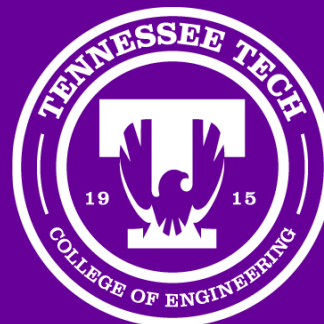
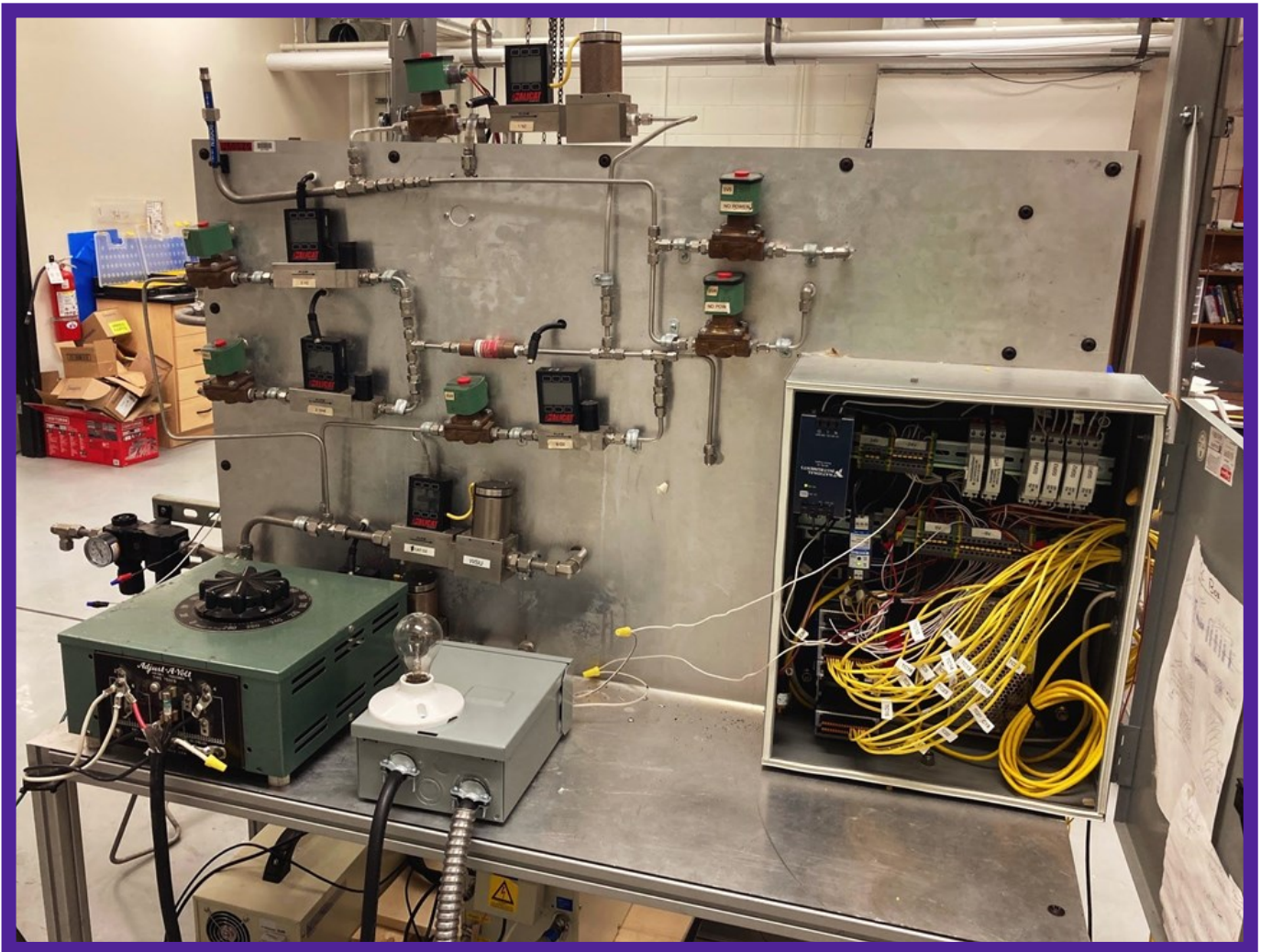


Center For Energy Systems Research

Tennessee Tech University

Annual Report for Fiscal Year 2021-2022



Annual Report for Fiscal Year

July 1, 2021—June 30, 2022

Satish M. Mahajan, Director

www.tntech.edu/cesr



Center for
Energy
Systems
Research

“Where research is put into practice.”



Tennessee
TECH

Center for Energy Systems Research

1020 Stadium Drive, PRSC 233

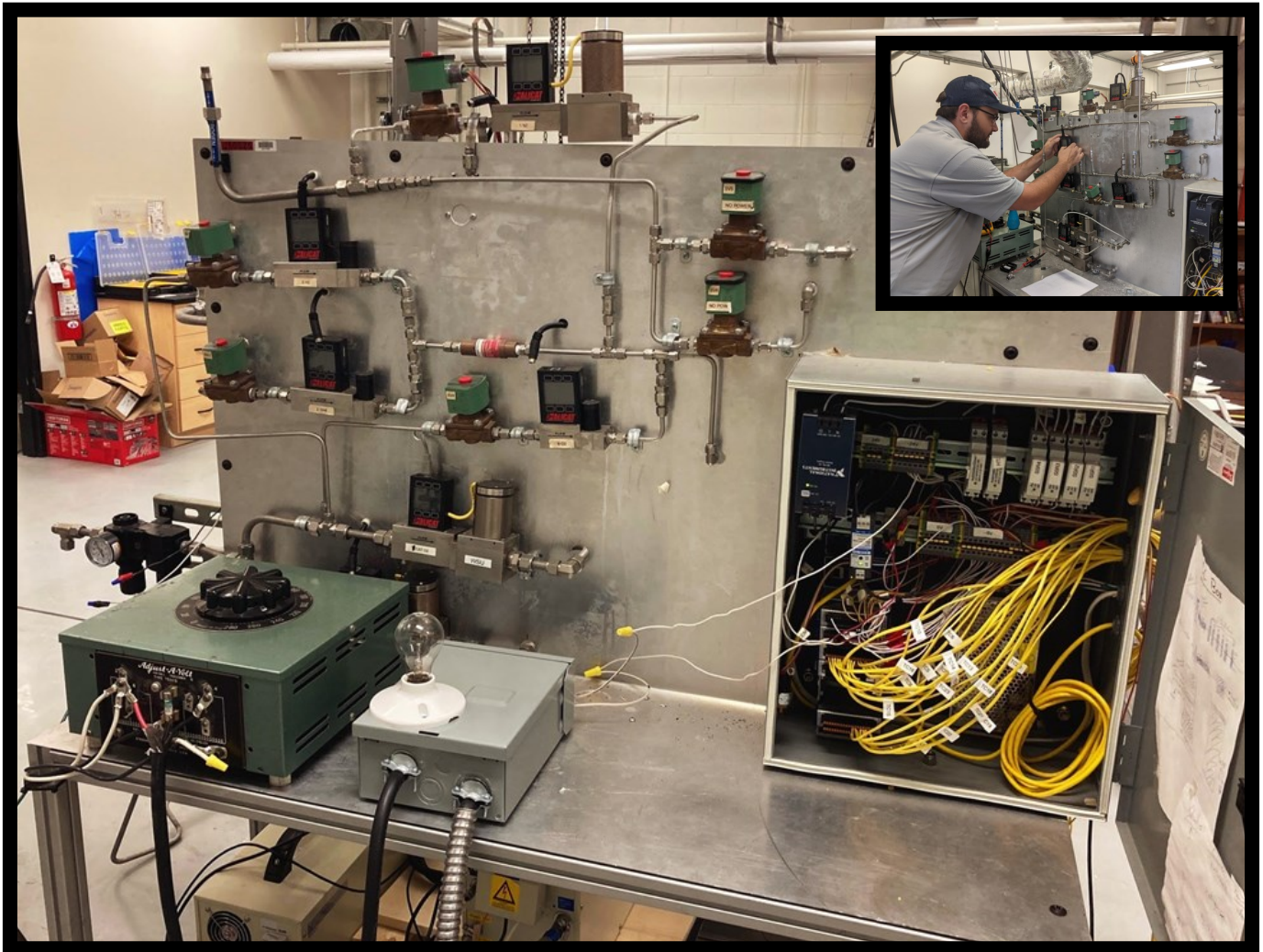
Campus Box 5032

Cookeville, TN 38505

931-372-3615

cesr@tntech.edu

www.tntech.edu/cesr



As part of the Test Stand research, shown above are mass flow controllers, electronic valves, and other data acquisition/control equipment. This project is sponsored by the Department of Energy-Advanced Research Projects, entitled, “High Power Density Carbon Neutral Electrical Power Generation for Air Vehicles,” Dr. Rory Roberts, Mechanical Engineering, PI. (See p. 16 for more pictures.)

Shown in insert is Ph.D. student Trevor Kramer.

TABLE OF CONTENTS

PROGRAMMATIC REPORT

MISSION	1
VISION	1
HISTORY	1
YEAR IN REVIEW	2
RESEARCH AREAS 2019-2022	3
CESR RESEARCH FUNDING 1985 THROUGH 2022.....	3
FACULTY AWARDS AND ACCOMPLISHMENTS 2020-2022	6
STUDENT AWARDS AND ACCOMPLISHMENTS 2020-2022	12
PLANS FOR 2022-2023	15

SUPPORTING MATERIALS

SUPPORT STAFF	SM-1	17
FACULTY PARTICIPATION	SM-2	18
CONTRACT AND GRANT AWARDS	SM-3	19
PROPOSALS	SM-4	24
PUBLICATIONS OF CESR FACULTY	SM-5	31
BOOK/CHAPTER/PATENTS OF CESR FACULTY	SM-6	32
SEMINAR SERIES	SM-7	33
CESR GRADUATES	SM-8	34
GRADUATE STUDENT SUPPORT	SM-9	39
HOURLY STUDENT PERSONNEL	SM-10	42
UNDERGRADUATE RESEARCH PROJECTS	SM-11	46

BUDGET MATERIALS

ACTUAL, PROPOSED, AND REQUESTED BUDGET—SCHEDULE 7	51
JUSTIFICATION FOR 2023-2024 APPROPRIATIONS REQUEST	52

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

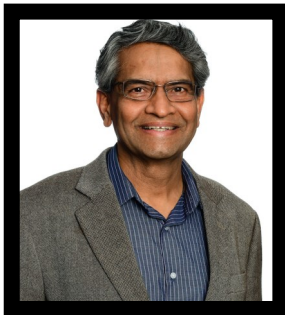
The State of Tennessee established the Center for Electric Power in 1985 in the College of Engineering at Tennessee Technological University. Reflecting the broadening of the activities of the Center, its name was changed to Center for Energy Systems Research. Over the years, research projects have been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

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 will be 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.

