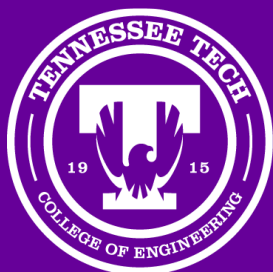


# Center For Energy Systems Research

## Tennessee Tech University

Annual Report for Fiscal Year 2022-2023



# Annual Report for Fiscal Year

July 1, 2022—June 30, 2023

Satish M. Mahajan, Director

[www.tntech.edu/cesr](http://www.tntech.edu/cesr)



Center for  
Energy  
Systems  
Research

*“Where research is put into practice.”*



**Tennessee**  
**TECH**

# Center for Energy Systems Research

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**Front Cover:** Atmospheric electricity measurement experiment using a fluorescent tube atop a fiberglass mast to enhance measurement results.

Photo submitted by Dr. Charles Van Neste.

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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 2022-2023. The CESR continues to focus on three strategic research areas: Smart Grid, Resilient Infrastructure, and Wireless Power Transfer.

Year 2022-2023 was another good year for the CESR. This year, the external funding increased by about 9.1 percent over the previous year for a total of **\$2,914,706.51, making 2022-2023 another record-breaking year** in the 38-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 seventh time since 1985 that the CESR activations have crossed \$2 million, and now five years in a row out of those seven years.

The proposal activity is holding steady at over \$20 million for 2022-2023. 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 2022-2023 fiscal year, the CESR funded 33 M.S. assistantships (12 on grants only, 15 on CESR only, and 6 on grants plus CESR, plus other University sources combined); and 41 Ph.D. assistantships (22 on grants only, 10 on CESR only, and 9 on grants plus CESR, plus other University sources). The CESR supported a total of 26 graduate students on an hourly basis. The combined headcount of the CESR-supported graduate students is 74. The CESR also supported a total of 32 undergraduate students, a significant number of them on the grants.

The CESR faculty associates received grants from QNRF, EPRI, DOE, TBR, DOT, LUNA, NSF, NASA, NIST, NSA, ORNL, SOCHE, SPIDA, UCDD/ARC, TVA, ARPA-E, 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.

Dr. Sherif Gaweesh joined the CESR in February 2023 as Research Assistant Professor. His presence meant a great deal to our Transportation Engineering group. Dr. Gaweesh has taken a tenure-track, Assistant Professor position for academic year 2023-2024. A search for a new Research Assistant Professor in the Transportation Engineering will begin shortly. The CESR will continue to invest in new faculty via start-up packages. This year the CESR is committing to the start-up packages of three new faculty—Dr. Yoon in Mechanical Engineering; and Dr. Nine and Dr. Skjellam, both in Computer Science. We welcome them and look forward to their contributions.

Both Ms. Anysa Milum and Ms. Sara Howard have left the CESR as Center Manager and Grants Analyst, respectively. Ms. Shanae Tyree joined the CESR as a Grants Analyst and has helped tremendously with pre-award and post-award support aspects. Ms. Linda Thurman has joined as an Administrative Associate and shows great promise in her attention to detail and diligence to customer service. Mr. Clay Kelsey has joined as a Financial Associate and is assisting with budgets, proposals, and activations. Ms. Barbara Fenlon was promoted to Financial Analyst and her dedication to the goals of the CESR are much appreciated. Mr. Robert Craven continues to provide excellent support in his role as research engineer. 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, 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, Financial Analyst, Financial Associate, 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.

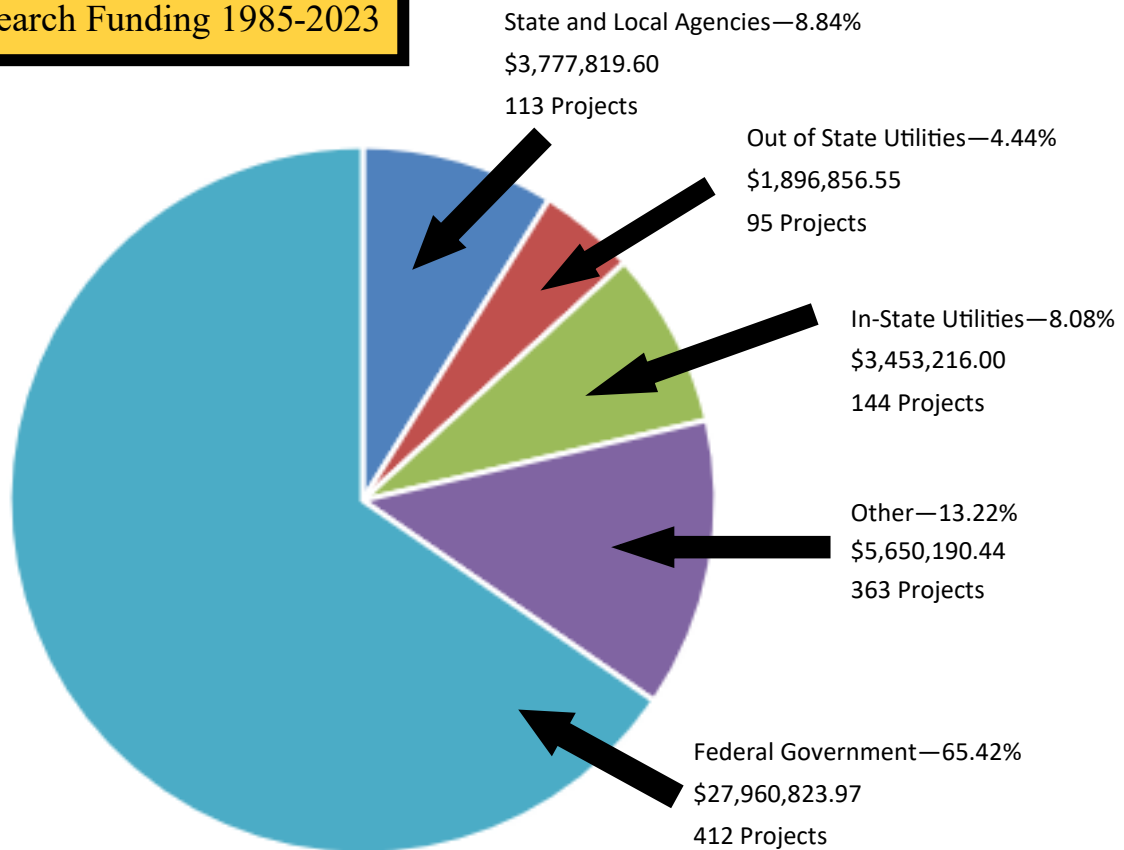
The Center promotes international collaboration by hosting visiting scholars, scientists and engineers and establishing Memoranda of Understanding with international academic institutions and research organizations.

**PROGRAMMATIC REPORT**

Research contract and grant awards included in Matching from July 1, 2022 thru June 30, 2023 total \$2,336,603.00. Indirect costs of approximately \$578,103 were also received during the 2022-2023 Fiscal Year. The result is that the 2022-2023 Matching and Indirect Costs total \$2,914,706. The State Appropriation was \$1,079,300 for 2022-2023.

CESR continues to enjoy a broad base of support. The funding categories for 1985 thru 2023 as illustrated in Figure 1 are: in-state utilities, 8.08 percent; out-of-state utilities, 4.44 percent; state and local agencies, 8.84 percent; federal government, 65.42 percent; other, 13.22 percent. The “other” category includes a variety of national and international industries, universities and professional societies. Through June 2023, the cumulative research funding of the Center is \$39,709,689. State appropriations are compared to matching, on an annual, cumulative basis, in Figure 2. 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 38-year match of about \$39.7 million represents 115 percent of the state appropriations of \$34.4 million. The cumulative total of indirect costs of approximately \$7.7 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 1985-2023**



**Figure 1: Types of Research Funding**

# Center for Energy Systems Research

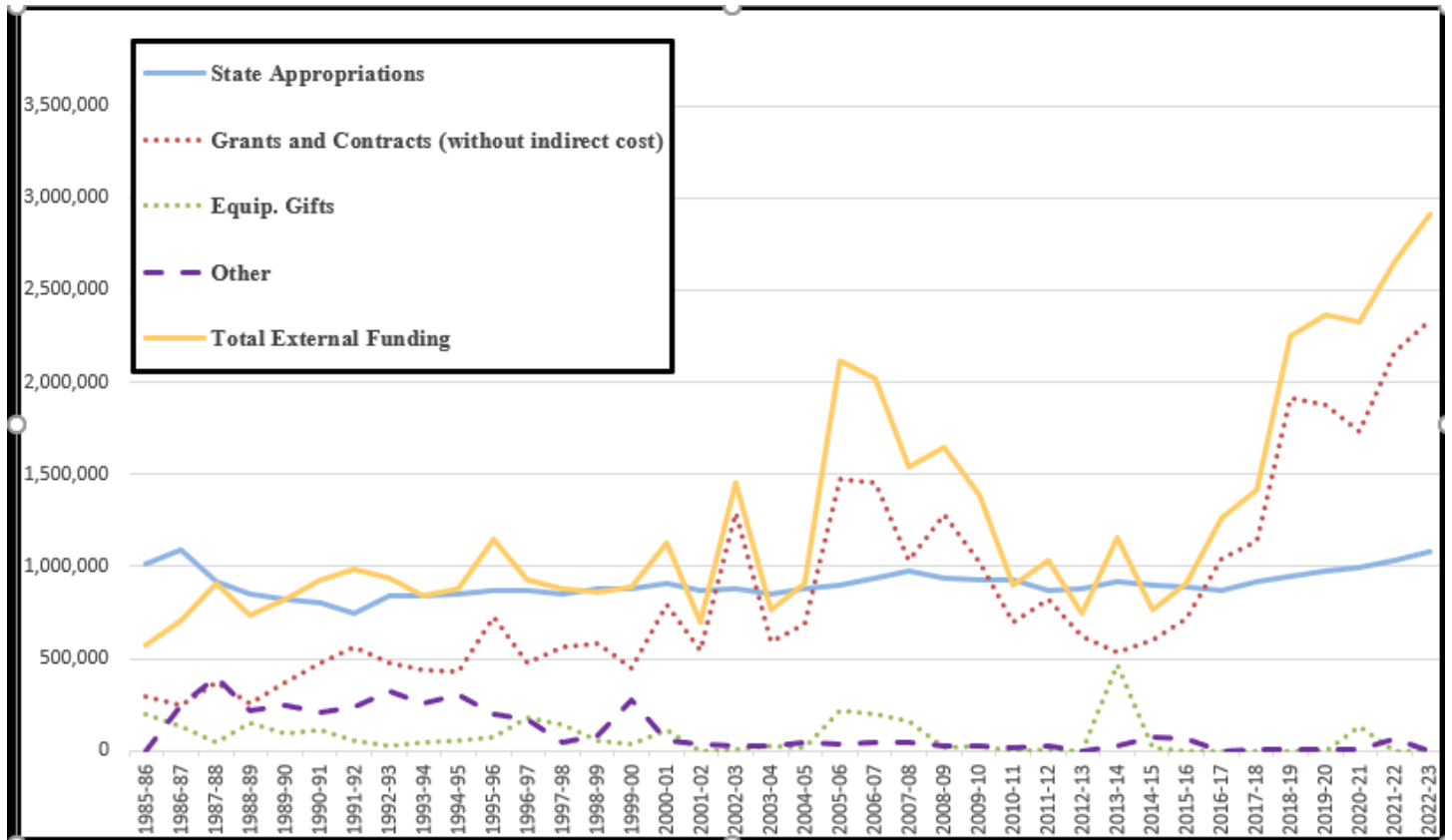


Figure 2: Historical State Appropriations, Matching & Total External Funding 1985-2023



