Dr. Muhammad Ismail |
| Tyler Marcrum | ECE | NSF & CESR | Dr. Charles Van Neste |
| M. Rayhan Ahmed Mithu | CSC | EPRI | Dr. Sheikh Ghafoor |
| Mohamed Shaban Mohamed | CSC | QNRF & NSF | Dr. Muhammad Ismail |
| Umair Mughal | CSC | QNRF & NSF | Dr. Muhammad Ismail |
| Grace Nansamba | CSC | CESR | Dr. Indranil Bhattacharya |
| Reza Nouri | ME | TVA Sequoyah Nuclear | Dr. Ahmed Vasselbehagh |
| Sushil Poudel | CSC | NSF | Dr. Muhammad Ismail |
| Mohsen Pourfallah | ME | CESR | Dr. Ethan Languri |
| Ashwini Rathod | ECE | CESR | Dr. Satish M. Mahajan |
| Kundan Rathod | CEE | TDOT & CESR | Dr. Timothy Huff |
| Sohag Kumar Saha | ECE | ARC UCDD & CESR | Dr. Satish M. Mahajan |
| Nabil Bin Shahadat Shuva | ECE | CESR | Dr. Satish M. Mahajan |
| Warren Sims | ME | NSF & TVA Sequoyah Nuclear | Dr. Ahmed Vasselbehagh |
| Robert John Thomas | ECE | CESR | Dr. Charles Van Neste |

ACRONYMS:

| | |
|-----------------------------------|--|
| ARC UCDD | Appalachian Regional Commission via Upper Cumberland Development District |
| ARPA-E | Advanced Research Projects Agency-Energy via Department of Energy |
| CEE | Civil & Environmental Engineering |
| CESR | Center for Energy Systems Research (Tennessee Technological University) |
| CHE | Chemical Engineering |
| CSC | Computer Science |
| ECE | Electrical & Computer Engineering |
| EPRI Distribution Energy Resource | Electric Power Research Institute |
| IUSE | Improved Undergraduate Success through Effective Critical Thinking via National Science Foundation |
| MBA | Master's of Business Administration |
| ME | Mechanical Engineering |
| NASA | National Aeronautics and Space Administration |
| NIBS | National Institute of Building Sciences |
| NIST | National Institute of Standards and Technology |
| NSF | National Science Foundation |
| QNRf | Qatar NRF |
| Qatar via TAMU | Qatar via Texas A&M University |
| RET | Research Experiences for Teachers |
| TBR SERS Project | Tennessee Board of Regents via Student Engagement, Retention, and Success Grant |
| TVA | Tennessee Valley Authority |
| TVA Endowment | Tennessee Valley Authority Endowment |
| TVA-Sequoyah Nuclear | Tennessee Valley Authority-Sequoyah Nuclear |

HOURLY STUDENT PERSONNEL

Undergraduate StudentsDegrees and Major

| | |
|--------------------|------------------|
| Gabriel Adams | B.S. CSC |
| Jessica Baugh | B.S. CSC |
| Matthew Beausoleil | B.S. ECE |
| Cricket Bergner | B.S. Physics |
| Matthew Burst | B.S. CSC |
| Israel Cansino | B.S. CEE |
| Easton Cash | B.S. CHE |
| Presley Connelly | B.S. Mathematics |
| Ryan Cunningham | B.S. CEE |
| Abbie Ferguson | B.S. CEE |
| Anna Gore | B.S. CEE |
| Calvin Guzman | B.S. CSC |
| Megan Hendrickson | B.S. CSC |
| Shaina Larsen | B.S. CHE |
| Isaac Legault | B.S. ME |
| Dakota Moye | B.S. ECE |
| Conor Orr | B.S. ECE |
| Micah Owens | B.S. CEE |
| Carson Pope | B.S. ECE |
| Sarah Shaw | B.S. CEE |
| Nikolas Vassilev | B.S. CHE |
| Ezekiel Vespie | B.S. Physics |
| Joel Wallace | B.S. CEE |
| Giovanni Williams | B.S. ECE |