YEAR IN REVIEW



Dr. Satish M. Mahajan continued as the Director of the Center for Energy Systems Research (CESR) for fiscal year 2021-2022. The CESR continues to focus on three strategic research areas: Smart Grid, Resilient Infrastructure, and Wireless Power Transfer.

Year 2021-2022 was another good year for the CESR. This year, the external funding increased by about 14.4 percent over the previous year for a total of **\$2,657,701, making 2021-2022 another record-breaking year** in the 37-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 sixth time since 1985 that the CESR activations have crossed \$2 million, and now four years in a row out of those six years.

This year, the CESR was associated with **two NSF Career Award winners**: Dr. Arman Sargolzaei, and Dr. Ahmad Vasselbehagh. They represent the quality of research performed at the CESR.

The proposal activity also shot up significantly higher to over \$21 million, representing a greater than 50 percent increase and another record in itself. The increased 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. I hope the long-awaited reorganization takes place and the shortage of trained staff is also addressed soon.

In the 2021-2022 fiscal year, the CESR funded 27 M.S. assistantships (10 on grants only, 11 on CESR only, and 6 on grants plus CESR, plus other University sources combined); and 28 Ph.D. assistantships (9 on grants only, 14 on CESR only, and 5 on grants plus CESR, plus other University sources). The CESR supported a total of 40 graduate students on an hourly basis. The combined headcount of the CESR-supported graduate students is 75. The CESR also supported a total of 33 undergraduate students, a significant number of them on the grants.

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

Dr. Ali Arzani joined the CESR in August 2021 as Research Assistant Professor. He comes from Clemson University and will certainly strengthen our Smart Grid group. Dr. Shirin Noei left the CESR after two years of service. A search for a new Research Assistant Professor in the Transportation Engineering area is currently underway. The CESR will continue to invest in new faculty via start-up packages. This year the CESR is committing to one more faculty member, Dr. Peng Zhang in Mechanical Engineering. We welcome him, and look forward to his contributions.

Ms. Sara Howard joined the CESR as a Financial Associate and helped tremendously with pre-award and post-award support aspects. Ms. Anysa Milum was away from the CESR for four months but rejoined as the Center Manager to bring back a welcomed relief. Ms. Barbara Fenlon and Mr. Robert Craven continue to provide excellent support for which the Center is known. Many thanks to their tireless efforts in support of students and faculty associated with the CESR! I would also like to thank Ms. Tracy Limper for her assistance with the preparation of this report.

PROGRAMMATIC REPORT

Research contract and grant awards included in Matching from July 1, 2021 thru June 30, 2022 total \$2,225,780. Gifts and Other Awards included in Matching total \$59,880. Therefore, the 2021-2022 Match is \$2,165,900. Indirect costs of approximately \$431,921 were also received during the 2021-2022 Fiscal Year. The result is that the 2021-2022 Matching and Indirect Costs total \$2,657,701. The State Appropriation was \$1,030,100 for 2021-2022.

The CESR continues to enjoy a broad base of support. The funding categories for 1985 thru 2022 as illustrated in Figure 1 are: in-state utilities, 8.60 percent; out-of-state utilities, 4.67 percent; state and local agencies, 9.21 percent; federal government, 63.60 percent; other, 13.92 percent. The “other” category includes a variety of national and international industries, universities and professional societies. Through June 2022, the cumulative research funding of the Center is \$39,824,200.05. State appropriations are compared to matching, on an annual basis, in Figure 2. Matching is divided into contracts and grants (without indirect costs); equipment; and all other items such as software, books and reports, and funding for faculty and student exchange programs. The 37-year match of about \$37.2 million represents 112.5% percent of the state appropriations of \$33.3 million. Indirect costs of approximately \$7.07 million were also received. A list of the projects conducted under the major research areas is given in SM-3 in this report.

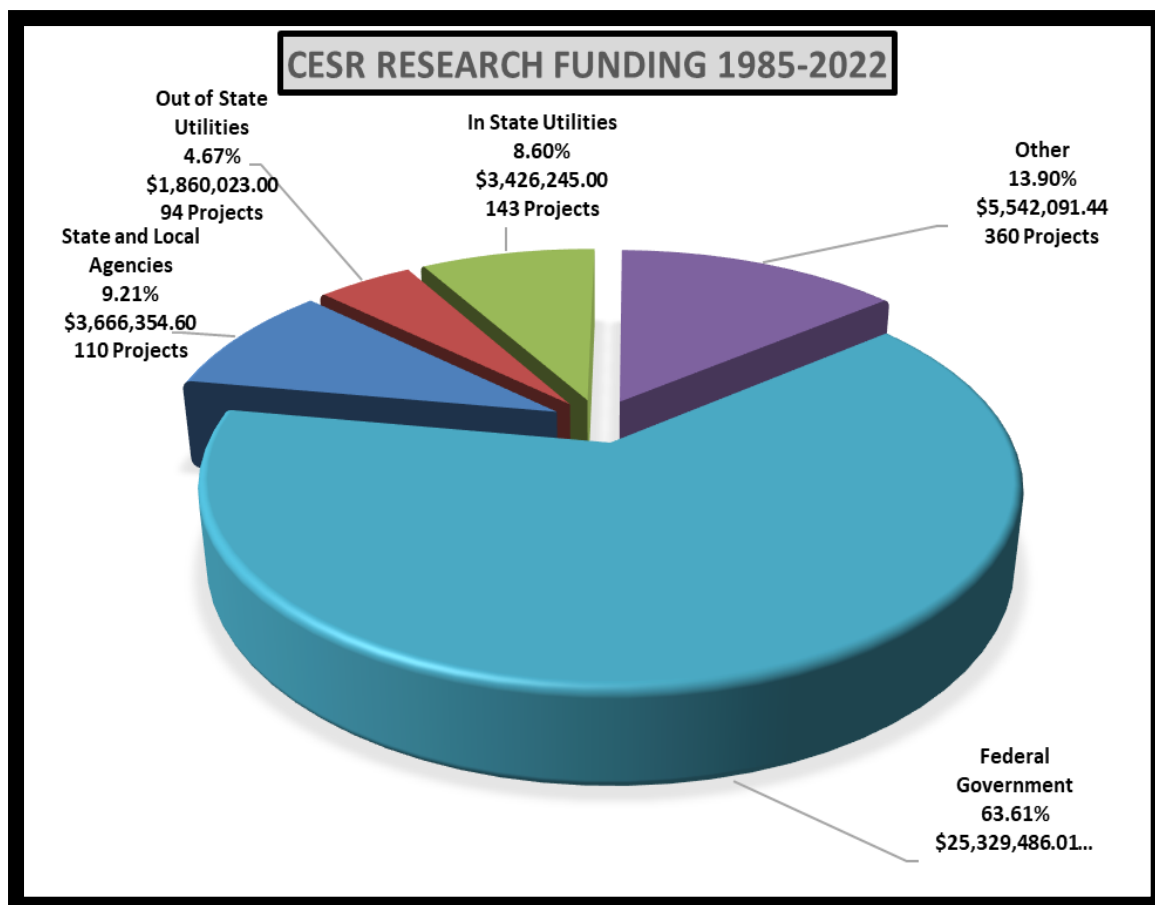


Figure 1: Types of Research Funding

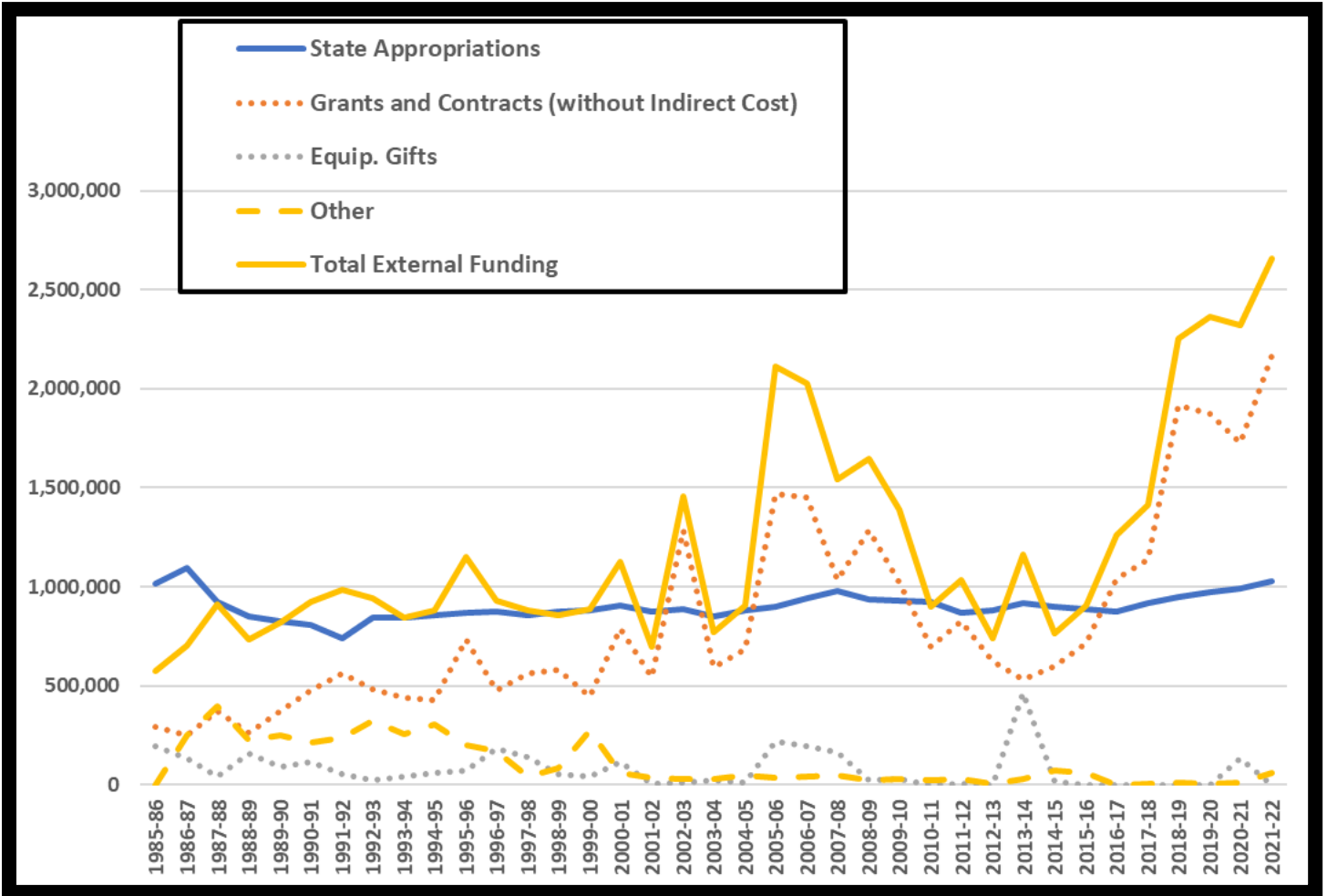


Figure 2: Historical State Appropriations, Matching & Total External Funding 1985-2022