## Center for Energy Systems Research

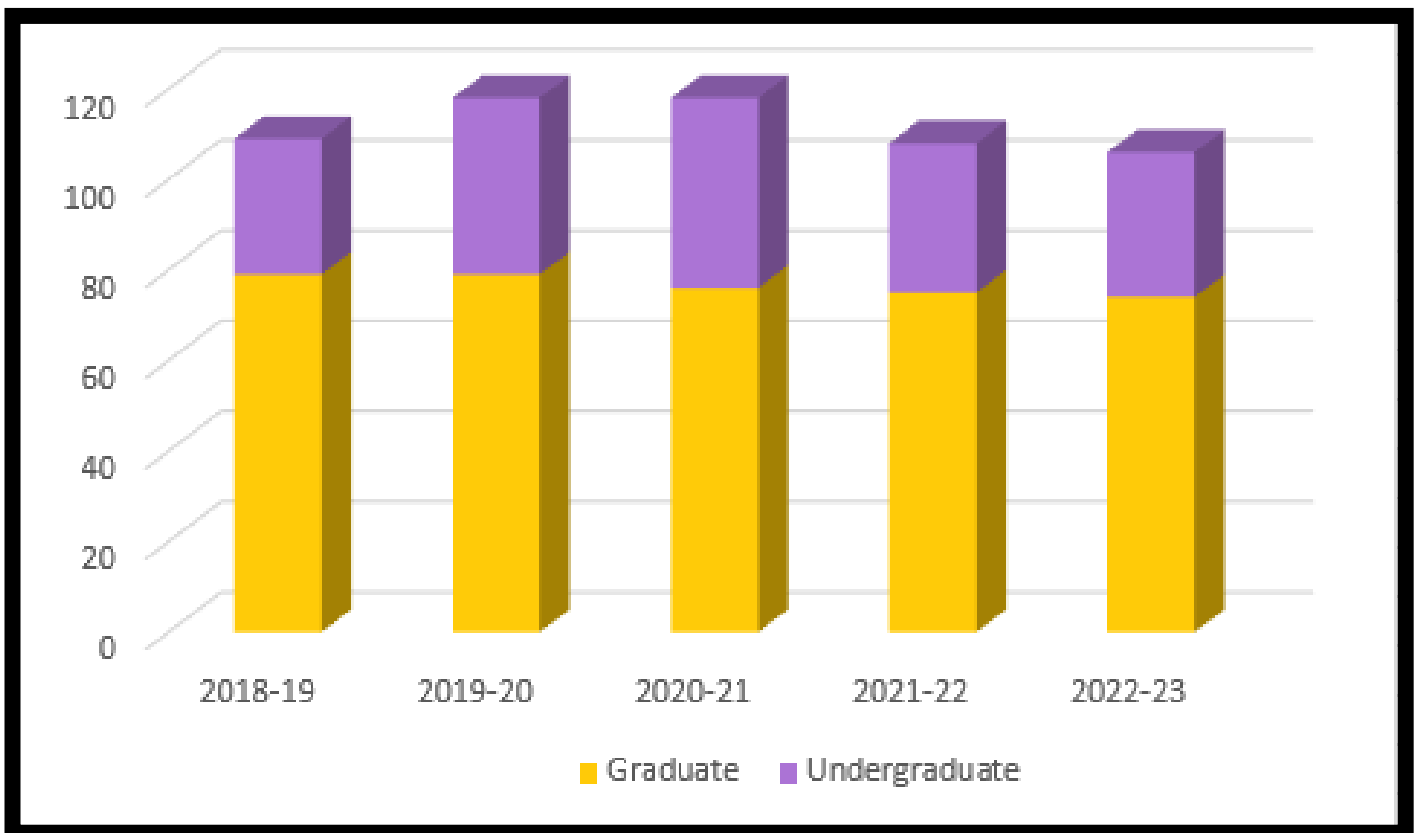


Figure 3: Number of Students Supported Financially

**Dr. Mohamed Mahmoud** of the ECE Department, was the winner of the **Caplenor Faculty Research Award** which is awarded annually to one member of the faculty of Tennessee Tech University for outstanding research accomplished while employed at the University.



Dr. Mohamed Mahmoud

**Dr. Mohamed Mahmoud** was also a recipient of the **Wings up 100 Research Achievement Award**. This award is given to TTU faculty members who activated at least \$100K of external research grants.



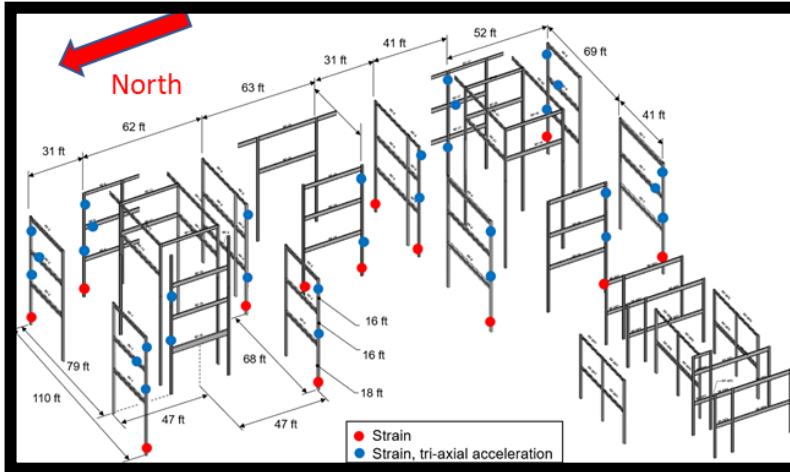
Dr. Syed Rizvi

**Dr. Syed Ali Asad Rizvi**, of the ECE Department, was the winner of the TTU Scholastic Research Award in April 2023



**Dr. Ahmad Vasselbehagh** of the ME Department, was the winner of the 2023 Brown-Henderson Outstanding Engineering Faculty Award. The award was established in honor of the late Dean Emeritus James Seay Brown and the late Dean James M. Henderson.

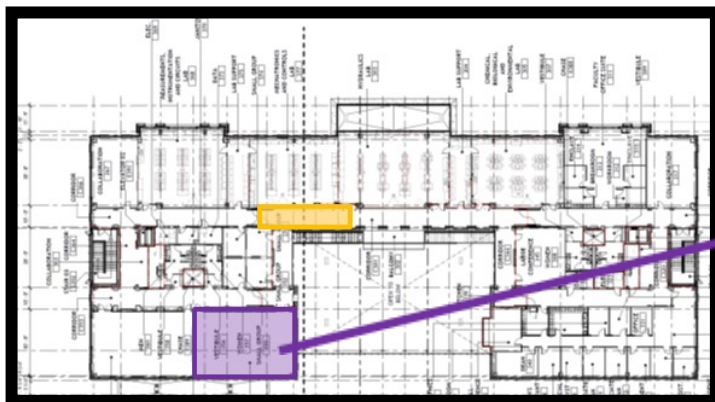
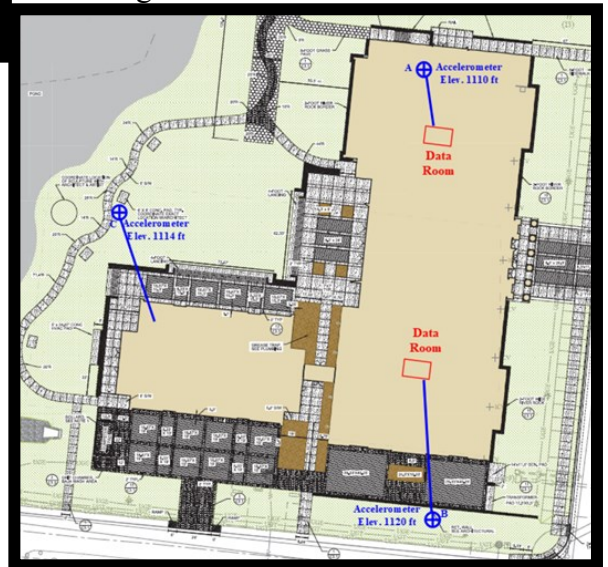
Above: Dr. Joseph Slater (at left), Dean of the College of Engineering, presenting the award to Dr. Vasselbehagh.



Dr. Craig Henderson



Dr. Steve Anton



Dr. Henderson (CEE) and Dr. Steve Anton (ME) are instrumenting the Ashraf Islam Engineering building as a ‘Smart Building’ with sensors (strain gauges and accelerometers) to measure high- and low-frequency building vibration and behavior. Few, if any, other buildings combine both a system of high-spatial density and spatially-distributed tri-axis accelerometers in conjunction with instruments for measuring dynamic strain and far-field acceleration.

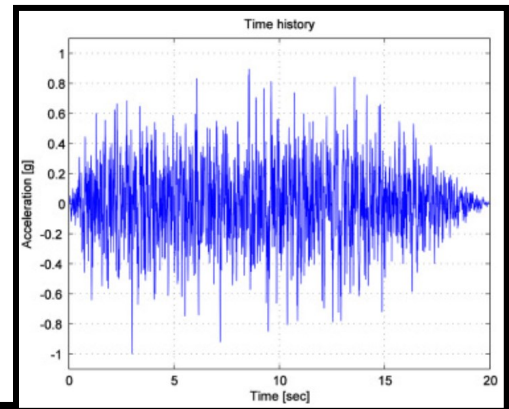
Instrumenting the Ashraf Islam Building with strain gauges and accelerometers



Acceleration input through ground shaker (future research)

Far-field Accelerometers

Strain/Acceleration Measurements



**WINGS UP 100 AWARDS**

For the fourth consecutive year, Tennessee Tech honored the top faculty who brought in \$100,000 or more in external funding for student research in the previous academic year during its Wings Up 100 awards. Of the 36 faculty across campus who had secured a total of \$17.9 million, half were from the College of Engineering.

The following faculty participating in the Strategic Research of the CESR were awarded the Wings Up 100 Awards in Fall 2022:

Dr. Rory Roberts, ME

Dr. Michael Rogers, CSC

Dr. Satish M. Mahajan, CESR

Dr. Mohamed Mahmoud, ECE

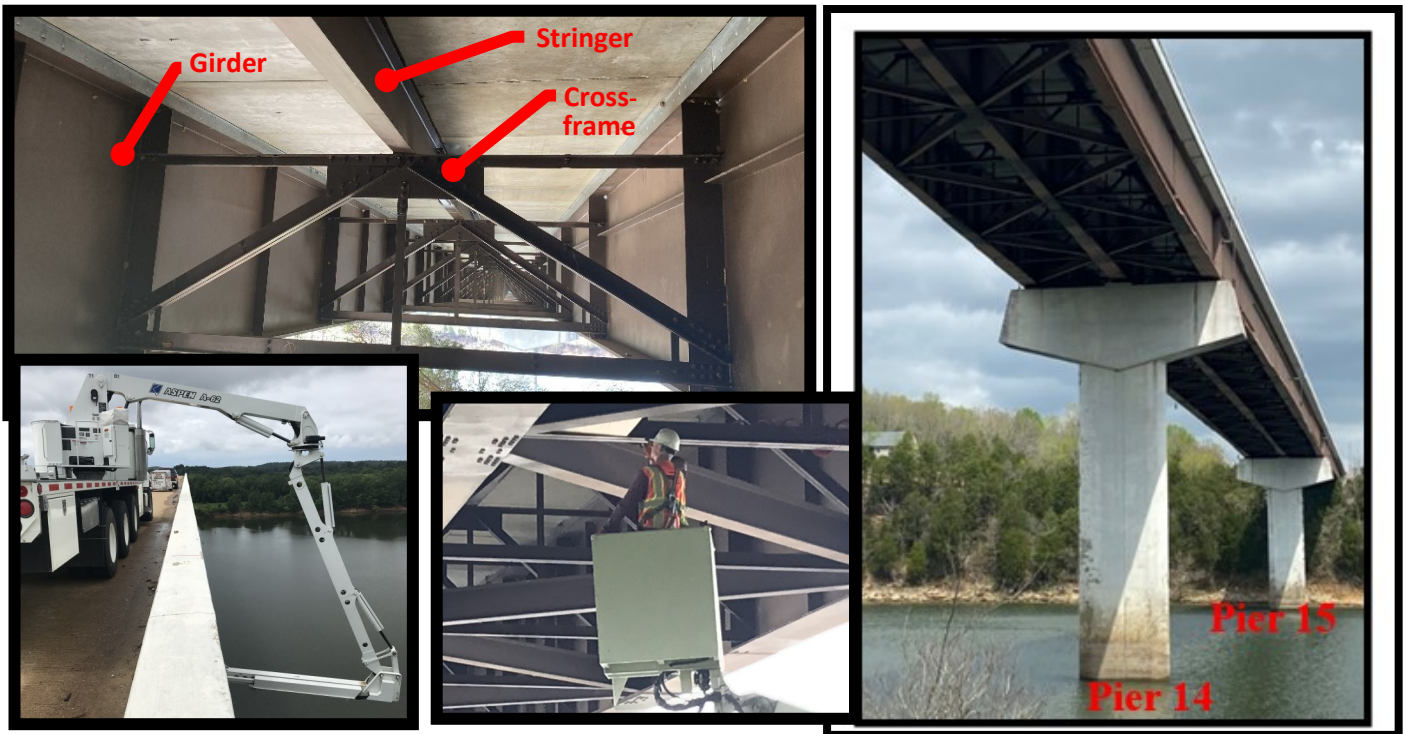
Dr. Sheikh Ghafoor, CSC

Dr. Ahmad Vasselbehagh, ME

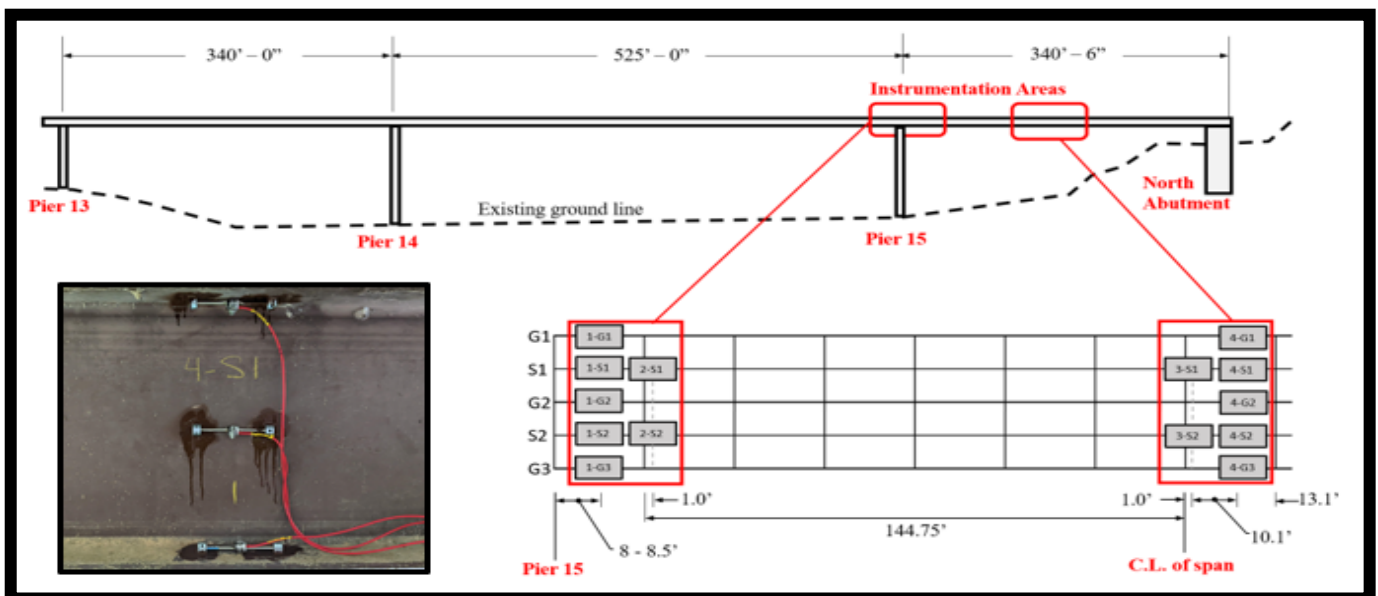
Dr. Joseph Biernacki, CHE

Dr. Craig Henderson, CEE

Dr. Muhammad Ismail CSC



The Tennessee Department of Transportation sponsored experimental research into the behavior of girder-stringer-floor beam bridges. Diagnostic load testing (i.e., the measurement of strain in the structural members) and analytical evaluation were performed by the research team (Dr. Henderson, Dr. Tim Huff, Dr. Matt Yarnold).



Dr. Van Neste and students and colleagues of Dr. Van Neste attended the IEEE 2022 Wireless Power Week (WPW) July 4-9, 2022 in Bordeaux, France, and presented the paper that won Second Place and was published. The paper was entitled “Thru-the-Soil Long Range Wireless Power Transfer.” The authors were: B.T. Nieman; M. G.S. Pearce; C.S. Johnson; M. Tidwell; J. Whitehead, and C. W. Van Neste. Below is a picture of the award ceremony.



Dr. Charles Van Neste



Above: Graduate students of Dr. Charles Van Neste attended and presented research at the 2023 IEEE Wireless Power Transfer Conference and Expo in San Diego in June 2023. The Conference was held aboard the USS Midway Museum. Pictured above from left are J.C. Williams, Storm Johnson, Chris Swindell, and Michael Tidwell.

Photo submitted by Dr. Van Neste.

“NASA has selected Tennessee Tech University engineering researchers to lead a team of universities and industry partners to help solve one of aviation’s key challenges for the future of commercial air travel: zero-emission aircraft by 2050. With an estimated budget of \$8 million, the CarbonLess Electric Aviation (CLEAN) project is led by Rory Roberts, Ph.D., of Mechanical Engineering and head of the Propulsion Power and Thermal Systems Laboratory at Tech.” (photo below)



Dr. Rory Roberts



Above Left to Right: Dr. Ahmad Vassel, Dr. Bruce Jo, Dr. Mingyang Gong, Aaron Bain, Alex Tharpe, David Schafer, Jeff Webster, Jimmy Meacham, Andrew Ellicott, Noah Simpson, Trevor Kramer, Dr. Rory Roberts.





Above Left to Right: Dr. Daniel VandenBerge, Leonardo Ramon (M.S. Spring 2023), Brendan Atarigiya (Ph.D. Student), Shushanta Chakraborty (M.S. Student), and Dr. Prince Turkson (Ph.D. Fall 2021) at the Geo-Congress 2023 Conference in Los Angeles, California March 26-29, 2023.

## 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 \$2.5 million level.

Center faculty and the R&D Engineer will produce at least five publications in total. This year we had a total of seven publications. Very soon a new research assistant professor in the area of Transportation Engineering is expected to join the CESR.

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 continue to support expansion of two laboratories this year. We will continue the development of the wireless power laboratory. Also, a laboratory for the maintenance of ice condensers (having a CO<sub>2</sub> laser for melting of the ice) will continue to receive support for further expansion.

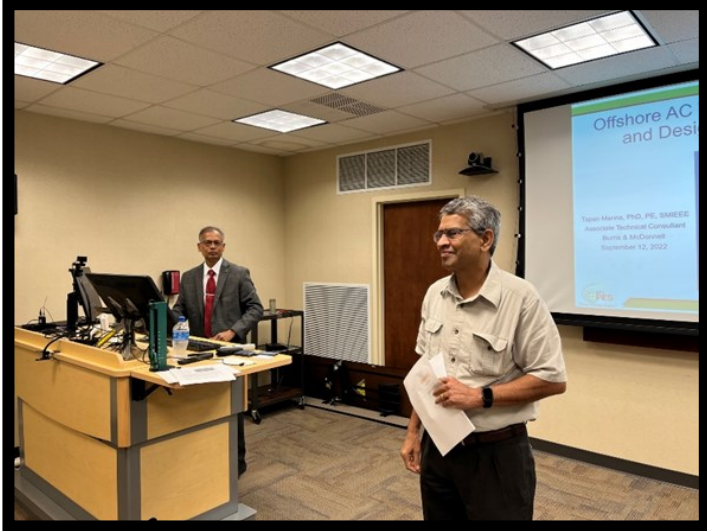
This goal intersects the University Flight Plan's Physical Infrastructure Priorities sub goal and the Technology Service to Students sub goal, and the Technology in Teaching sub goal. Better facilities in areas of national importance like the Smart Grid benefit research, education, and hire-ability of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

## Increase Outreach Activities

Now that the COVID-19 pandemic appears to be in decline, we will organize a minimum of two seminars by external speakers per year. Attempts will be made to arrange virtual seminars also.

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



Photos from Seminar of Dr. Tapan Manna of September 12, 2022.



**CESR FACULTY & STAFF – 2022-2023**

<b>Center Director:</b>	Dr. Satish M. Mahajan	Director; ECE Professor
<b>Center Faculty:</b>	Dr. Ali Arzani	Assistant Research Professor
	Dr. Sherif Gaweesh	Assistant Research Professor
<b>Center Staff:</b>	Mr. Robert Craven	Research & Development Engineer
	Ms. Barbara Fenlon	Financial Analyst
	Ms. Sara Howard	Grants Analyst
	Ms. Anysa Milum	Center Manager
	Ms. Linda Thurman	Administrative Associate 4
	Ms. Shanae Tyree	Grants Analyst

**CESR Staff (Part Time, Temporary):**

Dr. Sherif Ahmed	Research Engineer
Dr. Mahmoud Badr	Research Engineer
Dr. Sabrina Buer	Project Manager
Mr. Clay Kelsey	Financial Associate
Ms. Tracy Limper	Financial Associate

## Faculty participating in the Strategic Research of the Center

		<b>Wireless Power Transfer &amp; Wireless Charging</b>
<b>Smart Grid</b>	<b>Resilient Infrastructure</b>	
Ali Alouani, ECE	Alfred Kalyanapu, CEE	Charles Van Neste, ECE
Ghadir Radman, ECE	Ben Mohr, CEE	Indranil Bhattacharya, ECE
Indranil Bhattacharya, ECE	Daniel Badoe, CEE	Satish M. Mahajan, CESR
Mohamed Mahmoud, ECE	Daniel VandenBerge, CEE	
Satish M. Mahajan, CESR	Jane Liu, CEE	
Sheikh Ghafoor, CSC	Joe Biernacki, CHE	
Syed Rafay Hasan, ECE	L.K. Crouch, CEE	
Joseph Ojo, ECE	Laura Aries Chavez, CHE	
Ahmad Vasselbehagh, ME	Steven Click, CEE	
Charles Van Neste, ECE	Stephen Idem, ME	
Michael Rogers, CSC	Ethan Languri, ME	
Muhammad Ismail, CSC	Mustafa Rajabali, Physics	
Denis Ulybyshev, CSC	Craig Henderson, CEE	
Susmit Shannigrahi, CSC	Peng Zhang, ME	
Maanak Gupta, CSC	Robby Sanders, CHE	
Rory Roberts, ME	Pedro Arce, CHE	
Tarek Elfouly, ECE	Kumar Yelamarthi, COE	
Nan Chen, ECE	Sherif Gaweesh, CESR	
Ali Arzani, CESR	Jerry Gannod, CSC	
Syed Rizvi, ECE		
Robert Craven, CESR		

**CONTRACT AND GRANT AWARDS  
Activated Between July 1, 2022 and June 30, 2023**

<b>Contract Number</b>	<b>Title</b>	<b>Source</b>	<b>Project Dates</b>	<b>Total Amount</b>
531339	ERI: Empowering Data-Driven Resource Management in 5G+ HeNets	National Science Foundation	8/1/2022 to 7/31/2024	\$100,180.00
535286	Machine Learning-Based Design and Operation of Next Generation Software-Defined Heterogeneous Networks	Qatar National Research Fund (QRN) TAMU Engineering Experiment Station	5/15/2021 to 5/14/2024	\$47,940.00
533188	Reinforce Advanced Math Placement (RAMP) Program to Improve Success in Engineering	Tennessee Board of Regents	7/1/2022 to 6/30/2023	\$50,000.00
539399	Best Practices for Bridges with Pipe Piles	Federal Highway Administration - State	8/1/2022 to 7/31/2024	\$16,560.00
539400	Best Practices for Bridges with Pipe Piles	Federal Highway Administration - Federal	8/1/2022 to 7/31/2024	\$69,670.00
531337	CAREER: CAS-Climate: Understanding Thermal Transport Processes in Atmospheric Boundary Layer with Utility-Scale Solar Photovoltaic Plants	National Science Foundation	7/1/2022 to 6/30/2027	\$102,612.00
531338	NRT-FW-HTF: Engendering the Spirit of Gadugi at the Food-Energy-Water Nexus	National Science Foundation	7/1/2022 to 6/30/2027	271,395.00
<b>SUB - TOTAL, GRANTS AND CONTRACTS</b>				<b>\$658,357.00</b>