M.S. Graduate Students

Landon Davis

Christopher Elson

Joseph Hunter Himes

Rashed Rashidi

Ph.D. Graduate Students

Oluwaseyi Ayeni

Trapa Banik

D. Trevor Cannon

Nathan Duran-Ledezma

Mariam Gado

Eslam Hasan

Brandon Hines

Christopher (Storm) Johnson

Elmahedi Mahalal

Chloe (Cadence) Miller

Mohamed Shaban Mohamed

Umair Mughal

Owen O'Connor

Sushil Poudel

Nicholas Skjellum

Degrees and Major

M.S. CEE

M.S. CHE

M.S. CHE

M.S. CHE

Degrees and Major

Ph.D. CHE

Ph.D. ECE

Ph.D. ME

Ph.D. CHE

Ph.D. CSC

Ph.D. CSC

Ph.D. ME

Ph.D. ECE

Ph.D. CSC

Ph.D. Chemistry

Ph.D. CSC

Ph.D. CSC

PH.D. ECE

Ph.D. CSC

Ph.D. CSC

FWS & UAS

Gabriel Adams

Michael Ezelle

Nicolas Mangrum

Noah Tripucka

*FWS: Federal Work Study

*UAS: University Academic Service

Degrees and Major

B.S. CSC

B.S. ME

B.S. ECE

B.S. ETM

| 2023-2024 | | | | |
|--------------------|--|--|------------------------|--|
| Student | Sponsor | Program | Faculty Advisor | |
| Gabriel Adams | Federal Work Study | | Mr. Robert Craven | |
| Gabriel Adams | Appalachian Regional Commission | Smart Grid Development Consortium and HILLTOP Platform Expansion | Mr. Robert Craven | |
| Jessica Baugh | National Science Foundation | NSF: Collaborative Research: SHIELD: Strategic Holistic Framework for Intrusion Prevention Using Multi-modal Data in Power Systems | Dr. Muhammad Ismail | |
| Matthew Beausoleil | National Science Foundation | NSF: Collaborative Research: SitS: Collaborative: Long Range Wirelessly Powered Multi-variable Sensor Network for Continuous Monitoring of the Soil Health | Dr. Charles Van Neste | |
| Cricket Bergner | Department of Energy | DOE: The Structure of Neutron-Rich Deformed Nuclei Studied via Beta Decay | Dr. Mustafa Rajabali | |
| Matthew Burst | National Science Foundation | NSF: Collaborative Research: NeTS: Jun03: SWIFT: Softwarization of Intelligence for Efficient G6 Mobile Networks | Dr. Muhammad Ismail | |
| Israel Cansino | Tennessee Department of Transportation - Federal | TDOT Federal Project, Guidance for Chemical Stabilization of Pavement Subgrade Soils in Tennessee | Dr. Daniel VandenBerge | |
| Israel Cansino | Tennessee Department of Transportation - Federal | TDOT Federal-Early Age Concrete Acceptance | Dr. Benjamin Mohr | |

UNDERGRADUATE RESEARCH PROJECTS, continued SM-11

| | | | |
|-------------------|--|--|------------------------|
| Easton Cash | National Science Foundation | NSF: Collaborative Research: SitS: Collaborative: Long Range Wirelessly Powered Multi-variable Sensor Network for Continuous Monitoring of the Soil Health | Dr. Holly Stretz |
| Presley Connelly | National Science Foundation | NSF: Collaborative Research: SHIELD: Strategic Holistic Framework for Intrusion Prevention Using Multi-modal Data in Power Systems | Dr. Muhammad Ismail |
| Ryan Cunningham | Tennessee Department of Transportation - Federal | TDOT Federal Project, Guidance for Chemical Stabilization of Pavement Sub-grade Soils in Tennessee | Dr. Daniel VandenBerge |
| Michael Ezelle | Federal Work Study | Research Facilitator, Smart Grid Laboratory | Mr. Robert Craven |
| Abbie Ferguson | National Institute of Building Sciences | NIBS Academic Review and Rewrite of NAVFAC DM 7.03 | Dr. Daniel VandenBerge |
| Anna Gore | Tennessee Department of Transportation - Federal | TDOT Federal Project, Guidance for Chemical Stabilization of Pavement Sub-grade Soils in Tennessee | Dr. Daniel VandenBerge |
| Anna Gore | National Institute of Building Sciences | NIBS Academic Review and Rewrite of NAVFAC DM 7.03 | Dr. Daniel VandenBerge |
| Megan Hendrickson | University of North Carolina via NASA | UNC via NASA: Lake Observations from Citizen Scientists and Satellites | Dr. Sheikh Ghafoor |
| Shaina G. Larsen | National Science Foundation | Long Range Wirelessly Powered Multi-variable Sensor Network for Continuous Monitoring of the Soil Health | Dr. Holly Stretz |