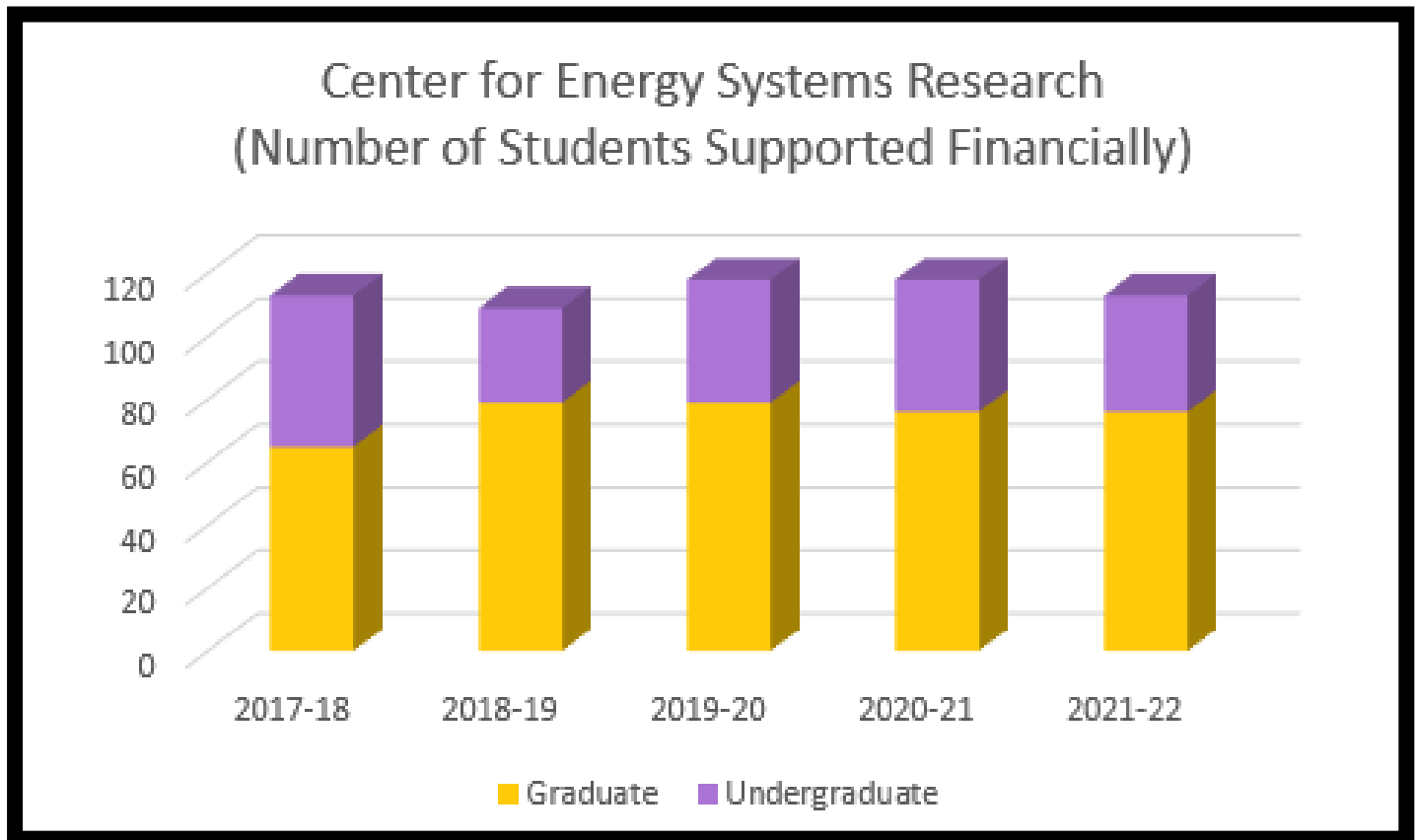


Figure 3: Number of Students Supported.

CESR Faculty Associates are Winners of the NSF Career Award



Dr. Arman Sargolzaei

Dr. Arman Sargolzaei, Assistant Professor of ME and a CESR Faculty Associate, was awarded the prestigious National Science Foundation (NSF) CAREER grant for his project entitled, “Systematic Approach for Extensively (SAfEly) Testing and Verifying the Security of Connected and Autonomous Vehicles,” beginning 02/15/2022 and ending 01/31/2027. Grant amount was \$500,000.00.

This Research and Development award is funded through the NSF 20-525 Faculty Early Career Development Program.



Dr. Ahmad Vasselbehagh

Title: Understanding Thermal Transport Processes in Atmospheric boundary Layer with Utility-Scale Solar Photovoltaic Plants

Amount: \$500,493.00

Duration: July 1, 2022 to June 30, 2027

Summary: Dr. Vasselbehagh’s NSF CAREER award will support his research and educational efforts in understanding and modeling thermal transport processes within the atmosphere. Using field campaigns and computer simulations, Dr. Vassel and his team will discover the impact of artificial canopies of millions of photovoltaic panels on thermal transport dynamics within the atmospheric boundary layer. The knowledge gained will allow the introduction of such giant solar plants into climate models. This research will also lead to a new Atmospheric Transport course, a textbook, and a mobile app, namely ATMOSPort. This NSF award will allow Dr. Vassel to advance lower-level curriculum courses and help students obtain "the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context," an ABET criterion currently missing in the department's undergraduate courses.



Dr. Joseph Biernacki

Dr. Joseph Biernacki, of Chemical Engineering, was awarded the TTU Scholastic Research Award for work on printing of cement-based materials culminating in the publication of H. Taheri Afarani, W. Carrol, E. J. Garboczi and J. J. Biernacki, Designing 3D Printable Cementitious Materials with Gel-Forming Polymers, Construction and Building Materials, 268, 121709 (2021).



Dr. Sheikh Ghafoor

Dr. Sheikh Ghafoor, of Computer Science, along with Dr. Mike Rogers (CSC) conducted a two-week long hands-on faculty development workshop on hoe to incorporate parallel and distributed computing in early computing classes. This workshop was funded by a National Science Foundation grant. Fifteen faculty from 15 different universities from all across the USA and one faculty from Nigeria have participated in the workshop. (See picture below.)





Dr. Maanak Gupta, Computer Science:

- Recipient of the TTU Kinslow Engineering Research Award, 2022.
- Received the Best Graduate Award (Runner Up) for “Anomaly Detection in Smart Farming using Machine Learning” presented by Mary Adkisson and Jeffrey Kimmel (Co-Authored with Maanak Gupta and Mahmoud Abdelsalam) at ACM Mid-Southeast Conference 2021.
- Invited speaker, “Security and Privacy for Emerging IoT and Cyber Physical Systems.”
- Invited Expert Lecturer at Rashtriya Raksha University, Gandhinagar, India, March 7, 2022.
- Invited speaker, "Evolving Cybersecurity Landscape: How can we prepare.”
- Invited Expert Lecturer at Faculty Development Program on Cloud Forensics: Techniques, Challenges and Research Directions, National Institute of Technology, Sikkim, India, October 18-22, 2021.
- Invited speaker, "Secure V2V and V2I Communication in Intelligent Transportation using Cloudlets" Invited paper presentation at IEEE Services Conference September 9, 2021, Virtual Event.
- Invited speaker, "Artificial Intelligence assisted Malware Analysis.”
- Workshop speaker at Women in Cybersecurity (WiCyS) conference, Denver, Colorado, USA, September 8, 2021.



Dr. Syed Rafay Hasan, Electrical and Computer Engineering:

- Became IEEE Senior Member (only 10% of IEEE’s more than 400,000 members hold this grade, which requires extensive experience, and reflects professional maturity and documented achievements of significance).

Served as an NSF Panel Reviewer for the following:

- CISE directorate’s SaTC program
- PFI program of Directorate for Technology, Innovation and Partnerships Translational Impacts
- Served as Conference Session Chair at IEEE/ACM International Great Lake Symposium on VLSI, June 2022