**CONTRACT AND GRANT AWARDS**  
**Activated Between July 1, 2022 and June 30, 2023**

<b>Contract Number</b>	<b>Title</b>	<b>Source</b>	<b>Project Dates</b>	<b>Total Amount</b>
532620	High Power Density Carbon Neutral Electrical Power Generation for Air Vehicles (50% with CMR)	Department of Energy -Advanced Research Projects Agency-Energy	7/12/2021 to 7/11/2023	\$257,470.00
532628	Network Attack Detection in Controller Area Networks of Heavy Vehicles	Oak Ridge National Laboratory	9/6/2022 to 12/31/2022	\$16,920.13
535306	Determine the Maximum Negative Operating and Collapse Pressure of Stocked Spiral Duct With and Without Corrugations	SPIDA	9/12/2022 to 5/31/2023	\$36,833.55
531342	Collaborative Research: SitS: Collaborative: Long Range Wirelessly Powered Multi-variable Sensor Network for Continuous Monitoring of the Soil Health	National Science Foundation	10/1/2022 to 9/30/2025	\$165,024.00
531340	Collaborative Research: NeTS: JUN03: SWIFT: Softwarization of Intelligence for Efficient 6G Mobile Networks	National Science Foundation	9/1/2022 to 8/31/2025	\$75,000.00
539492	Guidance for Chemical Stabilization of Pavement Subgrade Soils in Tennessee	Tennessee Department of Transportation-State	8/1/2022 to 7/31/2024	\$16,935.00
<b>SUB - TOTAL, GRANTS AND CONTRACTS</b>				<b>\$568,182.68</b>

**CONTRACT AND GRANT AWARDS  
Activated Between July 1, 2022 and June 30, 2023**

<b>Contract Number</b>	<b>Title</b>	<b>Source</b>	<b>Project Dates</b>	<b>Total Amount</b>
539493	Guidance for Chemical Stabilization of Pavement Subgrade Soils in Tennessee	Tennessee Department of Transportation-Federal	8/1/2022 to 7/31/2024	\$67,737.00
531331	CC* Compute: A GPU Cluster for Science Research and Education at Tennessee Tech University	National Science Foundation	9/1/2021 to 8/31/2023	\$18,687.00
532392	Regional Transportation Center on Reducing Congestion (STRIDE) D6 Project	University of Florida Transportation Institute, Department of Transportation	6/1/2022 to 5/31/2023	\$18,319.00
532392	Regional Transportation Center on Reducing Congestion (STRIDE) ADMIN	University of Florida Transportation Institute, Department of Transportation	1/19/2017 to 9/30/2023	\$23,064.00
531341	Collaborative Research: SHIELD: Strategic Holistic Framework for Intrusion Prevention Using Multi-modal Data in Power Systems	National Science Foundation	9/1/2022 to 8/31/2025	\$150,290.00
531323	Collaborative Research: CyberTraining: Implementation: Medium: Broadening Adoption of Parallel and Distributed Computing in Undergraduate Computer Science and Engineering Curricula	National Science Foundation	10/15/2020 to 9/30/2023	\$20,388.00
<b>SUB - TOTAL, GRANTS AND CONTRACTS</b>				<b>\$298,485.00</b>



**CONTRACT AND GRANT AWARDS**  
**Activated Between July 1, 2022 and June 30, 2023**

<b>Contract Number</b>	<b>Title</b>	<b>Source</b>	<b>Project Dates</b>	<b>Total Amount</b>
532816	A Game-Theoretic Reinforcement Learning Control Framework for Multi-Agent Control of Building HVAC Systems	National Institute of Standards & Technology	10/1/2022 to 9/30/2023	\$120,000.00
532459	Multi-Input Strength Loss Sensing for Webbing Structures	LUNA	12/1/2022 to 6/30/2023	\$35,000.00
532630	High-Precision Heat Delivery to Partly Melt Inaccessible Ice at Nuclear Plant's Condenser	Tennessee Valley Authority	1/1/2023 to 9/30/2023	\$277,975.00
535287	Development of a Testbed for Distributed Energy Resources (DER) and Controllable Loads Simulation	Electric Power Research Institute (EPRI)	6/1/2021 to 8/31/2023	\$26,971.00
532190	2023 C&I Engineering Grant	Tennessee Department of Commerce, Board of Architectural and Eng. Examiners	2/13/2023 to 6/30/2023	\$44,530.00
532628	Network Attack Detection in Controller Area Networks of Heavy Vehicles	Oak Ridge National Laboratory	9/6/2022 to 1/31/2024	\$42,305.33
532461	Lake Observations from Citizen Scientists and Satellites	University of North Carolina via NASA	12/25/2022 to 12/24/2025	\$92,326.00
<b>SUB - TOTAL, GRANTS AND CONTRACTS</b>				<b>\$639,107.33</b>

**CONTRACT AND GRANT AWARDS**  
**Activated Between July 1, 2022 and June 30, 2023**

<b>Contract Number</b>	<b>Title</b>	<b>Source</b>	<b>Project Dates</b>	<b>Total Amount</b>
531344	IPA Assignment	National Science Foundation	2/13/2023 to 2/12/2024	\$192,816.00
531325	Improving Undergraduate Success through Effective Critical Thinking Year 3	National Science Foundation	3/15/2021 to 2/29/2024	\$80,937.00
539215	Modeling of Renewables for Demand Response via HILLTOP-Supplement	Upper Cumberland Development District/ARC	7/1/2021 to 5/31/2023	\$50,210.00
531309	Tennessee Louis Stokes Alliance for Minority Participation (TLSAMP) - Year 5	National Science Foundation via Tennessee State University	9/1/2018 to 8/31/2023	\$26,100.00
532446	National CyberSecurity Teaching Academy: Southeast Consortium	University of Louisville Research Foundation, Inc., via NSA	8/6/2021 to 8/5/2023	\$30,000.00
531345	RET Site: Energize Teachers	National Science Foundation	5/1/2023 to 4/30/2026	\$212,880.00
532621	Regional Transportation Center on Reducing Congestion CAV Project	University of Florida Transportation Institute, Department of Transportation	8/1/2021 to 8/31/2023	\$53,645.00
535298	Secure Federated Edge Intelligence Framework for AI-driven 6G Applications	Qatar National Research Fund	3/23/2022 to 4/19/2024	\$25,159.00
<b>SUB - TOTAL, GRANTS AND CONTRACTS</b>				<b>\$671,747.00</b>

**CONTRACT AND GRANT AWARDS**

**Activated Between July 1, 2022 and June 30, 2023**

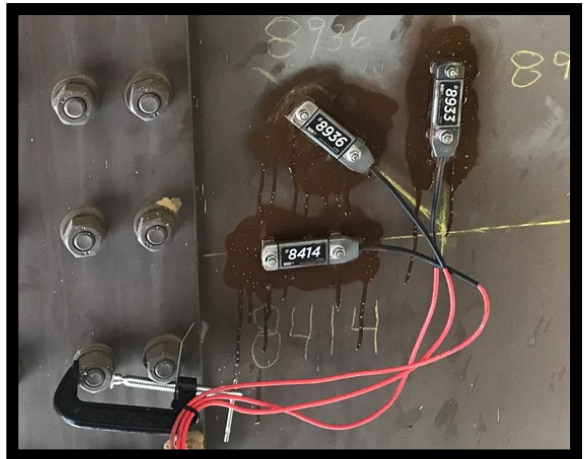
<b>Contract Number</b>	<b>Title</b>	<b>Source</b>	<b>Project Dates</b>	<b>Total Amount</b>
539238	Atmosphere Independent Bipropellant Consuming Additively Manufactured Solid Oxide Fuel Cells (SOFCs) - 50% with CMR	Southwestern Ohio Council for Higher Education (SOCHE) via DOD funds	8/1/2023 to 10/31/2023	\$54,668.50
532619	Cryo Thermal Management of High Power Density Motors and Drives - 50% with CMR	ARPA-e via Hyper Tech	4/26/2021 to 10/30/2024	\$24,159.00
<b>SUB - TOTAL, GRANTS AND CONTRACTS</b>				<b>\$78,827.50</b>
<b>POWER-TEST-SERVICE ACCOUNT</b>				<b>-</b>
<b>TOTAL CONTRACTS AND GRANTS DURING 2022 - 2023</b>				<b>\$2,914,706.51</b>



**Above and Right:** Soldering of spatially distributed sensors in the Ashraf Islam Smart Building.



**Left and Below:** TDOT load testing and shear strain measurement using a rosette configuration of vibrating wire strain gauges.



**CENTER FOR ENERGY SYSTEMS RESEARCH**  
**STATUS OF PROPOSALS**  
**Submitted Between July 1, 2022 through June 30, 2023**

	<b>TITLE</b>	<b>INVESTIGATORS</b>	<b>SOURCE</b>	<b>AMOUNT</b>	<b>STATUS</b>
1.	Through the Soil Wireless Power Transfer for Agriculture Sensors	Charles Van Neste	National Science Foundation	\$250,000.00	Pending
2.	CAREER: RISE: Robust Machine Learning for Resource Management in LiFi Programmable Wireless Environments	Muhammad Ismail	National Science Foundation	\$400,000.00	Pending
3.	CAREER: Exploring Non-Linear Electromagnetic Wave Phenomena Over & Through the Soil for Long-Range Wireless Power Transfer, Recapture, & Harvesting	Charles Van Neste	National Science Foundation	\$527,883.00	Declined
4.	Invertless Multipotential AC/DC Energy Storage (IMADES)	Rory Roberts	Department of Energy - ARPA-e	\$4,259,157.00	Pending
5.	Multifunctional Active Battery Intelligent Management Systems (MABIMS)	Rory Roberts	Department of Energy - EERE	\$3,747,997.00	Pending
<b>SUBTOTAL, PROPOSALS FOR 2022-2023</b>				<b>\$9,185,037.00</b>	

**CENTER FOR ENERGY SYSTEMS RESEARCH  
STATUS OF PROPOSALS  
Submitted Between July 1, 2022 through June 30, 2023**

	<b>TITLE</b>	<b>INVESTIGATORS</b>	<b>SOURCE</b>	<b>AMOUNT</b>	<b>STATUS</b>
6.	CRII: RI: A Stabilizing Reinforcement Learning Control Framework for Constrained Control Problems	Syed Rizvi	National Science Foundation	\$175,000.00	Pending
7.	High-Precision Heat Delivery to Partly Melt Inaccessible Ice at a Nuclear Plant's Condenser	Ahmad Vasselbehagh and Charles Van Neste	Tennessee Valley Authority	\$370,603.00	Funded
8.	RET Site: Energize Teachers	Joe Biernacki, Indranil Bhattacharya, Stephanie Wendt, Jennifer Meadows	National Science Foundation	\$599,997.00	Funded
9.	ERI: A Stabilizing Reinforcement Learning Framework for Constrained Sensing and Actuation Problems with Application to Building HVAC Controls	Syed Rizvi	National Science Foundation	\$200,000.00	Pending
10.	Multi-Input Strength Loss Sensing for Webbing Structures	Peng Zhang	LUNA	\$35,000.00	Funded
<b>SUBTOTAL, PROPOSALS FOR 2022-2023</b>				<b>\$1,380,600.00</b>	

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

**Submitted Between July 1, 2022 through June 30, 2023**

	<b>TITLE</b>	<b>INVESTIGATORS</b>	<b>SOURCE</b>	<b>AMOUNT</b>	<b>STATUS</b>
11.	Improving Converter-Interfaced Generation Fault Response in Weak Grids	Ali Arzani	National Science Foundation	\$194,876.00	Pending
12.	Multi-input Quantification of Fluid-Structure Interactions Toward High-Speed Aircraft Design	Peng Zhang	National Science Foundation	\$316,084.00	Pending
13.	Extension of Modeling of renewables for demand response via HILLTOP	Satish M. Mahajan, Michael Rogers, Michael Aikens	Upper Cumberland Development District/ARC	\$50,210.00	Funded
14.	Multi-input Quantification of Fluid-Structure Interactions Toward High-Speed Aircraft Design - REVISED	Peng Zhang	National Science Foundation	\$287,567.00	Pending
15.	UTAP Task Order Request	Daniel Badoe and Steven Click	Tennessee Department of Transportation	\$80,000.00	Declined
<b>SUBTOTAL, PROPOSALS FOR 2022-2023</b>				<b>\$928,737.00</b>	