UNDERGRADUATE RESEARCH PROJECTS, continued SM-11

| | | | |
|---------------|--|--|------------------------|
| Isaac Legault | Center for Energy Systems Research | Smart Grid Development Consortium and HILLTOP Platform Expansion | Mr. Robert Craven |
| Dakota Moye | Department of Energy | The Structure of Neutron-Rich Deformed Nuclei Studied via Beta Decay | Dr. Mustafa Rajabali |
| Conor Orr | National Science Foundation | Long Range Wirelessly Powered Multi-variable Sensor Network for Continuous Monitoring of the Soil Health | Dr. Charles Van Neste |
| Micah Owens | Tennessee Department of Transportation - Federal | TDOT Federal Project, Guidance for Chemical Stabilization of Pavement Subgrade Soils in Tennessee | Dr. Daniel VandenBerge |
| Micah Owens | Tennessee Department of Transportation - Federal | TDOT Federal-Early Age Concrete Acceptance | Dr. Benjamin Mohr |
| Carson Pope | National Science Foundation | NSF: Collaborative Research: SitS: Collaborative: Long Range Wirelessly Powered Multi-variable Sensor Network for Continuous Monitoring of the Soil Health | Dr. Charles Van Neste |
| Carson Pope | National Aeronautics and Space Administration | Quasi-Wireless Capacitive (QWiC) Surface Power for Adaptive and Reconfigurable Sensor Elements on Space Infrastructure | Dr. Charles Van Neste |
| Sarah Shaw | Tennessee Department of Transportation - State | TDOT State-Early Age Concrete Acceptance | Dr. Benjamin Mohr |
| Sarah Shaw | Tennessee Department of Transportation - Federal | TDOT Federal-Early Age Concrete Acceptance | Dr. Benjamin Mohr |

| | | | |
|-------------------|--------------------------------|--|-----------------------|
| Nikolas Vassilev | Department of Energy | DOE: The Structure of Neutron-Rich Deformed Nuclei Studied via Beta Decay | Dr. Mustafa Rajabali |
| Ezekiel Vespie | Department of Energy | DOE: The Structure of Neutron-Rich Deformed Nuclei Studied via Beta Decay | Dr. Mustafa Rajabali |
| Joel Wallace | Tennessee Concrete Association | Reduction in Compressive Strength Test Results due to Above Specification Initial Concrete Cylinder Curing Temperature | Dr. Lewis Crouch |
| Giovanni Williams | National Science Foundation | NSF: Collaborative Research: SitS: Collaborative: Long Range Wirelessly Powered Multi-variable Sensor Network for Continuous Monitoring of the Soil Health | Dr. Charles Van Neste |

FELLOWSHIP RECIPIENTS

2023-2024

| | | | | | |
|-------------------|-----|-----|---------|-----------------------|---|
| Creek Anderson | MS | ES | Arce | 8/1/2023 to 7/31/2024 | NSF NRT Engendering the Spirit of Gadugi at the FEW Nexus Program |
| Ronnie Dunn | PhD | ES | Arce | 8/1/2023 to 7/31/2024 | NSF NRT Engendering the Spirit of Gadugi at the FEW Nexus Program |
| Jessee Griffith | MS | ES | Arce | 8/1/2023 to 7/31/2024 | NSF NRT Engendering the Spirit of Gadugi at the FEW Nexus Program |
| Michael Miner | MS | ECE | Mahajan | 1/1/2024 to 7/31/2024 | NSF NRT Engendering the Spirit of Gadugi at the FEW Nexus Program |
| Katie Pabody | MS | ES | Arce | 8/1/2023 to 7/31/2024 | NSF NRT Engendering the Spirit of Gadugi at the FEW Nexus Program |
| Catherine Philips | PhD | ES | Arce | 8/1/2023 to 7/31/2024 | NSF NRT Engendering the Spirit of Gadugi at the FEW Nexus Program |
| Carey Wilson | PhD | ES | Arce | 8/1/2023 to 7/31/2024 | NSF NRT Engendering the Spirit of Gadugi at the FEW Nexus Program |



ACTUAL, PROPOSED, AND REQUESTED BUDGET SCHEDULE 7

Schedule 7

CENTERS OF EXCELLENCE ACTUAL, PROPOSED, AND REQUESTED BUDGET

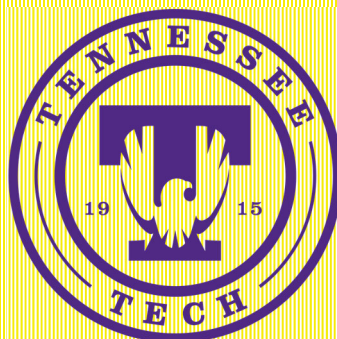
Institution:

Tennessee Technological University

Center:

Center for Energy Systems Research

| | FY 2023-24 Actual | | | FY 2024-25 Proposed | | | FY 2025-26 Requested | | |
|--|---|--------------------|--------------------|---------------------|--------------------|--------------------|----------------------|--------------------|--------------------|
| | Matching | Appopr. | Total | Matching | Appopr. | Total | Matching | Appopr. | Total |
| Expenditures | | | | | | | | | |
| Salaries | | | | | | | | | |
| Faculty | \$825,380 | \$220,661 | \$1,046,041 | \$200,000 | \$489,618 | \$689,618 | \$180,000 | \$400,000 | \$580,000 |
| Other Professional | \$398,841 | \$220,022 | \$618,862 | \$20,000 | \$254,088 | \$274,088 | \$17,000 | \$220,000 | \$237,000 |
| Clerical/ Supporting | \$0 | \$46,215 | \$46,215 | \$0 | \$52,700 | \$52,700 | \$0 | \$60,000 | \$60,000 |
| Assistantships | \$476,949 | \$218,155 | \$695,104 | \$170,000 | \$170,000 | \$340,000 | \$150,000 | \$200,000 | \$350,000 |
| Hourly Students | \$81,108 | \$9,417 | \$90,525 | \$50,000 | \$9,000 | \$59,000 | \$20,000 | \$12,000 | \$32,000 |
| Total Salaries | \$1,782,277 | \$714,469 | \$2,496,746 | \$440,000 | \$975,406 | \$1,415,406 | \$367,000 | \$892,000 | \$1,259,000 |
| Fringe Benefits | \$642,821 | \$284,569 | \$927,390 | \$259,388 | \$180,000 | \$439,388 | \$200,000 | \$300,000 | \$500,000 |
| Total Personnel | \$2,425,099 | \$999,038 | \$3,424,137 | \$699,388 | \$1,155,406 | \$1,854,794 | \$567,000 | \$1,192,000 | \$1,759,000 |
| Non-Personnel | | | | | | | | | |
| Travel | \$96,627 | \$31,059 | \$127,686 | \$30,552 | \$3,294 | \$33,846 | \$20,000 | \$10,000 | \$30,000 |
| Software | \$0 | \$3,617 | \$3,617 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 |
| Books & Journals | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 |
| Other Supplies | \$205,319 | \$64,250 | \$269,568 | \$50,000 | \$547,078 | \$597,078 | \$50,000 | \$76,270 | \$126,270 |
| Equipment | \$816,136 | \$0 | \$816,136 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 |
| Maintenance | \$0 | \$7,385 | \$7,385 | \$0 | \$0 | \$0 | \$0 | \$10,000 | \$10,000 |
| Scholarships | \$378,007 | \$0 | \$378,007 | \$0 | \$0 | \$0 | \$10,000 | \$0 | \$10,000 |
| Consultants | \$2,096,723 | \$4,169 | \$2,100,892 | \$0 | \$0 | \$0 | \$0 | \$5,000 | \$5,000 |
| Renovation | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 |
| Other (Specify): | | | \$0 | | | \$0 | | | \$0 |
| Seminars/Workshops/Conf | \$0 | \$2,679 | \$2,679 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 |
| | | | \$0 | | | \$0 | | | \$0 |
| | | | \$0 | | | \$0 | | | \$0 |
| Total Non-Personnel | \$3,592,812 | \$113,159 | \$3,705,970 | \$80,552 | \$550,372 | \$630,924 | \$80,000 | \$101,270 | \$181,270 |
| GRAND TOTAL | \$6,017,910 | \$1,112,197 | \$7,130,107 | \$779,940 | \$1,705,778 | \$2,485,718 | \$647,000 | \$1,293,270 | \$1,940,270 |
| Revenue | NOTE: Actual Matching Funds do not include Indirect Costs of \$1,074,948.04 for FY 2023-2024. | | | | | | | | |
| New State Appropriation | | \$1,138,300 | \$1,138,300 | | \$1,175,700 | \$1,175,700 | | \$1,293,270 | \$1,293,270 |
| Carryover State | | \$580,318 | \$580,318 | | \$606,421 | \$606,421 | | | \$0 |
| New Matching Funds | \$6,017,910 | | \$6,017,910 | \$779,940 | | \$779,940 | \$740,000 | | \$740,000 |
| Carryover from Previous Matching Funds | | \$401,435 | \$401,435 | | | \$0 | | | \$0 |
| Total Revenue | \$6,017,910 | \$2,120,054 | \$8,137,964 | \$779,940 | \$1,782,121 | \$2,562,061 | \$740,000 | \$1,293,270 | \$2,033,270 |



JUSTIFICATION FOR 2025-2026 APPROPRIATIONS REQUEST

The Center for Energy Systems Research (CESR) is requesting a 10% increase in anticipation of additional expenses during 2025-2026. The increased expenses include additional costs for personnel appointments of support staff, the third Research Assistant Professor, and funding for additional undergraduate and graduate students increased tuition and stipends that will allow them to participate in the research activities of the CESR.