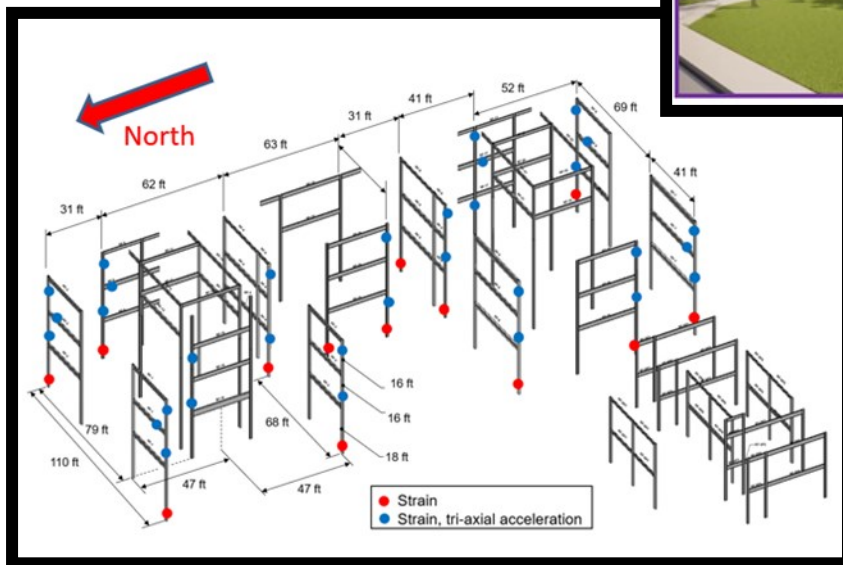
Dr. R. Craig Henderson

Dr. Craig Henderson, Civil and Environmental Engineering



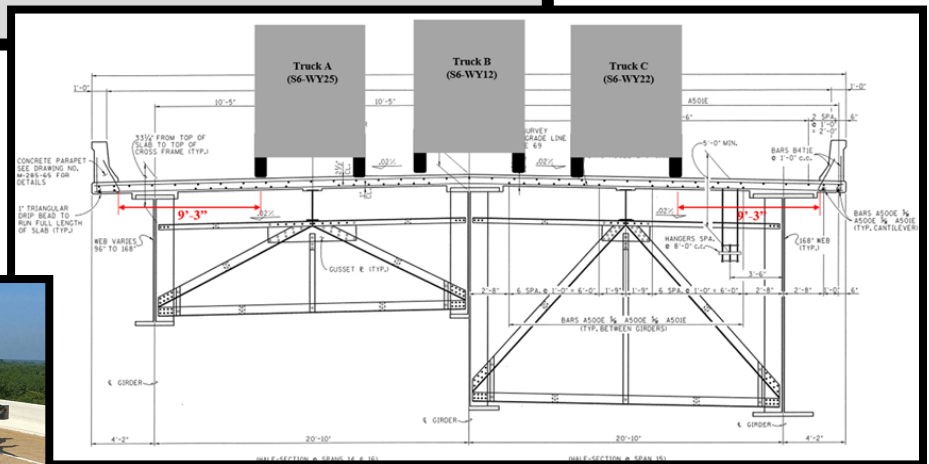
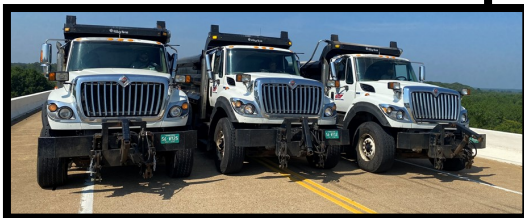
Above: Upgraded the Building Information Modeling Lab in PRSC 313

Research was conducted by Dr. Henderson to determine the appropriate type of instrumentation for the new Engineering Building (to include accelerometers and strain gages). This work was conducted in conjunction with Mechanical Engineering (Dr. Steve Anton is PI from ME).



Dr. Craig Henderson, Civil and Environmental Engineering (continued)

Below: Dr. Henderson provided research with the Tennessee Department of Transportation (TDOT) to update the load rating on the State’s 31 older bridges with superstructure systems consisting of steel girders, stringers, and floorbeams. The research project will study the behavior of the girder-stringer-floorbeam bridges by experimentally measuring strain in the stringers of a bridge through live load testing while also performing analytical computer modeling.



Dr. Mohamed Mahmoud, Electrical and Computer Engineering, was awarded the following:

- Fulbright US Scholar Award, 2022 to 2023, US national/federal award, offered for excellence in research, teaching, leadership, and outreach.
- T.S. McCord Engineering Faculty Award, College of Engineering, TTU, 2022. The award is primarily to recognize an outstanding faculty member who has demonstrated a deep compassion for the students. Examples of such activities could include outstanding advising to students, outstanding teaching, engaging/impacting students in meaningful research activity, etc.



Dr. Denis Ulybyshev, Computer Science, was awarded the Tennessee Tech Faculty Research Award, Track II. "Mobile Navigation, Object Detection, Recommendation and Notification Software Assistant for Visually Impaired People in Campuses and Smart Cities". PI: Denis Ulybyshev



Dr. Daniel VandenBerge, Civil and Environmental Engineering, reports an update to the following:

- Book: "Output Feedback Reinforcement Learning Control for Linear Systems" published in Springer (June, 2022)
- Book Chapter published in the Book: "Handbook of Reinforcement Learning and Control" (July, 2021)



Dr. Indranil Bhattacharya

Dr. Indranil Bhattacharya, ECE, reports that his Ph.D. student, Trapa Banik, and his MS student, Abiodun Olatunji, won first prizes, respectively, in the research and creative inquiry day poster presentations. His undergraduate student, Joshua Thomas, won the best research paper award for an undergraduate student.



Shown at right: L-R: Dr. Indranil Bhattacharya, Mr. Webster Adepoju, Ms. Trapa Banik, and Mr. Abiodun Olatunji.



Dr. Joseph Biernacki

Dr. Joseph Biernacki, CHE, reports that his Ph.D. student, Hajar Taheri Afarani, was awarded the COE Spectrum Award for Best Paper: H. Taheri Afarani, W. Carrol, E. J. Garboczi and J. J. Biernacki, Designing 3D Printable Cementitious Materials with Gel-Forming Polymers, Construction and Building Materials, 268, 121709 (2021).

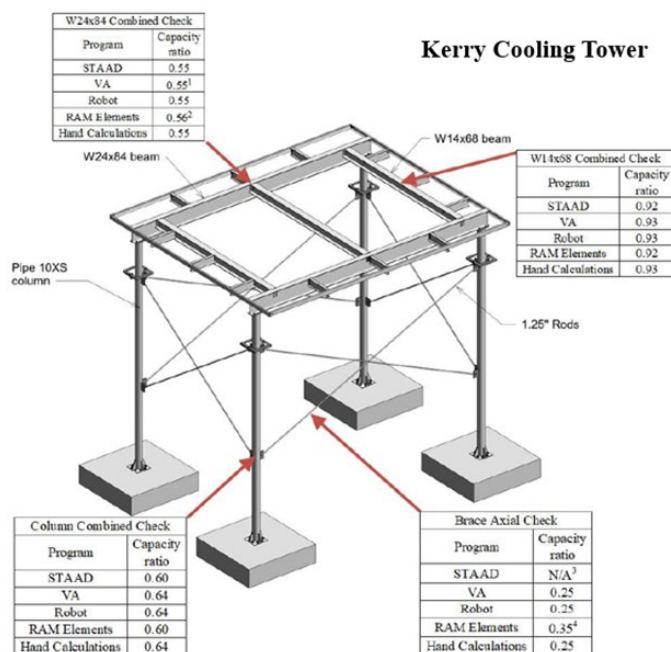


Dr. Mohamed Mahmoud

Dr. Mohamed Mahmoud (ECE) reports that his former Ph.D. student, Dr. Ahmed Alsharif, has joined The University of Alabama at Tuscaloosa, which is classified as an R-1 university.



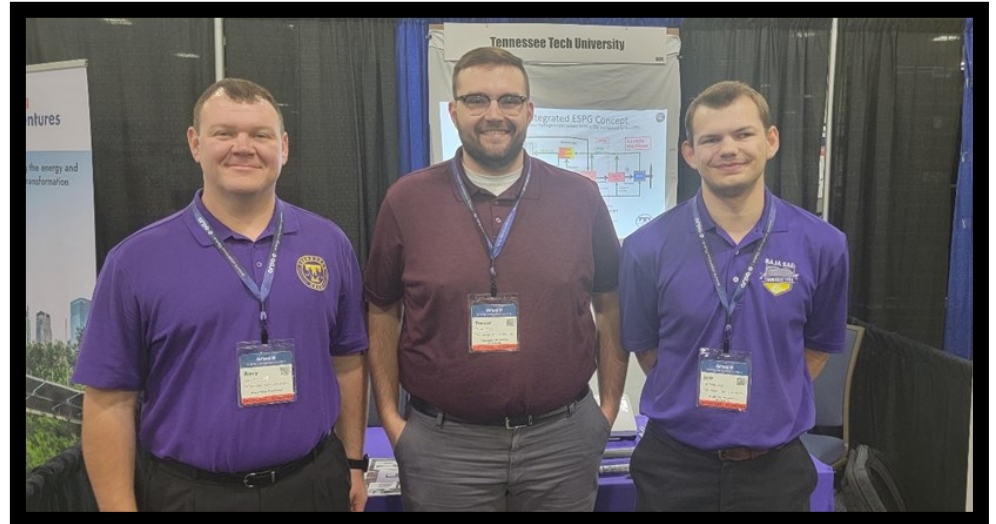
Above: Building Information modeling research and BIM curriculum development were conducted with 4 undergraduates and 1 graduate student with guidance from **Dr. R. Craig Henderson**, Civil and Environmental Engineering. Dr. Henderson is shown at far right in photo.



At left: Research was conducted examining the ‘Interoperability’ of Building Information Modeling software with the assistance of graduate student Nicholas Lawson, student of Dr. R. Craig Henderson.



Dr. Rory Roberts



Above Right: **Dr. Rory Roberts**, ME, with his graduate students, Trevor Kramer and Jeff Webster, shown at the ARPA-E Energy Summit 2022 where they showcased their progress in testing and design of a new power generation system for electrifying a large Boeing 737 class aircraft. Our power generation technology utilizes a solid oxide fuel cell integrated with gas turbine generator to create a carbon neutral high-efficiency and high-specific power density solution for electrifying aviation. We are currently on target to exceed current state-of-the-art propulsion systems with extending flight range and 50% reduction in fuel burn.

<https://sites.tntech.edu/ppats/arpa-e-reeach-range-extenders-for-electric-aviation-with-low-carbon-and-high-efficiency/>

PLANS FOR 2022-2023

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 ten 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 year the CESR continued the activity called 'Faculty Research Associate' to release department faculty from a course so that they can write significant proposals. A CEE faculty member was supported via this program in the spring 2022 semester. 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 CO₂ 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

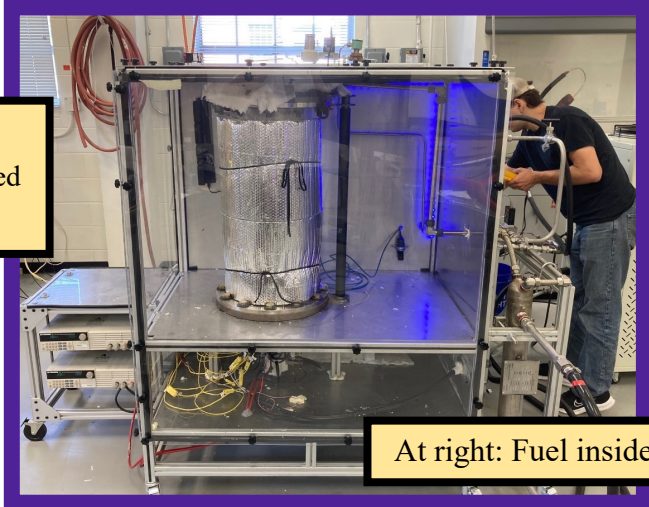
Now that the COVID-19 pandemic appears to be in decline, we will organize a minimum of two seminars by external speakers per year. Attempts will be made to arrange virtual seminars also.