**CENTER FOR ENERGY SYSTEMS RESEARCH**

**STATUS OF PROPOSALS**

**Submitted Between July 1, 2022 through June 30, 2023**

	<b>TITLE</b>	<b>INVESTIGATORS</b>	<b>SOURCE</b>	<b>AMOUNT</b>	<b>STATUS</b>
16.	NSF Engines: Type - 2: Preserving Traditions and Innovating for the Future: Sustainable Agriculture and Energy Practices in Tennessee	Charles Van Neste, Ahmad Vasselbehagh, Steve Anton, Craig Henderson, Michael Aikens	National Science Foundation	\$2,300,000.00	Pending
17.	CyberTraining: Implementation: Small: training AI-Skilled and Fairness-aware research workforce for Cloud Infrastructure Cybersecurity	Manaak Gupta, Indranil Bhattacharya, Kumar Yelamarthi	National Science Foundation	\$350,000.00	Pending
18.	Use of Coarse Aggregates for Retaining Wall Backfill	Daniel VandenBerge	Tennessee Department of Transportation	\$248,959.00	Pending
19.	Development of Tennessee UHPC for Bridge Applications	Benjamin Mohr, Craig Henderson, Timothy Huff	Tennessee Department of Transportation	\$221,959.00	Funded
20.	Early Age Concrete Acceptance	Benjamin Mohr	Tennessee Department of Transportation	\$129,435.00	Funded
<b>SUBTOTAL, PROPOSALS FOR 2022-2023</b>				<b>\$3,250,353.00</b>	



**CENTER FOR ENERGY SYSTEMS RESEARCH  
STATUS OF PROPOSALS  
Submitted Between July 1, 2022 through June 30, 2023**

	<b>TITLE</b>	<b>INVESTIGATORS</b>	<b>SOURCE</b>	<b>AMOUNT</b>	<b>STATUS</b>
21.	Academic Review and Rewrite of NAVFAC DM 7.02	Daniel VandenBerge	US Naval Facilities Command via National Institute of Building Sciences	\$623,560.00	Pending
22.	Development of a Statewide Mitigation Plan for Wildlife Related Crashes in TN: Assessment, Procedures and Standards	Sherif Gaweesh	Tennessee Department of Transportation	\$248,210.00	Pending
23.	Collaborative Research: CyberTraining: Implementation: Medium: Introductory Computing Course Sequence Exemplars Infused with Parallel and Distributed Computing	Gerald Gannod and April Crockett	National Science Foundation	\$185,687.00	Pending
24.	Reduction in Compressive Strength Test Results due to Above Specification Initial Concrete Cylinder Curing Temperature	L.K. Crouch	Tennessee Concrete Association	\$7,192.00	Funded
25.	Supporting Undergraduate Student Resistance and Graduation in STEM Disciplines (SPEAR)	Kumar Yelamarthi, Manaak Gupta, Indranil Bhattacharya, Ada Haynes, Tania Datta	National Science Foundation	\$2,440,029.00	Pending
<b>SUBTOTAL, PROPOSALS FOR 2022-2023</b>				<b>\$3,504,678.00</b>	

**CENTER FOR ENERGY SYSTEMS RESEARCH**

**STATUS OF PROPOSALS**

**Submitted Between July 1, 2022 through June 30, 2023**

	<b>TITLE</b>	<b>INVESTIGATORS</b>	<b>SOURCE</b>	<b>AMOUNT</b>	<b>STATUS</b>
26.	Interrogating Carbee Chemistry using Microwave Spectroscopy and Laser Photolysis: Unambiguous Characterization of Triplet Ethylidene	Ranil Gurusinghe	American Chemical Society	\$55,000.00	Pending
27.	Q-Shield: A Practical QKD Platform with Resilience to RF Attacks	Tarek Elfouly	Qatar	\$44,891.00	Pending
28.	Active Thermal Management to Achieve Higher Mach Numbers with Low Observability	Rory Roberts	UCAH	\$1,487,088.00	Pending
29.	Secure Diabetic non-invasive Monitoring and Personalized Recommendations powered by Explainable Artificial Intelligence	Mohamed Mahmoud	QNRf	\$122,415.00	Pending
30.	Intelligent Condition Monitoring of Civil Infrastructure via Mobile Crowd Sensing	Tarek Elfouly	Qatar-TAMU	\$145,858.00	Pending
<b>SUBTOTAL, PROPOSALS FOR 2022-2023</b>				<b>\$1,855,252.00</b>	
<b>TOTAL, PROPOSALS FOR 2022-2023</b>				<b>\$20,104,657.00</b>	

*Journal Papers*

“Exploring a Variant of PTC 4-2013 for Real-Time Performance Monitoring of Fossil Fuel Power Plants,” Staller, J. M., Craven, R. P. M., Idem, S., Munukutla, S., Kirkpatrick, K., Benton, D., Eisenstadt, S., Leedy, S., McHale, J., Licata, A., Andrei, D., September 26, 2022, **ASME Open Journal of Engineering**

“The Impact of Inverter Dead-Time in a Single-Phase Wireless Power Transfer Systems,” With Utkarsh D. Kavimandan, V. P. Galigekere, B. Ozpineci, and O. Onar; **IEEE Transactions on Power Electronics** (Volume: 37, Issue: 1, Jan. 2022); <https://doi:10.1109/TPEL.2021.3092400>

*Conference Papers*

“Testbed for Evaluating and Analyzing Smart Grid Behavior in Demand Response Scenarios,” Rajesh Manicavasagam, Anthony Palmer, Mike Rogers, Satish Mahajan, Robert Craven, Chikezie Emeghara and Ryan Senz, Nov 18 2022 14th International Congress on Ultra Modern Telecommunications and Control Systems and Workshops (ICUMT), IEEE; <https://doi:10.1109/ICUMT57764.2022.9943371>

“A Modified F-Factor Approach for Real-Time Performance Monitoring of Fossil Fuel Power Plants,” Staller, J. M., Craven, R. P. M., Idem, S., Munukutla, S., Kirkpatrick, K., Benton, D., Eisenstadt, S., et al., 2022, Proceedings of the ASME Power Conference, Pittsburgh, PA, July 18–19 2022, pp. 1–8.

“A Computational Method for Impact Assessment of Power Flow Disturbances in Smart Grids,” Brook W. Abegaz and Satish M. Mahajan; IEEE International Conference on Environment and Electrical Engineering (EEEIC); Pages 1-5; July 2022; <https://doi.org/10.1109/EEEIC/ICPSEurope54979.2022.9854604>

“Load Balancing and Interlacing of Storage Units in Smart Grids;” Brook W. Abegaz and Satish M. Mahajan; IEEE International Conference on Environment and Electrical Engineering (EEEIC); Pages 1-6; July 2022; <https://doi.org/10.1109/EEEIC/ICPSEurope54979.2022.9854796>

“Peak Shaving using Battery Energy Storage Systems via Hardware-in-the-Loop (HIL);” With Sohag Kumar Saha, and Chikezie M. Emeghara; Appalachian Energy Summit; Boone, NC, June 2023.

**Book chapter:**

Meadow, J., Moore, K., Pardue, S., Suters, L. and **VandenBerge, D.**  
“Peer-to-Peer Collaborative Professional Learning Framework for  
Transferring STEM Teaching Practices.” Strengthening Teaching and  
Learning in Higher Education through the use of Faculty Learning  
Communities: Research and Stories from the Field, Ed. K. N. Rainville,  
D. G. Title, and C. G. Desrochers.



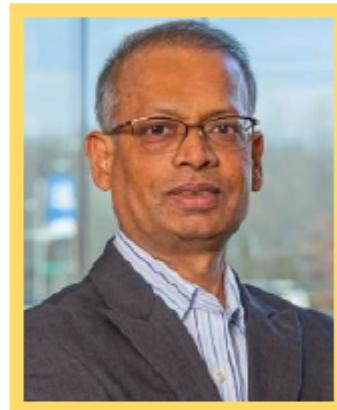
## CENTER FOR ENERGY SYSTEMS RESEARCH SEMINAR ANNOUNCEMENT

### “Offshore AC Wind Topology and Design Considerations”

Presented by:

**Dr. Tapan Manna**

Associate Technical Consultant  
Burns & McDonnell—T&D, USA



Date: Monday, September 12, 2022

Time: 11:00 a.m. to 12:00 noon

Location: Prescott Hall 225

*Abstract:*

With growing concerns over climate change and fossil fuel depletion, the exploitation of renewable energy has become paramount in electricity generation. Currently wind energy is the fastest-growing power generation resource. The stability of system network operation with a large penetration of wind energy has been one of the most important issues. This presentation topic includes global installed wind capacity, 2025 market outlooks, wind farms topology, turbine types and configurations, and VAR control including the reactive power contribution by AC submarine cable and Q-compensation impacts on AC submarine cable.

*Speaker Bio:*

Dr. Tapan Manna is an Associate Technical Consultant at Burns & McDonnell - T&D, USA. He has a total of 30+ years of experience in the power industry and academia. Tapan obtained his PhD from Tennessee Tech University (TTU). Before migrating to the USA, he worked for 10 years at two large utilities (CESC & WBPDC) in India. Prior to joining Burns & McDonnell, he was with URS (currently AECOM), Black & Veatch, and Tennessee Tech University. Dr. Manna's interests include power systems, power system protection, HV/EHV power apparatus, HVDC and FACTS, grounding impulse, lightning transients, geomagnetic disturbances (GMD), and electromagnetic pulse (EMP). He has delivered about 50 presentations (at Burns & McDonnell, IEEE PES/IAS/PLS/CED Chapters, PES-JTCM, Universities, and Institutions) on various technical topics related to T&D applications. Dr. Manna is a Professional Engineer, a Chartered Engineer, and a Senior IEEE Member. He has contributed to over twenty (20+) IEEE-PES and CIGRE working groups and written several technical articles and papers. Dr. Manna has been recognized many times for his contributions at Burns & McDonnell including the 2019 Keith W. Jeffers Technical Excellence Award.



## CENTER FOR ENERGY SYSTEMS RESEARCH SEMINAR ANNOUNCEMENT

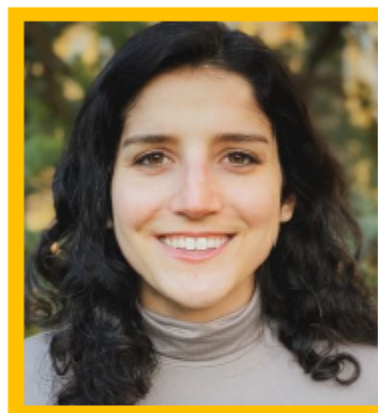
### “Rare Earth Element Mineralization in the Adirondack Mountains, NY”

Presented by:

**Kaitlyn Suarez**

PhD Candidate

NSF GRFP Fellow at the University of  
Massachusetts Amherst



Date: Friday, March 10, 2023

Time: 1:00 p.m. to 2:00 p.m.

Location: Prescott Hall 225

*Abstract:*

Rare earth elements are critical components of many electronic devices, medical instruments, solar panels, military equipment, and more. Future rare earth element availability is a concern due to increasing demand and difficulty finding new. Rare earth element concentrations have been recognized with iron oxide-apatite deposits worldwide; however, not all deposits are rare earth-bearing. Given the growing demand for rare earth elements, it is critical to develop methods to find new iron oxide-apatite deposits and especially those that are rare earth-bearing. Numerous iron oxide-apatite deposits are present in the Adirondack Mountains of New York. Here we report on the integration of multiple techniques in order to locate deposits, including handheld gamma-ray spectroscopy, portable x-ray fluorescence (pXRF), airborne geophysics, and petrography. Further, we compare the mineral modes, textures, and compositions for rare earth-bearing vs. rare earth-poor deposits.

*Speaker Bio:*

Kaitlyn Suarez is a Ph.D. candidate and NSF GRFP fellow at the University of Massachusetts Amherst. Her research interests include metamorphic petrology, petrochronology, and rare earth element mineralization. Research in rare earth element mineralization is in collaboration with the United States Geological Survey. Much of her research is focused on Precambrian rocks from the Adirondack Mountains.



## CENTER FOR ENERGY SYSTEMS RESEARCH

### “Real-Time Management of Power Systems with V2G for Smart-Grid Applications”

Presented by:

**Dr. Uwakwe Christian Chukwu**

Associate Professor of Industrial &  
Electrical Engineering Technology  
South Carolina State University

Date: Thursday, April 20, 2023

Time: 11:00 a.m. to 12:00 noon

Location: LSC Room 1205



#### *Abstract:*

The penetration of vehicle-to-grid (V2G) into the power system may introduce a high-level of volatility due to precarious charging/discharging operations, hence emphasizing the need for a real-time management of the modern-day electric power system. In this lecture, a real-time monitoring diagnostic of the power system with V2G is presented. The system parameters for consideration are voltage profile, voltage stability, step voltage regulator (SVR) operations, reactive power compensations, as well as power and energy loss reduction profiles. Economic studies are also considered. Results show that for a given V2G penetration level, three-phase and system-wide V2G integration results in an improved system performance and economic operation of the power system than a one-phase V2G integration. Results also indicate that using V2G parking lots to inject reactive power to the grid at an optimal location can promise about 95% power/energy loss reduction (relative to power loss without V2G installed). The results are suitable for further applications of smart grids.