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.

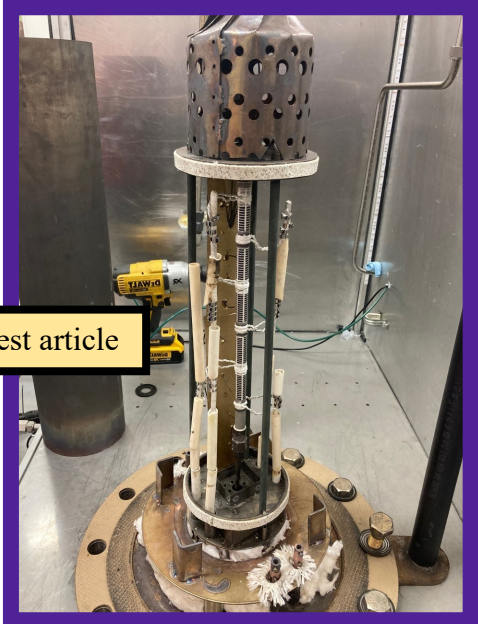
SUPPORTING MATERIALS

(From Page ii)

At right:
Fully Assembled
Test Stand



At right: Fuel inside test article



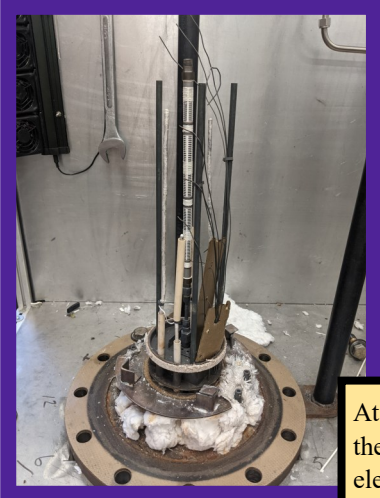
Below: Bottom of Test Stand. The black coils are induction heaters that preheat the incoming air and fuel. The gas inlets and sensors can also be seen.



Below: Big vessel being lowered onto the fuel cell with the white heater around it.



Below: Research Team, L-R: Alex Tharpe, Will (Jimmy) Meacham, Trevor Kramer, Jeff Webster, and David Schafer



At left: Bottom flange for the large pressure vessel shown in previous pictures. The fixture at the bottom with the white insulation underneath allows for the fuel cell, flow manifold, and electrical feed-throughs to be supported. The tube in the middle is the fuel cell and the three rods along the outside support the combustion. The various wires sprawling around are thermocouples which help measure temperature. The two pairs of silver rods next to the fuel cell are how we draw power from the fuel cell.

CESR FACULTY & STAFF—2021-2022

Center Director:	Dr. Satish M. Mahajan, Professor	Director, CESR
Center Faculty:	Dr. Ali Arzani	Assistant Research Professor
	Dr. Shirin Noei	Assistant Research Professor
	Dr. Matthew Pearce	Post-Doc Researcher
Center Staff:	Mr. Robert Craven	Research Engineer
	Ms. Barbara Fenlon	Administrative Associate 4
	Ms. Sara Howard	Financial Associate 6
	Ms. Erin Huelskamp (Part Time)	Financial Associate
	Ms. Anysa Milum	Center Manager
CESR Staff (Part Time, Temporary):		
	Dr. Mohamed Baza	Research Engineer
	Mr. Jeffrey Graves	Research Assistant
	Mr. H. Hunter Himes	Research Assistant
	Mr. Jackson Penfield	Research Assistant
	Dr. Ahmed Sherif	Research Engineer

Faculty participating in the Strategic Research of the Center are:

Smart Grid

Ali Alouani – ECE
Ali Arzani—CESR
Indranil Bhattacharya – ECE
Nan Chen—ECE
Robert Craven – CESR
Tarek Elfouly—ECE
Sheikh Ghafoor – CSC
Maanak Gupta—CSC
Syed Rafay Hasan – ECE
Muhammad Ismail—CSC
Brian Leckie—Agriculture
Satish Mahajan – ECE
Mohamed Mahmoud – ECE
Joseph Ojo – ECE
Ghadir Radman – ECE
Syed Rizvi—ECE
Rory Roberts—ME
Michael Rogers—CSC
Arman Sargolzaei—ME
Ambareen Siraj – CSC
Denis Ulybyshev—CSC
Charles Van Neste – ECE
Ahmad Vasselbehagh—ME

Resilient Infrastructure

Daniel Badoe – CEE
Joseph Biernacki – CHE
J.W. Bruce—ECE
Laura Arias Chavez – CHE
Steven Click – CEE
L. K. Crouch – CEE
Jie Cui—ME
Jerry Gannod – CSC
Craig Henderson – CEE
Timothy Huff – CEE
Stephen Idem – ME
Alfred Kalyanapu—CEE
Ethan Languri – ME
Jane Liu – CEE
Allen MacKenzie—ECE
Benjamin Mohr – CEE
Shirin Noei—CESR
Mustafa Rajabali - PHY
Daniel VandenBerge – CEE
Liqun Zhang – CHE

**CONTRACT AND GRANT AWARDS
Activated Between July 1, 2021 and June 30, 2022**

Contract Number	Title	Source	Project Dates	Total Amount
535286	Machine Learning-Based Design and Operation of Next Generation Software-Defined Heterogeneous Networks-(Dr. Muhammad Ismail)	Qatar National Research Fund (QNRF) Texas A&M Engineering	5/15/2021 to 5/14/2024	\$49,198.80
535287	Development of a Testbed for Distributed Energy Resources (DER) and Controllable Loads Simulation-(Dr. Sheikh Ghafoor)	Electric Power Research Institute (EPRI)	6/1/2021 to 5/31/2022	\$43,665.00
532620	High Power Density Carbon Neutral Electrical Power Generation for Air Vehicles-(Dr. Rory Roberts)	Department of Energy -Advanced Research Projects Agency-Energy	7/12/2021 to 7/11/2023	\$411,171.00
533186	Building Pathways into Civil and Environmental Engineering for First Year Students-(Dr. Daniel VandenBerge)	Tennessee Board of Regents	7/1/2021 to 6/30/2022	\$43,211.00
532621	Regional Transportation Center on Reducing Congestion CAV Project-(Dr. Shirin Noei)	UFTI - DOT	8/1/2021 to 9/30/2022	\$61,725.00
531317	CC*CRIA: Planning a Regional Cyber-Infrastructure-Research Consortium for Middle Tennessee-(Dr. Sheikh Ghafoor)	National Science Foundation via UTC	07/01/2021 to 12/31/2021	\$11,235.00
532392	Regional Transportation Center on Reducing Congestion (STRIDE) C4-(Dr. Steven Click)	UFTI-DOT	01/19/2017 to 09/30/2022	27,677.00
531331	CC* Compute: A GPU Cluster for Science Research and Education at Tennessee Tech University-(Dr. Michael Rogers)	NSF	9/1/2021 to 8/31/2023	\$381,296.00
SUB - TOTAL, GRANTS AND CONTRACTS				1,029,178.80

**CONTRACT AND GRANT AWARDS
Activated Between July 1, 2021 and June 30, 2022**

Contract Number	Title	Source	Project Dates	Total Amount
532439	Lake Observations from Citizen Scientists and Satellites: Validation of Satellite Altimetry to Support Hydrologic Science-(Dr. Sheikh Ghafoor)	UNC Chapel Hill via NASA	6/25/2021 to 6/24/2022	\$64,999.00
531323	Collaborative Research: Cyber Training: Implementation: Medium: Broadening Adoption of Parallel and Distributed Computing in Under-(Dr. Sheikh Ghafoor)	NSF	10/15/2020 to 9/30/2023	\$20,043.00
539306	MRI: Hardware/Vehicle-in-the-Loop Environment for Verification of Connected and Autonomous Vehicles (Year 2)-(Dr. Arman Sargolzaei)	Florida Polytechnic University via NSF	10/1/2020 to 9/30/2022	\$21,065.00
531309	Tennessee Louis Stokes Alliance for Minority Participation (TLSAMP)-Year 4-(Dr. Kumar Yelamarthi)	NSF via TSU	9/1/2018 to 8/31/2023	\$26,100.00
532446	National Cybersecurity Teaching Academy: Southeast Consortium-(Dr. Mohamed Mahmoud)	University of Louisville Research Foundation, Inc., via NSA	8/6/2021 to 8/5/2023	\$30,000.00
539215	Modeling of renewables for demand response via HILLTOP-(Dr. Satish M. Mahajan)	UCDD/ARC	7/1/2021 to 9/30/2022	\$345,465.00
532392	Transportation Workforce Development Related to Traffic Signal Systems – Phase II (Project F5)-(Dr. Steven Click)	UFTI - DOT	10/1/2021 to 04/30/2023	\$16,780.00
532625	Thermal Treatment of Nuclear Plants' Ice TVA Condensers Using Laser, Phase II-(Dr. Ahmad Vasselbehagh)		2/10/2022 to 12/31/2022	\$250,000.00
SUB - TOTAL, GRANTS AND CONTRACTS				\$774,452.00

CONTRACT AND GRANT AWARDS
Activated Between July 1, 2021 and June 30, 2022

Contract Number	Title	Source	Project Dates	Total Amount
535272	Enabling Efficient Integration of Electric Vehicles in Qatar's Smart Grid: Planning, Operation, and Cybersecurity - Year 3 of 3 -(Dr. Mohamed Mahmoud)	Texas A&M Engineering Experiment Station, Funding from QNRF	1/1/2020 to 1/1/2023	\$29,494.80
535271	Enabling Efficient Integration of Electric Vehicles in Qatar's Smart Grid: Planning, Operation, and Cybersecurity - Year 3 of 3 -(Dr. Muhammad Ismail)	Texas A&M Engineering Experiment Station, Funding from QNRF	1/1/2020 to 1/1/2023	\$34,995.60
531291	2022 C&I Engineering Grant-(Dr. Kumar Yelamarthi)	TN Dept of Commerce Board of Architectural and Engineering Examiners	2/15/2022 to 6/30/2022	\$37,492.00
535296	Privacy-Preserving Health Monitoring System Using AI and Non-Intrusive Smart Sensors-(Dr. Mohamed Mahmoud)	Qatar National Research Fund (QNRF)	2/19/2022 to 4/11/2023	\$96,213.00
535295	Impact of DER Performance on Bulk Power System Inverter Behavior-(Dr. Ali Arzani)	EPRI	3/14/2022 to 9/14/2022	\$29,000.00
539398	Load Rating of Girder Stringer Floor Beam Bridges/FEDERAL PORTION-(Dr. Craig Henderson)	TN-DOT	3/15/2022 to 3/14/2023	\$80,000.00
539397	Load Rating of Girder Stringer Floor Beam Bridges/State portion-(Dr. Craig Henderson)	TN-DOT	3/15/2022 to 3/14/2023	\$20,000.00
531325	Improving Undergraduate Success through Effective Critical Thinking Year 2-(Dr. Joseph Biernacki)	NSF	3/15/2021 to 2/29/2024	\$109,742.00
SUB - TOTAL, GRANTS AND CONTRACTS				\$436,937.40

CONTRACT AND GRANT AWARDS
Activated Between July 1, 2021 and June 30, 2022

Contract Number	Title	Source	Project Dates	Total Amount
535298	Secure Federated Edge Intelligence Framework for AI-driven 6G Applications-(Dr. Mohamed Mahmoud)	Qatar National Research Fund (QNRF)	3/23/2022 to 4/19/2024	\$51,744.00
532279	The Structure of Neutron-Rich Deformed Nuclei Studied via Beta Decay-(Dr. Mustafa Rajabali)	DOE	2/1/2017 to 4/30/2023	\$82,000.00
531334	CAREER: Systematic Approach for Extensively (SAfEly) Testing and verifying the Security of Connected and Autonomous Vehicle-(Dr. Arman Sargolzaei)	National Science Foundation	2/15/2022 to 01/31/2027	\$83,900.00
535287	Development of a Testbed for Distributed Energy Resources (DER) and Controllable Loads Simulation-(Dr. Michael Rogers)	Electric Power Research Institute (EPRI)	6/1/2021 to 1/31/2023	\$27,958.00
532619	Cryo Thermal Management of High Power Density Motors and Drives-(Dr. Rory Roberts)	ARPA-E via Hyper Tech	04/12/2021 to 10/11/2024	\$25,631.00
539238	Atmosphere Independent Bipropellant Consuming Additively Manufactured Solid Oxide Fuel Cells (SOFCs) for Assured On-Orbit Space Power-(Dr. Rory Roberts)	Southwestern Ohio Council for Higher Education(SOCHE) via DOD funds	8/1/2020 to 10/31/2023	\$69,000.00
539238	Atmosphere Independent Bipropellant Consuming Additively Manufactured Solid Oxide Fuel Cells (SOFCs) for Assured On-Orbit Space Power-(Dr. Rory Roberts)	Southwestern Ohio Council for Higher Education(SOCHE) via DOD funds	8/1/2020 to 10/31/2023	\$17,020.00
SUB - TOTAL, GRANTS AND CONTRACTS				\$357,253.00
POWER-TEST-SERVICE ACCOUNT				-
TOTAL CONTRACTS AND GRANTS DURING 2021 - 2022				2,597,821.20



At left: Dr. Matthew Pearce, a Post Doc working in the CESR under the direction of Dr. Charles Van Neste, connects a 2W incandescent bulb to a receiving well, demonstrating long-range wireless power transfer over 45m (150 feet) through the soil.

At right: Graduate Students of Dr. Charles Van Neste, Brandon Nieman, Tyler Marcrum, and Storm Johnson (and Kane the farm dog), take measurements of wireless power transferred through the soil at TTU's Shipley Research Farm.



At left: Graduate Students of Dr. Rory Roberts, working on the DOE ARPA-E REEACH Project, (L-R) Alex Tharpe, Will (Jimmy) Meacham, Trevor Kramer, Jeff Webster, and David Schafer.



Undergraduate student, Michael Ezelle, at left: At the solar trailer at Shipley Farm; at right: working on heat pump.



STATUS OF PROPOSALS
Submitted Between July 1, 2021 through June 30, 2022

	TITLE	INVESTIGATORS	SOURCE	AMOUNT	STATUS
1.	Modeling of renewables for demand response via HILLTOP	Satish M. Mahajan Michael Rogers	UCDD/ARC	245,506.00	Funded
2.	Regional Transportation Center on Reducing Congestion CAV Project	Shirin Noei	University of Florida Traffic Institute via Department of Transportation	61,725.00	Funded
3.	Improving Racial Equity in STEM Education and Research in Biomedical, Cyber Security, Advanced Manufacturing	Indranil Bhattacharya Ismail Fidan Maanak Gupta Jonathan Sanders George Chitiyo	National Science Foundation	854,186.00	Not Funded
4.	CAREER: Systematic Approach for Extensively (SAfEly) Testing and Verifying the Security of Connected and Autonomous Vehicle	Arman Sargolzaei	National Science Foundation	500,000.00	Funded
5.	CAREER: Mobile-Energy Storages: Multi-Resource Implementation and Operation	Nan Chen	National Science Foundation	500,105.00	Not funded
SUBTOTAL, PROPOSALS FOR 2021-2022				2,161,522.00	

STATUS OF PROPOSALS
Submitted Between July 1, 2021 through June 30, 2022

	TITLE	INVESTIGATORS	SOURCE	AMOUNT	STATUS
6.	CAREER: Understanding and Modeling of Thermal Transport Processes within the Atmospheric Boundary Layer I the Presence of Utility-Scale Solar Photovoltaics Plants	Ahmad Vaselbehagh	National Science Foundation	500,493.00	Funded
7.	CAREER: Exploring Non-Linear Electromagnetic Wave Phenomena Over and Through the Soil for Long-Range Wireless Power Transfer, Recapture, and Harvesting	Charles Van Neste	National Science Foundation	527,883.00	Not funded
8.	Determine the Absolute Roughness of Phenolic	Venkat Paruchuri Stephen Idem	Kingspan Insulation, LLC	52,465.00	Not funded
9.	PIPP Phase I: Develop and evaluate probabilistic frameworks to predict and prevent future coronavirus pandemics	Peng Zhang	National Science Foundation	175,245.00	Pending
10.	Thru-the-Soil Long Range Wireless Power Transfer Integrated with Geothermal Heat Pump Systems	Charles Van Neste Ahaman Vaselbehagh Daniel VandenBerge	Department of Energy	8,615,957.00	Not funded
SUBTOTAL, PROPOSALS FOR 2021-2022				9,872,043.00	

STATUS OF PROPOSALS
Submitted Between July 1, 2021 through June 30, 2022

	TITLE	INVESTIGATORS	SOURCE	AMOUNT	STATUS
11.	NRT-FW-HTF: Engineering the Spirit of Gadugi at the Food-Energy-Water Nexus	Pedro Arce Ada Haynes Satish M. Mahajan Jonathan Sanders	National Science Foundation	3,000,000.00	Funded
12.	Reconstructing fluid's memory using deep-learning	Ahamad Vaselbehagh Doug Talbert	National Science Foundation	277,473.00	Not funded
13.	Attack Resistant Multivector architecture in Cyber-Physical Systems (ARM-CPS)	Arman Sargolzaei	Office of Naval Research	442,309.00	Not funded
14.	Reinforcement Learning-Based Resilient COntroller ValiDation of Autonomous SystEms (RECODE)	Arman Sargolzaei Shirin Noei	Office of Naval Research	321,336.00	Not funded
15.	RET Site: Energizing Teachers	Joseph Biernacki Indranil Bhattacharya	National Science Foundation	599,996.00	Funded
16.	Secure energy management for smart power grid using machine learning	Mohamed Mahmoud Allen B. MacKenzie	NASEM	200,000.00	Not funded
17.	Collaborative Research: NeTS: JUN03: SWIFT: SoftWarization of Intelligence for Efficient 6G Mobile NeTworks	Muhammad Ismail	National Science Foundation	224,999.00	Funded
18.	Load Rating of Girder Stringer Floor Beam Bridges	Craig Henderson	Tennessee Department of Transportation	100,000.00	Funded
SUBTOTAL, PROPOSALS FOR 2021-2022				5,166,113.00	

STATUS OF PROPOSALS
Submitted Between July 1, 2021 through June 30, 2022

	TITLE	INVESTIGATORS	SOURCE	AMOUNT	STATUS
19.	Thermal treatment of nuclear plants' ice condensers using laser	Ahmad Vaselbehagh	Tennessee Valley Authority	250,000.00	Funded
20.	Phase 3: Project D - Evaluation of Advanced Vehicle and Communication Technologies through Traffic Microsimulation	Arman Sargolzaei Shirin Noei	University of Florida Transportation Institute/DOT	53,645.00	Funded
21.	THummingBirdTMS	Elfouly	TDOT	100,000.00	Not funded
22.	Guidance for Chemical Stabilization of Pavement Subgrade Soils in Tennessee	VandenBerge, Mohr	TDOT	170,523.00	Funded
23.	Influencing Mode Shift Through Behavioral Change Strategies	Badoe, Click, Noei	TDOT	150,000.00	Not funded
24.	Highway Slope Monitoring Systems	VandenBerge, Hart, Asante	TDOT	324,910.00	Not funded
25.	Motion Booster Platform: An AI-Based Model to Minimize the Impact of Battle-Induced Damages in Real-Time	Vaselbehagh	Misha Technologies, LLC via Air Force	34,000.00	Pending
26.	Impact of DER Performance on Bulk Power System Inverter Behavior	Arzani	EPRI	29,000	Funded
SUBTOTAL, PROPOSALS FOR 2021-2022				1,112,078.00	

STATUS OF PROPOSALS
Submitted Between July 1, 2021 through June 30, 2022

	TITLE	INVESTIGATORS	SOURCE	AMOUNT	STATUS
27.	Compact Thermal Energy Storage System Utilizing Functionalized Nanoparticle Additives	Languri	NAVY	73,998	Pending
28.	Collaborative Research: SHIELD: Strategic Holistic Framework for Intrusion Prevention using Multi-model Data in Power Systems	Ismail	NSF	375,000	Funded
29.	FGC-DES: Towards Futuristic Grid Codes with Enhanced Distributed Energy System Controllers	Arzani	NSF	316,406.00	Pending
30.	Risk Monitoring and Management of Downhole Oil Wells using Novel Wireless Power Transfer Technology	Bhattacharya	American Chemical Society Petroleum Research Fund	110,000.00	Pending
31.	Genetic algorithmn-based material datamining, optical and electrical modeling and understanding of atomic scale mechanisms to improve stability in all perovskite multijunction solar cells	Bhattacharya	DOE	300,000.00	Pending
32.	Center for Agile and Intelligent Power Systems (CAIPS): Cybersecurity Research, Development, and Workforce Training	Hasan, Mahajan	Florida International University via DOE	174,816.00	Pending
SUBTOTAL, PROPOSALS FOR 2021-2022				1,350,220.00	