#### *Speaker Bio:*

Dr. Chukwu is an Associate Professor in the Department of Engineering Technology of SC State University. He has over 25 years of Research and Teaching experience in power system analysis, planning and operations. He has conducted advanced research in Vehicle-to-Grid (V2G) and Energy scavenging technologies. He is a member of IEEE.

**CENTER FOR ENERGY SYSTEMS RESEARCH  
SEMINAR ANNOUNCEMENT**

“A novel, patented, and trademarked power electronic design approach for unifying active battery management, dynamic charge/discharge control, power conversion/inversion, and software-defined systems functionality.”

Presented by:

**Kent Kristensen**

Founder, President, and CEO of  
GLX Power Systems, Inc.

Date: Thursday, April 27, 2023

Time: 11:00 a.m. to 12:00 noon

Location: LSC 1205



***Abstract:***

Until now the global electrification focus has been on batteries and advancing battery chemistries for the automotive industry while mission critical power electronics has been left to its own lingering evolution leaving innovations and break-throughs in the battery management system (BMS) to achieve only small advances, “over engineering” and inclusion of more or less irrelevant functionality without solving the underlying safety problems. Meanwhile, this same outdated battery approach also enforces complex designs, create siloed-domain expertise, cause inefficient system integration and increase cost and complexity across the overall balance of system.

Yet in the same time period, the Department of Energy (DOE), its willing academic partners, industry professionals, and other actors or influencers have poured unthinkable amounts of time, money, resources and research into wideband gap power technologies (i.e., Silicon Carbide (SiC) and Gallium Nitrate (GaN)) only to conclude the complex process of growing ingots, processing crystals and wafers, and specialized epitaxy as well as complicated circuit design requirements is still 5-10 years away for mainstream and cost adoption in traction motor drives, charge converters, charging stations, grid-tie inverters, etc.

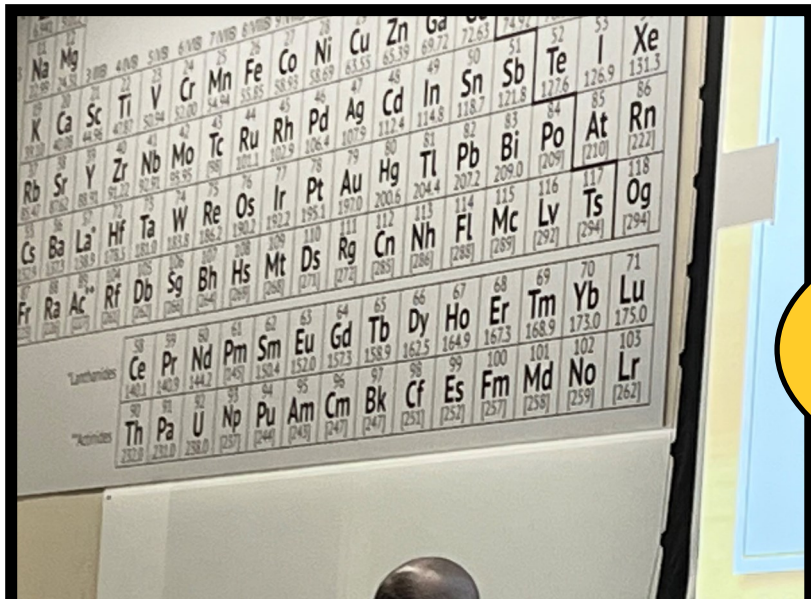
Meanwhile, advancements in traditional Silicon (Si) based MOSFET and IGBT nodes, improved tooling, automation, and industrial scale-up of these more cost-effective process technologies enable for new advanced manufacturing, power electronics packaging, and systems integration opportunities that will forever disrupt the industry, simplify end-products, eliminate unnecessary “box” dependencies, lower overall cost and accelerate the entire electrification across a much wider area of applications, including; on/off-road vehicles and equipment, ships and submarines, aircrafts and eVTOLs, grid-connected-, microgrid-, and distributed-battery energy storage systems, hybrid power generation and battery systems, power equipment and tools, medical devices, consumer electronics, etc.

GLX will discuss its modular, multi-cell, multi-level (M3) AC battery solution that eliminate charge converters and DC charging stations. While also driving an electric motor directly from the battery and allowing for better and more efficient packing of power electronics and batteries in a single enclosure.

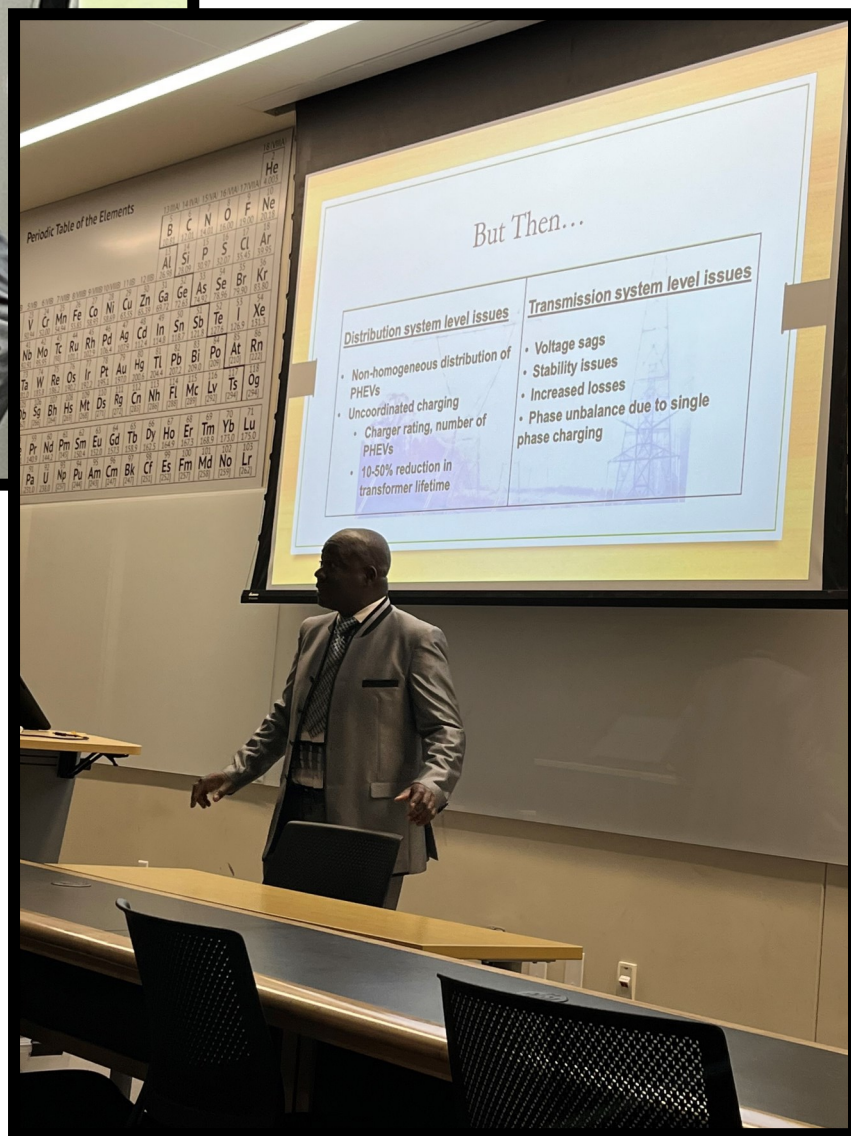
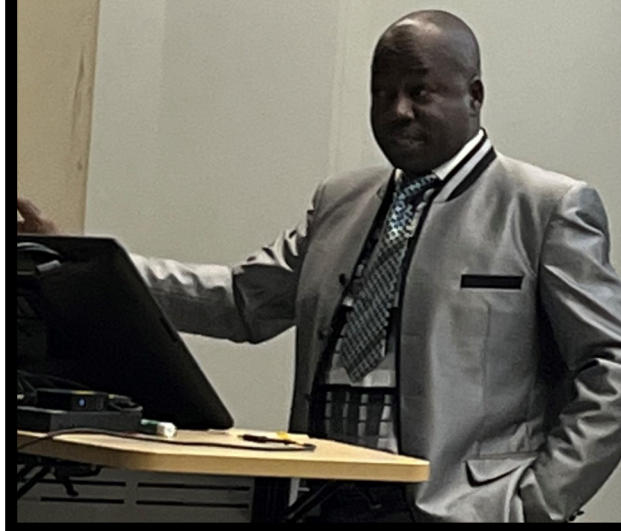
***Speaker Bio:***

With 30 years of electronics manufacturing, global corporate management, venture capital, M&A advisory and management consulting experience, Kent Kristensen is founder, President and CEO of GLX Power Systems, Inc. Kent has an Electronics Engineering (BsEE) degree from Sonderborg Tekniskskole (SDU) in Sonderborg, Denmark and a post graduate Executive Business Admin. (BAA) degree from Copenhagen Business School (CBS) in Copenhagen, Denmark.





Photos from Seminar of  
Dr. Uwakwe Chukwu of  
April 20, 2023



**GRADUATE THESIS/DISSERTATIONS AND OTHER STUDENT PUBLICATIONS****MASTERS****JAMES HOLLAND**

Summer 2022  
Dr. Arman Sargolzaei  
Mechanical Engineering

**QUY T. LE**

“Smart Grid Implementation Using Multiple Smart Agents”  
Summer 2022  
Dr. Satish M. Mahajan  
Electrical and Computer Engineering

**DYLAN ALISSANDRELLO**

“Investigation of Advanced Non-Circular Slip Surface Algorithms for Slope Stability”  
Fall 2022  
Dr. Daniel VandenBerge  
Civil and Environmental Engineering

**JUMANH ATOUM**

“Optimal Threshold Policy for Minimization of User Delay and Spectral Resources Wastage in a Content Caching aided Millimeter-wave Network”  
Fall 2022  
Dr. Allen MacKenzie  
Electrical and Computer Engineering

**TRAPA BANIK**

“A Novel P2 Type Ti/V Co-Doped Sodium Iron Manganese Oxide Cathode for High Energy Density Sodium-Ion Battery”  
Fall 2022  
Dr. Indranil Bhattacharya  
Electrical and Computer Engineering

**ANTHONY DONTOH**

“Temporal Transferability of Regional Trip Generation Models Updated with Spatially Transferred Data”  
Fall 2022  
Dr. Daniel Badoe  
Civil and Environmental Engineering

**GRADUATE THESIS/DISSERTATIONS AND OTHER STUDENT PUBLICATIONS****MASTERS (continued)****ALIREZA SHIRI**

“A Practical Approach for the Application of Simple and Advanced Soil Constitutive Models by the Use of the Interrelation of Their Parameters”

Fall 2022

Dr. Daniel VandenBerge

Civil and Environmental Engineering

**ZACHARY WISNIOWSKI**

“Comparison of Freeway Free-Flow Speed Distribution within and between Urban Areas in Tennessee for Use of Calibration of VISSIM”

Fall 2022

Dr. Steven Click

Civil and Environmental Engineering

**ABEL LAMKAI**

“Exploring Remove and Replace Remediation for Shallow Foundations”

Spring 2023

Dr. Daniel VandenBerge

Civil and Environmental Engineering

**M. RAYHAN AHMED MITHU**

Spring 2023

Dr. Michael Rogers

Computer Science

**ANDREW MOORE**

“Load Rating of Girder-Stringer-Floorbeam Bridges”

Spring 2023

Dr. Craig Henderson

Civil and Environmental Engineering

**ABIODUN OLATUNJU**

“Application of Artificial Intelligence in Optimization of Solid State Transformer Core for Modern Electric Vehicles Using Analytical and Finite Element Method Based Multi-Objective Genetic Algorithm”

Spring 2023

Dr. Indranil Bhattacharya

Electrical and Computer Engineering

**GRADUATE THESIS/DISSERTATIONS AND OTHER STUDENT PUBLICATIONS**  
**MASTERS (continued)**

**NICHOLAS SKJELLUM**

“Secure and Efficient Entanglement Distribution Protocols for Near-Term Quantum Internet”