**STATUS OF PROPOSALS
Submitted Between July 1, 2021 through June 30, 2022**

	TITLE	INVESTIGATORS	SOURCE	AMOUNT	STATUS
33.	Collaborative Research: SitS: Collaborative: Long Range Wirelessly Powered Multi-Variable Sensor Network for Continuous Monitoring of the Soil Health	Van Neste, Leckie, Gupta, Stretz, Craven	NSF	400,000.00	Funded
34.	Eagle ExCEL-Engineers Connect, Engage, and Learn: An At-Risk Advisement Program	Elizabeth Powell Harry Ingle Kumar Yelamarthi	Tennessee Board of Regents	39,550.00	Pending
35.	Reinforce Advanced Math Placement (RAMP) Program to Improve Success in Engineering	K. Yelamarthi, S. Narimetia, T. Brachey, M. Rogers	Tennessee Board of Regents	50,000.00	Funded
36.	Cyber Training: Small: IPDC - Curriculum Material and Faculty Training for Integrating Parallel and Distributed Computing in Early Computing Classes	Ghafoor, M.Rogers, A. Haynes, J.W.Bruce	NSF	498,707.00	Pending
37.	Network Attack Detection in Controller Area Networks of Heavy Vehicles	Ghafoor	Oak Ridge National Laboratory	15,964.57	Pending
SUBTOTAL, PROPOSALS FOR 2021-2022				1,004,221.57	

STATUS OF PROPOSALS
Submitted Between July 1, 2021 through June 30, 2022

	TITLE	INVESTIGATORS	SOURCE	AMOUNT	STATUS
38.	A Game-Theoretic Reinforcement Learning Framework for Optimizing Building HVAC Controls	Rizvi	National Institute of Standards and Technology	120,000.00	Pending
39.	In-situ Telluric Grid Health Monitoring and Fault Location Detection	Van Neste	Tennessee Valley Public Power Association	33,958.00	Pending
40.	Best Practices for Bridges with Pipe Piles	Huff	TDOT	165,000.00	Funded
41.	Determine the Maximum Negative Operating and Collapse Pressure of Stocked Spiral Duct with and without corrugations	Paruchuri	Spiral Duct Manufacturers Association (SPIDA)	36,833.55	Funded
42.	Lake Observations from Citizen Scientists and Satellites: Validation of Satellite Altimetry to Support Hydrologic Science	Ghafoor	University of North Carolina via NASA	258,143.00	Pending
SUBTOTAL, PROPOSALS FOR 2021-2022				613,934.55	
TOTAL, PROPOSALS FOR 2021-2022				21,280,132.12	

Journal Papers:

1. Brian Brown, and **Satish M. Mahajan**, “Circuit-Based Mathematical Model of an Arc Heater for Control System Development,” IEEE Access, Volume 9, October 2021; Digital Object Identifier 10.1109/ACCESS.2021.3121189.
2. Utkarsh D. Kavimandan, V. P. Galigekere, B. Ozpineci, O. Onar, and **Satish M. Mahajan**; “The Impact of Inverter Dead-Time in a Single-Phase Wireless Power Transfer Systems,” IEEE Transactions on Power Electronics (Volume: 37, Issue: 1, Jan. 2022); DOI: 10.1109/TPEL.2021.3092400.
3. **Shirin Noei**, Mohammadreza Parvizimosaed, and Mohammadreza Noei; Longitudinal Control for Connected and Automated Vehicles in Contested Environments; Electronics 2021, 10(16), 1994; <https://doi.org/10.3390/electronics10161994> - 18 Aug 2021.
4. **Noei, Shirin**, Xilei Zhao, and Carl Crane. “Longitudinal Control for Automated Vehicles in Traffic Microsimulation.” Accepted for *Transportation Research Part C: Emerging Technologies* (Acceptance Date: January 30, 2022
5. **Noei, Shirin**, Arman Sargolzaei, Xilei Zhao, Zoleikha Biron, and Carl Crane. “Cooperative Driving Automation in Contested Environments.” Accepted for *IEEE Transactions on Intelligent Transportation Systems* Acceptance Date: March 20, 2022;
6. M. Nasiri, **A. Arzani**, and J.M. Guerrero, “LVRT Operation Enhancement of Single-Stage Photovoltaic Power Plants: An Analytical Approach”, IEEE Transactions on Smart Grid, vol. 12, no. 6, pp. 5020-5029, August 2021.
7. M. Nasiri, **A. Arzani**, and S.J. McCormack, “A Simple and Effective Grid-Supporting Low Voltage Ride-Through Scheme for Single-Stage Photovoltaic Power Plants”, Solar Energy, vol. 232, pp. 248-262, January 2022.
8. M. Nasiri, S. Mobayen, and **A. Arzani**, “PID-type Terminal Sliding Mode Control for Permanent Magnet Synchronous Generator Based Enhanced Wind Energy Conversion Systems”, CSEE Journal of Power & Energy Systems, vol. 8, pp. 993-1003, November 2021.

Conference Papers:

- Robert Craven**, Keith Kirkpatrick, Stephen Idem; “Combustion Turbine Exhaust Duct, Silencer, and Stack Scale Modeling”, Power2021-64118, July 20-22, 2021, Proceedings of the ASME 2021 Power Conference.
- Noei, Shirin**, Mohammadreza Parvizimosaed, and Mohammadreza Noei. “A Simulation Platform for Connected and Automated Vehicles in Contested Environments.” 101st Transportation Research Board Annual Meeting (Conference Dates: January 9–13, 2022; Location: Washington, D.C.; Peer-Reviewed).



Dr. Charles Van Neste

Dr. Charles Van Neste, Electrical and Computer Engineering, was awarded a fully-granted patent. For more information, visit the following:

<https://patents.google.com/patent/US11360200B2/en?q=Charles&inventor=VanNeste&oq=Charles+VanNeste>



Dr. Denis Ulybyshev

Dr. Denis Ulybyshev, Computer Science, has submitted a provisional patent: Bradley Northern, Denis Ulybyshev, Trey Burks, Marlana Hatcher, Michael Rogers, “Systems and Methods for Cyber Risk Assessment for Computing Systems”. Provisional patent application was approved by Intellectual Property Advisory Committee (IPAC) of Tennessee Tech University. Provisional patent application has been submitted to United States Patent and Trademark Office (USPTO).



Dr. Syed Ali Asad Rizvi

Dr. Syed Ali Asad Rizvi, Electrical and Computer Engineering published the following:

- Book: “Output Feedback Reinforcement Learning Control for Linear Systems” published in Springer (June, 2022)
- Book Chapter published in the Book: “Handbook of Reinforcement Learning and Control” (July, 2021)

“Field Performance of State-of-the-Art HVAC Systems”

Presented by:

Dr. Jeffrey D. Spitler

Regents Professor and
OG&E Energy Technology Chair
Oklahoma State University



Date: Friday, December 17, 2021
Time: 9:30 a.m. to 10:30 a.m.
Location: Prescott Hall 225

Abstract:

Real-world performance of heating and air conditioning systems often deviates substantially from what might be predicted by simulations, laboratory experiments, or equipment ratings. When the ASHRAE headquarters building in Atlanta, Georgia was renovated in 2008, two separate heat pump systems were installed and instrumented: – a variable refrigerant flow (VRF) air-to-air heat pump system serving the first floor and a water-to-air ground source heat pump (GSHP) system, primarily serving the second floor. In the other hemisphere, the Studenthuset building at the University of Stockholm is also served by a water-to-water GSHP system with a very different design from the ASHRAE headquarters GSHP system. All three systems perform counterintuitively, if one’s intuition is based primarily on thermodynamic theory. Deviations from expected performance, reasons for the counterintuitive performance, and the broader implications will be discussed in the presentation.

Speaker Bio:

Dr. Jeffrey D. Spitler is Regents Professor of mechanical engineering at Oklahoma State University where he holds the OG&E Energy Technology Chair. He is Editor-in-Chief of ASHRAE’s research journal, Science and Technology for the Built Environment. He is a past president and Fellow of the International Building Performance Simulation Association, and a Fellow of ASHRAE. He has authored or co-authored over 150 technical publications including seven books. In the 2014-2015 academic year, he served as the Fulbright Distinguished Chair of Alternative Energy Technology at Chalmers University of Technology in Gothenburg, Sweden, where he worked on methods for predicting borehole thermal resistance and other ground-source heat pump system research.

GRADUATE THESIS/DISSERTATIONS AND OTHER STUDENT PUBLICATIONS**MASTERS****MATTHEW E. CRISPI**

Numerical Nonlinear Analysis of Beam-Reinforced Thin Plates for Modeling of Duct System
Summer 2021
Dr. Jane Liu
Civil Engineering

MARCO A. GONZALEZ RIVAS

Short-Term Voltage Stability Enhancement Using Advanced PV Control in Distribution Feeders
Summer 2021
Dr. Satish M. Mahajan
Electrical and Computer Engineering

CALEB T. HUCK

OpenMPy: A Core OpenMP Library for Python
Summer 2021
Dr. Sheikh Ghafoor
Computer Science

AUNG KYAW KHANT

Convergence Study of Metamaterial Mechanical Properties and Thermal Analysis of Concrete-Metamaterial Composites
Summer 2021
Dr. Jane Liu
Civil Engineering

DEBORAH OLUBUNMI AFOLAYAN

Modeling and Implementation of PID Controller for Efficient EV Suspension Energy Harvesting
Fall 2021
Dr. Satish M. Mahajan
Electrical and Computer Engineering

ANUSHA SAI GOLLAPUDI

Center of Inertia Based Frequency Control for Multi-Machine Power Systems Using PID Controller
Fall 2021
Dr. Ghadir Radman
Electrical and Computer Engineering

GRADUATE THESIS/DISSERTATIONS AND OTHER STUDENT PUBLICATIONS**MASTERS (continued)****MICHAEL R. HACKLER**

On the Effect of Reynolds Number and Structural parameters on Vortex-Induced Vibrations of Circular Cylinders

Fall 2021

Dr. Ahmad Vasselbehagh

Mechanical Engineering

MARKUS J.R. HOEGMAN MOELLER

Ground Motion Duration: Effects on Single-Degree-of-Freedom Bilinear Systems

Fall 2021

Dr. Timothy Huff

Civil Engineering

ROBERT TYLER HUGHES

Going Beyond ACI 332: Commercial / Residential Enhanced Durability Concrete: Phase II: What If?