Spring 2023

Dr. Muhammad Ismail

Computer Science

**MATTHEW WEBB**

“Dynamic Flow Rheology of Portland Cement Paste – Review and Analysis”

Spring 2023

Dr. Robby Sanders

Chemical Engineering

Number of M.S. Students: 14

**GRADUATE THESIS/DISSERTATIONS AND OTHER STUDENT PUBLICATIONS**

**PHD**

**MAHMOUD ABOUYOUSSEF**

“S-Ban: Secure Blockchain-based Anonymous Networking for Smart Grid Applications”

Summer 2022

Dr. Muhammad Ismail

Engineering

**AGOSTON KISS**

“Enhanced Near-Infrared Emission in Supramarble Coatings of Egyptian Blue”

Spring 2023

Dr. Holly Stretz

Engineering

Number of Ph.D. Students: 2

**M.S. STUDENTS**

<b>Name</b>	<b>Dept.</b>	<b>Source of Support</b>	<b>Advisor</b>
Dylan Alissandrello	CEE	NIBS	Dr. Daniel VandenBerge
Samuel Asare-Duah	CEE	CESR	Dr. Daniel Badoe
Jumanh Atoum	ECE	CESR	Dr. Allen MacKenzie
Zack Bikakis	ECE	CESR	Dr. Indranil Bhattacharya
Shushanta Chakraborty	CEE	TDOT	Dr. Daniel VandenBerge
Anthony Dontoh	CEE	CESR	Dr. Daniel Badoe
Blake Evans	MBA	ARPA-e	Dr. Rory Roberts
Abigail Farris	ECE	TVA Endowment	Dr. Charles Van Neste
Samuel Fisher	CEE	CESR	Dr. Craig Henderson
John Forth	MBA	ARC UCDD	Mr. Michael Aikens
Isaac Gyasi	Math	TBR SERS Project	Dr. Kumar Yelamarthi
Brett Harden	ECE	TVA Endowment	Dr. Charles Van Neste
S M Mostaq Hossain	CSC	NSF & CESR	Dr. Sheikh Ghafoor
Hailey Kincer	MA	NIBS	Dr. Daniel VandenBerge
Abel Lamkai	CEE	NIBS	Dr. Daniel VandenBerge
Quy T. Le	ECE	CESR	Dr. Satish M. Mahajan
Michael Miner	ECE	CESR	Dr. Ali Alouani
Andrew Moore	CEE	TDOT & CESR	Dr. Craig Henderson
Owen O'Connor	ECE	CESR	Dr. Tarek Elfouly
Abiodun Olatunji	ECE	IUSE	Dr. Indranil Bhattacharya
Khushi Patel	ECE	CESR	Dr. Indranil Bhattacharya
Devin Roland	ME	TVA	Dr. Ahmed Vasselbehagh
Alireza Shiri	CEE	CESR	Dr. Daniel VandenBerge
Nabil Shuva	ECE	CESR	Dr. Satish M. Mahajan
Noah Simpson	ME	CESR	Dr. Arman Sargolzaei
William Stump	ECE	NSF & CESR	Dr. Charles Van Neste
Joshua Thomas	ECE	CESR	Dr. Indranil Bhattacharya
Michael Tidwell	ECE	NSF & CESR	Dr. Charles Van Neste
Devin Threet	ME	TVA	Dr. Ahmed Vasselbehagh
Matthew Webb	CHE	IUSE	Dr. Joseph Biernacki
Jeff Webster	ME	ARPA-e	Dr. Rory Roberts
Zachary Wisniowski	CEE	CESR	Dr. Steven Click
Yang Zheng	ECE	CESR	Dr. Nan Chen

**Ph.D. STUDENTS**

<b>Name</b>	<b>Dept.</b>	<b>Source of Support</b>	<b>Advisor</b>
Mahmoud Abouyoussef	CSC	QNRf via TAMU	Dr. Muhammad Ismail
A. Isaac Adeleke	CHE	CESR	Dr. Pedro Arce
Ahmed Ahmed	ECE	CESR	Dr. Mohamed Mahmoud
Junaid Anwar	ECE	NIST	Dr. Syed Rizvi
Brendan Atarigiya	CEE	NIBS	Dr. Daniel VandenBerge
Oluwaseyi Ayeni	CHE	NSF RET	Dr. Holly Stretz
Shampa Banik	CSC	CESR	Dr. Michael Rogers
Trapa Banik	ECE	TVA Endowment & NSF RET	Dr. Indranil Bhattacharya
Rajat Bhattarai	CSC	NASA via UNC	Dr. Indranil Bhattacharya
Atef Bondok	ECE	QNRf & CESR	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 & CESR	Dr. Mohamed Mahmoud
Chikezie Emeghara	ECE	ARC UCDD & CESR	Dr. Satish M. Mahajan
Mariam Gado	CSC	CESR & NSF	Dr. Muhammad Ismail
Ty Hagan	ME	TVA Sequoyah Nuclear	Dr. Ahmed Vasselbehagh
Eslam Hasan	CSC	QNRf via TAMU & NSF	Dr. Muhammad Ismail
James Holland	ME	CESR	Dr. Arman Sargolzaei
Saanyol Igbax	ME	CESR	Dr. Stephen Idem
Md Shariful Islam	CEE	CESR	Dr. Benjamin Mohr
C. Storm Johnson	ECE	CESR	Dr. Charles Van Neste
Shafieh Karami	CHE	CESR	Dr. Pedro Arce
Agoston Kiss	CHE	CESR	Dr. Holly Stretz
Trevor Kramer	ME	ARPA-E	Dr. Rory Roberts
W. Luke Lambert	CSC	ORNL & CESR	Dr. Sheikh Ghafoor
Elmahedi Mahalal	CSC	NSF	Dr. Muhammad Ismail
Rajesh Manicavasagam	CSC	ARC UCDD & CESR	Dr. Michael Rogers
Tyler Marcum	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
Ebrahim Nasr Esfahani	ECE	CESR	Dr. Indranil Bhattacharya

**Ph.D STUDENTS, Continued**

<b>Name</b>	<b>Dept.</b>	<b>Source of Support</b>	<b>Advisor</b>
Reza Nouri	ME	TVA Sequoyah Nuclear	Dr. Ahmed Vasselbehagh
Sushil Poudel	CSC	NSF	Dr. Muhammad Ismail
Kundan Rathod	CEE	TDOT & CESR	Dr. Timothy Huff
Sohag Kumar Saha	ECE	ARC UCDD & CESR	Dr. Satish M. Mahajan
S. Mohammad Seyed Sabour	CHE	Rural Reimagined	Dr. Pedro Arce
Warren Sims	ME	NSF & TVA Sequoyah Nuclear	Dr. Ahmed Vasselbehagh
Nicholas Skjellum	CSC	NSF	Dr. Muhammad Ismail
Dipendra Wagale	CHE	Rural Reimagined	Dr. Pedro Arce
Andrew Worley	CSC	NSF	Dr. Sheikh Ghafoor



## 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 StudentsDegree and Major

Omar Abdelsalem	B.S. CSC
Jessica Baugh	B.S. CSC
Matthew Beausoleil	B.S. ECE
Haley Burnell	B.S. CSC
Matthew Burst	B.S. CSC
Siyapa Chanhorm	B.S. CSC
Kasandra Chavez	B.S. CSC
Ryan Cunningham	B.S. CEE
Austin Day	B.S. ME
Caleb Eldridge	B.S. Physics & Math
Michael Ezelle	B.S. ME
Jordan Frerichs	B.S. ME
Miguel Fuentes Garcia	BS. ME
Jake Gregory	B.S. CHE
Calvin Guzman	B.S. CSC
Laykayleh Helton	B.S. CHE
Megan Hendrickson	B.S. CSC
Justice Kittell	B.S. CHE
Shaina Larsen	B.S. CHE
Richard Mitchell	B.S. Physics & CSC
Imran Mohammed	B.S. Physics & CSC
Renie Morrow	B.S. CHE
Dakota Moye	B.S. ECE
Conor Orr	B.S. ECE
Daniel Rhoton	B.S. MET
Austin Ring	B.S. CSC

**HOURLY STUDENT PERSONNEL, Continued**Undergraduate StudentsDegree and Major

David Schafer	B.S. ME
Alex Tharpe	B.S. ME
Marton Varga	B.S. CSC & CHE
Ezekiel Vespie	B.S. Physics
Minh-nghi Vu	B.S. CSC
C. Dylan Walker	B.S. MET

M.S. Graduate StudentsDegree and Major

Anthony Dontoh	M.S. CEE
Isaac Gyasi	M.S. Math
Abel Lamkai	M.S. CEE
Andrew Moore	M.S. CEE
Khushi Patel	M.S. ECE
Devin Roland	M.S. ME
William Stump	M.S. ECE
Devin Threet	M.S. ME
Zachary Wisniowski	M.S. CEE

**HOURLY STUDENT PERSONNEL, Continued****Ph.D. Graduate Students****Degree and Major**

Ahmed Ahmed	Ph.D. ECE
Oluwaseyi Ayeni	Ph.D. CHE
Atef Bondok	Ph.D. ECE
D. Trevor Cannon	Ph.D. ME
Nathan Duran-Ledezma	Ph.D. CHE
Mariam Gado	Ph.D. CSC
Eslam Hasan	Ph.D. CSC
Agoston Kiss	Ph.D. CHE
W. Luke Lambert	Ph.D. CSC
Elmahedi Mahalal	Ph.D. CSC
Tyler Marcrum	Ph.D. ECE
Mohamed Shaban Mohamed	Ph.D. CSC
Umair Mughal	Ph.D. CSC
Reza Nouri	Ph.D. ME
Sushil Poudel	Ph.D. CSC
Warren Sims	Ph.D. ME
Nicholas Skjellum	Ph.D. CSC

**Work Study/Work Scholarship****Degree and Major**

Gabriel Adams	B.S. Physics & CSC
Michael Ezelle	B.S. ME

## 2022-2023

Student	Sponsor	Program	Faculty Advisor
Omar Abdelsalem	Tennessee Board of Regents	TBR Ramp: Reinforce Advanced Math Placement (RAMP) Program to Improve Success in Engineering	Dr. Elizabeth Powell & Dr. Kumar Yelamarthi
Gabriel Adams	Federal Work Study	Wireless Power Turnable Coil Testbed	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
Haley Burnell	National Science Foundation	NSF: Collaborative Research: CyberTraining: Implementation: Medium: Broadening Adoption of Parallel and Distributed Computing in Under	Dr. Sheikh Ghafoor
Matthew Burst	National Science Foundation	NSF: Collaborative Research: NeTS: Jun03: SWIFT: Softwarization of Intelligence for Efficient G6 Mobile Networks	Dr. Muhammad Ismail
Matthew Burst	National Science Foundation ERI	NSF ERI: Empowering Data-Driven Resource Management in 5G+ HeNets	Dr. Muhammad Ismail
Siyapa Chanhorm	National Science Foundation	NSF: Collaborative Research: CyberTraining: Implementation: Medium: Broadening Adoption of Parallel and Distributed Computing in Under	Dr. Sheikh Ghafoor

# UNDERGRADUATE RESEARCH PROJECTS, continued SM-11

Student	Sponsor	2022-2023 Program	Faculty Advisor
Kasandra Chavez	University of North Carolina via NASA	UNC via NASA: Lake Observations from Citizen Scientists and Satellites	Dr. Sheikh Ghafoor
Ryan Cunningham	Tennessee Department of Transportation - Federal	TDOT Federal Project, Guidance for Chemical Stabilization of Pavement Subgrade Soils in Tennessee	Dr. Daniel VandenBerge
Austin Day	Center For Energy Systems Research	SPS USAF Thermal Mgmt. System	Dr. Rory Roberts
Caleb Eldridge	Department of Energy	DOE: The Structure of Neutron-Rich Deformed Nuclei Studied via Beta Decay	Dr. Mustafa Rajabali
Michael Ezelle	Tennessee Valley Authority Endowment & Federal Work Study	Research Facilitator, Smart Grid Laboratory	Mr. Robert Craven
Michael Ezelle	Upper Cumberland Development District - ARC	Modeling of renewables for demand response via HILLTOP	Dr. Satish M. Mahajan
Jordan Frerichs	Tennessee Valley Authority	TVA: Thermal Treatment of Nuclear Plants' Ice Condensers Using Laser, Phase II & Phase III	Dr. Ahmad Vasselbehagh
Miguel Fuentes Garcia	STRIDE	Southeastern Transportation, Research, Innovation, Development, and Education Center (STRIDE)	Dr. Arman Sargolzaei

# UNDERGRADUATE RESEARCH PROJECTS, continued SM-11

2022-2023

Student	Sponsor	Program	Faculty Advisor
Jake Gregory	Tennessee Board of Regents	TBR Ramp: Reinforce Advanced Math Placement (RAMP) Program to Improve Success in Engineering	Dr. Elizabeth Powell & Dr. Kumar Yelamarthi
Calvin Guzman	National Science Foundation	NSF: ERI: Empowering Data-Driven Resource Management in 5G+ HeNets	Dr. Muhammad Ismail
Laykayleh Helton	Tennessee Board of Regents	TBR Ramp: Reinforce Advanced Math Placement (RAMP) Program to Improve Success in Engineering	Dr. Elizabeth Powell & Dr. Kumar Yelamarthi
Megan Hendrickson	University of North Carolina via NASA	UNC via NASA: Lake Observations from Citizen Scientists and Satellites	Dr. Sheikh Ghafoor
Justice Kittell	Tennessee Board of Regents	TBR Ramp: Reinforce Advanced Math Placement (RAMP) Program to Improve Success in Engineering	Dr. Elizabeth Powell & Dr. Kumar Yelamarthi
Shaina Larsen	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
Richard Mitchell	National Science Foundation	NSF-MRI: Development of a high resolution neutron detector for decay and reaction studies with exotic nuclei	Dr. Mustafa Rajabali
Richard Mitchell	Department of Energy	DOE: The Structure of Neutron-Rich Deformed Nuclei Studied via Beta Decay	Dr. Mustafa Rajabali

# UNDERGRADUATE RESEARCH PROJECTS, continued SM-11

2022-2023

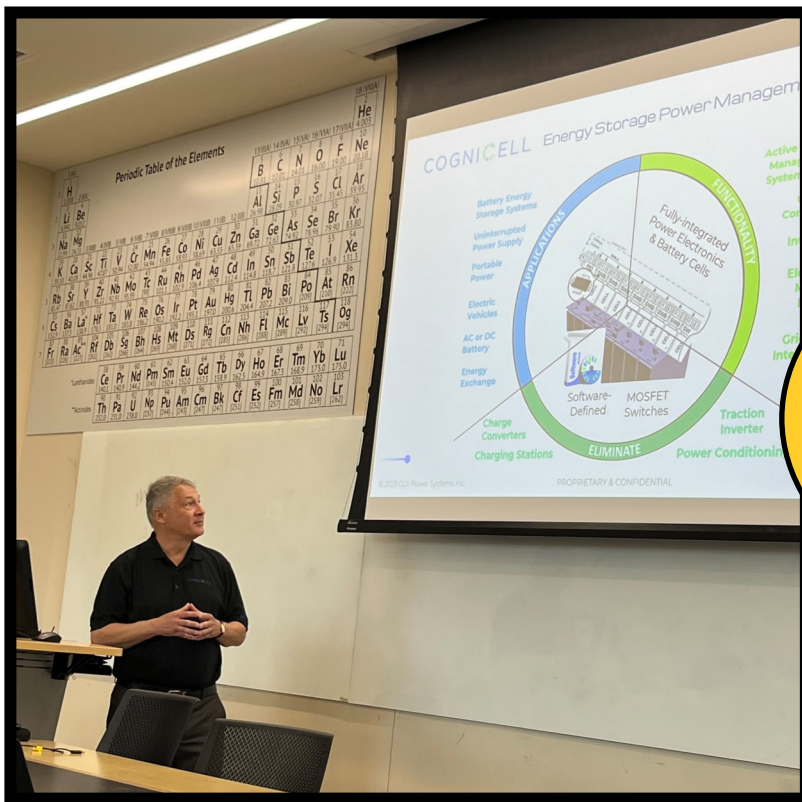
Student	Sponsor	Program	Faculty Advisor
Imran Mohammed	National Science Foundation	NSF-MRI: Development of a high resolution neutron detector for decay and reaction studies with exotic nuclei	Dr. Mustafa Rajabali
Imran Mohammed	Department of Energy	DOE: The Structure of Neutron-Rich Deformed Nuclei Studied via Beta Decay	Dr. Mustafa Rajabali
Renie Morrow	Tennessee Board of Regents	TBR Ramp: Reinforce Advanced Math Placement (RAMP) Program to Improve Success in Engineering	Dr. Elizabeth Powell & Dr. Kumar Yelamarthi
Dakota Moye	Department of Energy	DOE: The Structure of Neutron-Rich Deformed Nuclei Studied via Beta Decay	Dr. Mustafa Rajabali
Conor Orr	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
Daniel Rhoton	Tennessee Board of Regents	TBR Ramp: Reinforce Advanced Math Placement (RAMP) Program to Improve Success in Engineering	Dr. Elizabeth Powell & Dr. Kumar Yelamarthi
Austin Ring	Tennessee Board of Regents	TBR Ramp: Reinforce Advanced Math Placement (RAMP) Program to Improve Success in Engineering	Dr. Elizabeth Powell & Dr. Kumar Yelamarthi
David Schafer	Center for Energy Systems Research	SPS USAF Thermal Mgmt. System	Dr. Rory Roberts



# UNDERGRADUATE RESEARCH PROJECTS, continued SM-11

2022-2023

Student	Sponsor	Program	Faculty Advisor
Alex Tharpe	Center for Energy Systems Research	DOE ARPA-e REEACH	Dr. Rory Roberts
Marton Varga	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
Ezekiel Vespie	Department of Energy	DOE: The Structure of Neutron-Rich Deformed Nuclei Studied via Beta Decay	Dr. Mustafa Rajabali
Minh-nghi Vu	National Science Foundation	NSF: Collaborative Research: NeTS: JUN03: SWIFT: Softwarization of Intelligence for Efficient 6G Mobile Networks	Dr. Muhammad Ismail
C. Dylan Walker	SPIDA	SPIDA: Determine the Maximum Negative Operating and Collapse Pressure of Stocked Spiral Duct With and Without Corrugations	Dr. Venkata Paruchuri & Dr. Stephen Idem



Photos from Seminar of Mr. Kent Kristensen of GLX, and lunch meeting with Mr. Kristensen, CESR faculty and staff, and Nissan officials on April 27, 2023



# ACTUAL, PROPOSED, AND REQUESTED BUDGET SCHEDULE 7

## CENTERS OF EXCELLENCE ACTUAL, PROPOSED, AND REQUESTED BUDGET

Institution	Tennessee Technological University						Center	Center for Energy Systems Research		
	FY 2022-23 Actual			FY 2023-24 Proposed			FY 2024-25 Requested			
	Matching	Appropriation	Total	Matching	Appropriation	Total	Matching	Appropriation	Total	
<b>Expenditures</b>										
<b>Salaries</b>										
Faculty	\$ 646,975	\$ 266,800	\$ 913,775	\$ 118,000	\$ 395,876	\$ 513,876	\$ 181,892	\$ 350,000	\$ 531,892	
Other Professional	\$ 82,720	\$ 142,867	\$ 225,587	\$ 5,000	\$ 247,893	\$ 252,893	\$ 6,000	\$ 260,000	\$ 266,000	
Clerical/ Supporting	\$ -	\$ 57,883	\$ 57,883	\$ -	\$ 56,633	\$ 56,633	\$ -	\$ 30,000	\$ 30,000	
Assistantships	\$ 397,836	\$ 152,476	\$ 550,312	\$ 160,000	\$ 195,766	\$ 355,766	\$ 110,216	\$ 160,000	\$ 270,216	
Hourly Students	\$ 101,529	\$ 24,195	\$ 125,724	\$ 24,000	\$ 42,591	\$ 66,591	\$ 20,000	\$ 26,000	\$ 46,000	
<b>Total Salaries</b>	<b>\$ 1,229,060</b>	<b>\$ 644,221</b>	<b>\$ 1,873,281</b>	<b>\$ 307,000</b>	<b>\$ 938,759</b>	<b>\$ 1,245,759</b>	<b>\$ 318,108</b>	<b>\$ 826,000</b>	<b>\$ 1,144,108</b>	
Fringe Benefits	\$ 161,653	\$ 129,190	\$ 290,843	\$ 24,150	\$ 226,821	\$ 250,971	\$ 55,000	\$ 110,000	\$ 165,000	
Grad Tuition/Fees	\$ 210,167	\$ 94,109	\$ 304,276	\$ 118,000	\$ 143,323	\$ 261,323	\$ 83,000	\$ 152,000	\$ 235,000	
<b>Total Personnel</b>	<b>\$ 1,600,880</b>	<b>\$ 867,520</b>	<b>\$ 2,468,400</b>	<b>\$ 449,150</b>	<b>\$ 1,308,903</b>	<b>\$ 1,758,053</b>	<b>\$ 456,108</b>	<b>\$ 1,088,000</b>	<b>\$ 1,544,108</b>	
<b>Non-Personnel</b>										
Travel	\$ 85,971	\$ 11,623	\$ 97,594	\$ 40,000	\$ 51,892	\$ 91,892	\$ 25,000	\$ 20,000	\$ 45,000	
Software	\$ -	\$ 8,281	\$ 8,281	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
Books & Journals	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
Other Supplies	\$ 88,162	\$ 19,952	\$ 108,113	\$ 40,000	\$ 357,824	\$ 397,824	\$ 15,000	\$ 33,765	\$ 48,765	
Equipment	\$ 125,022	\$ -	\$ 125,022	\$ 40,000	\$ -	\$ 40,000	\$ 40,000	\$ 50,000	\$ 90,000	
Maintenance	\$ -	\$ 13,976	\$ 13,976	\$ -	\$ -	\$ -	\$ -	\$ 450	\$ 450	
Scholarships for Service	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
Consultants/Subcontracts	\$ 253,977	\$ 415	\$ 254,392	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
Renovation	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
Seminars/Workshops/Con	\$ 182,591	\$ 4,182	\$ 186,773	\$ -	\$ -	\$ -	\$ 60,000	\$ -	\$ 60,000	
<b>Total Non-Personnel</b>	<b>\$ 735,723</b>	<b>\$ 58,429</b>	<b>\$ 794,151</b>	<b>\$ 120,000</b>	<b>\$ 409,716</b>	<b>\$ 529,716</b>	<b>\$ 140,000</b>	<b>\$ 104,215</b>	<b>\$ 244,215</b>	
<b>GRAND TOTAL</b>	<b>\$ 2,336,603</b>	<b>\$ 925,948</b>	<b>\$ 3,262,551</b>	<b>\$ 569,150</b>	<b>\$ 1,718,618</b>	<b>\$ 2,287,768</b>	<b>\$ 596,108</b>	<b>\$ 1,192,215</b>	<b>\$ 1,788,323</b>	
<b>Revenue</b>	<b>NOTE: Actual Matching Funds do not include Indirect Costs of \$578,103.39 for FY 2022-2023.</b>									
New State Appropriation	\$ -	\$ 1,079,300	\$ 1,079,300	\$ -	\$ 1,138,300	\$ 1,138,300	\$ -	\$ 1,192,215	\$ 1,192,215	
Carryover State Appropriation	\$ -	\$ 426,966	\$ 426,966	\$ -	\$ 580,318	\$ 580,318	\$ -	\$ -	\$ -	
New Matching Funds	\$ 2,336,603	\$ -	\$ 2,336,603	\$ 569,150	\$ -	\$ 569,150	\$ 596,108	\$ -	\$ 596,108	
Carryover from Previous Matching Funds	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
<b>Total Revenue</b>	<b>\$ 2,336,603</b>	<b>\$ 1,506,266</b>	<b>\$ 3,842,869</b>	<b>\$ 569,150</b>	<b>\$ 1,718,618</b>	<b>\$ 2,287,768</b>	<b>\$ 596,108</b>	<b>\$ 1,192,215</b>	<b>\$ 1,788,323</b>	
<b>NOTE: Carryover funds of \$580,318 are committed to: 1) beginning investigators and early-career faculty (to build a foundation of leadership in energy-related research); 2) graduate student support; 3) cost-sharing for external grants;</b>										

## JUSTIFICATION FOR 2024-2025 APPROPRIATIONS REQUEST

The Center for Energy Systems Research (CESR) is requesting a 10% increase in anticipation of additional expenses during 2024-2025. The increased expenses include additional costs for personnel appointments of support staff and the second Research Assistant Professor, and funding for additional undergraduate and graduate students to participate in the research activities of the CESR.