Fall 2021

Dr. Lewis K. Crouch

Civil Engineering

DEBOLINA HALDER LINA

Scheduling Elastic Message Passing Parallel Application in HPC Environment

Fall 2021

Dr. Motevalli

Computer Science

Number of MS Students: 10

GRADUATE THESIS/DISSERTATIONS AND OTHER STUDENT PUBLICATIONS**PHD****MUHAMMAD ENAGI BIMA**

Novel Magnetic Coil Structure, Beam Steering and Artificial Intelligence-Based Coupling Coefficient Estimation for Efficient High-Power Wireless Power Transfer System

Summer 2021

Dr. Indranil Bhattacharya

Engineering

MOHAMED IBRAHEM MOHAMED IBRAHEM

Privacy-Preserving and Efficient Electricity Theft Detection and Data Collection for AMI Using Machine Learning

Summer 2021

Dr. Mohamed Mahmoud

Engineering

DEVENDRASINH UDAISINH DARDAR

Cobalt Free Cathode for Li/Na-ion Battery Technologies and Artificial Intelligence-Based State of Charge Estimation

Fall 2021

Dr. Indranil Bhattacharya

Engineering

QING FENG

Early Detection of Power System Anomaly and Its Location Via Application of Random Matric Theory to PMU Measurements

Fall 2021

Dr. Ghadir Radman

Engineering

DIVYA SUSMITHA JALADI

Fundamental Study of Sustainable and Efficient Evaporation Methods

Fall 2021

Dr. Ethan Languri

Engineering

GRADUATE THESIS/DISSERTATIONS AND OTHER STUDENT PUBLICATIONS**PHD (continued)****UTKARSH D. KAVIMANDAN**

Investigation of Inverter Dead-Time Effects in Single-Phase Wireless Power Transfer Systems

Fall 2021

Dr. Satish M. Mahajan

Engineering

HAWZHIN RAOOF MOHAMMED

Hardware Intrinsic Attacks on IoT Based Network: A Secure Edge Intelligence Perspective

Fall 2021

Dr. Syed Rafay Hasan

Engineering

KUSESO ONAI

A Systematic Approach to the Design and Control of Inductive Power Transfer for Electric Vehicle Battery Charging

Fall 2021

Dr. Joseph Ojo

Engineering

HAJAR TAHERI AFARANI

Identification and Assessment of Admixtures for Portland Cement-Based Printing Pastes

Fall 2021

Dr. Joseph Biernacki

Engineering

PRINCE TURKSON

Total and Effective Stress Rapid Drawdown Analysis of Levees

Fall 2021

Dr. Daniel VandenBerge

Engineering

GRADUATE THESIS/DISSERTATIONS AND OTHER STUDENT PUBLICATIONS**PHD (continued)****BRANDON T. NIEMAN**

Development of Wireless Through-the-Soil Power Transfer System and Sensor Network

Spring 2022

Dr. Charles Van Neste

Engineering

BRADLEY ALAN NORTHERN

Vulnerability Analysis and Cyber Risk Assessment

Spring 2022

Dr. Denis Ulybyshev

Engineering

GEORGE R. RUCKER

Molecular Dynamic Simulations of Polymer Modified Asphalt and Asphalt Air/Water Interface Systems

Spring 2022

Dr. Liqun Zhang

Engineering

Number of Ph.D. Students: 13

MS STUDENTS

Name	Dept.	Source of Support	Advisor
Dylan Alissandrello	CEE	NIBS	Dr. Daniel VandenBerge
Muzakhir Amanzholov	CSC	NASA/CESR	Dr. Sheikh Ghafoor
Jumanh Atoum	ECE	CESR	Dr. Allen MacKenzie
Trapa Banik	ECE	TVA Endowment	Dr. Indranil Bhattacharya
Samuel Dunham	CEE	CESR	Dr. Jane Liu
Tyler Edwards	ME	Private	Dr. Rory Roberts
Blake Evans	MBA	ARPA-E	Dr. Rory Roberts
John Forth	MBA	ARC UCDD	Mr. Michael Aikens
Michael Hackler	ME	CESR/TVA-Sequoyah Nuclear	Dr. Ahmed Vasselbehagh
R. Tyler Hughes	CEE	CESR	Dr. Lewis K. Crouch
Trevor Kramer	ME	ARPA-E	Dr. Rory Roberts
Nicholas Lawson	CEE	CESR	Dr. Craig Henderson
Quy T. Le	ECE	CESR	Dr. Satish M. Mahajan
Richard L. McMeans	MBA	ARC UCDD	Mr. Michael Aikens
Michael Miner	ECE	CESR	Dr. Ali Alouani
Brandon Neiman	ECE	TVA Endowment	Dr. Charles Van Neste
Abiodun Olatunji	ECE	CESR/IUSE	Dr. Indranil Bhattacharya
Leonardo Ramon	CEE	TBR SERS Project	Dr. Daniel VandenBerge
Athena Rastegarpouyani	ECE	CESR	Dr. Ghadir Radman
George Rucker	CHE	CESR	Dr. Liqun Zhang
Alireza Shiri	CEE	CESR	Dr. Daniel VandenBerge
Noah Simpson	ME	STRIDE: CAV-I5	Dr. Arman Sargolzaei
Joseph Staller	ME	McHale	Dr. Stephen Idem
Joseph Staller	ME	CESR	Dr. Stephen Idem
Joshua Thomas	ECE	CESR	Dr. Indranil Bhattacharya
Jeff Webster	ME	ARPA-E	Dr. Rory Roberts
Zachary Wisniowski	CEE	STRIDE	Dr. Steven Click

PHD STUDENTS

Name	Dept.	Source of Support	Advisor
Basem Abdellatif	ECE	CESR	Dr. Tarek Elfouly
Mahmoud Abouyoussef	CSC	CESR/Qatar	Dr. Muhammad Ismail
Brendan Atarigiya	CEE	NIBS	Dr. Daniel VandenBerge
Shampa Banik	CSC	CESR	Dr. Michael Rogers
Trapa Banik	ECE	TVA Endowment/CESR	Dr. Indranil Bhattacharya
Rajat Bhattarai	CSC	CESR	Dr. Sheikh Ghafoor
Atef Bondok	ECE	Qatar via TAMU	Dr. Mohamed Mahmoud
Islam Elgarhy	ECE	CESR	Dr. Mohamed Mahmoud
Andrew Ellicott	ME	CESR	Dr. Rory Roberts
Mohamed Elmahallawy	ECE	CESR	Dr. Tarek Elfouly
Chikezie Emeghara	ECE	ARC UCDD	Dr. Satish M. Mahajan
Mariam Gado	CSC	CESR	Dr. Muhammad Ismail
Ty Hagan	ME	TVA/CESR	Dr. Ahmed Vasselbehagh
James Holland	ME	CESR/STRIDE	Dr. Arman Sargolzaei
Saanyol Igbax	ME	CESR	Dr. Stephen Idem
C. Storm Johnson	ECE	CESR	Dr. Charles Van Neste
Utkarsh Kavimandan	ECE	CESR	Dr. Satish M. Mahajan
Trevor Kramer	ME	ARPA-E	Dr. Rory Roberts
Elmahedi Mahalal	CSC	Qatar via TAMU	Dr. Muhammad Ismail
Rajesh Manicavasagam	CSC	ARC UCDD	Dr. Michael Rogers
M. Rayhan Ahmed Mithu	CSC	EPRI Distribution Energy Resource	Dr. Michael Rogers
Ebrahim Nasr Esfahani	ECE	CESR	Dr. Indranil Bhattacharya
Reza Nouri	ME	CESR/TVA Sequoyah	Dr. Ahmed Vasselbehagh
Babajide Onanuga	CHE	CESR	Dr. Joseph Biernacki
Vinit Prabhu	ME	CESR	Dr. Ethan Languri
Sohag Kumar Saha	ECE	ARC UCDD	Dr. Satish M. Mahajan
Prince Turkson	CEE	USUCGER/CESR	Dr. Daniel VandenBerge
Dipendra Wagale	CHE	CESR	Dr. Jonathan Sanders

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
McHale	McHale and Associates, Inc.
ME	Mechanical Engineering
NASA	National Aeronautics and Space Administration
NIBS	National Institute of Building Sciences
QNRF	Qatar NRF
Qatar via TAMU	Qatar via Texas A&M University
UFTI	University of Florida Transportation Institute
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
USUCGER/CESR	United States Universities Council on Geotechnical Education and Research

Undergraduate StudentsDegree and Major

Ann Brewer	B.S. CHE
Katelyn Carpenter	B.S. CEE
Ryan Colon	B.S. ECE
Austin Day	B.S. ME
Jackson Dittert	B.S. ME
Caleb Eldridge	B.S. Physics & Math
Michael Ezelle	B.S. ME
Miguel A. Fuentes Garcia	B.S. ME
Brian Hawkins	B.S. CEE
Zachary Hinchman	B.S. ME
Daniel Holman	B.S. CSC
Carson Kennedy	B.S. CEE
Vadim Kholodilo	B.S. CSC
Aaron Kindred	B.S. Physics
Braden Long	B.S. CEE
Logan Malotte	B.S. CEE
William McCarty	B.S. ME
Emma Mitchell	B.S. Physics
Richard Mitchell	B.S. Physics & Math
Imran Mohammed	B.S. CSC & Physics
Andrew Moore	B.S. CEE
Dakota Moye	B.S. ECE
Luke Olson	B.S. ME
Brandon Patel	B.S. ME
Isaac Sandoval	B.S. ECE
David Schafer	B.S. ME
Ryan Senz	B.S. ECE
Chrystopher Shaward	B.S. CEE
Alex Tharpe	B.S. ME
Michael Tidwell	B.S. ECE

Undergraduate Students

Kyle Wendt
Coby White
Pierce Wooten

Degree and Major

B.S. CEE
B.S. ECE
B.S. ME

M.S. Graduate Students

Deborah Afolayan
Muzakhir Amanzholov
Glen Cathey
Matthew Crispi
Anthony Dontoh
Samuel Dunham
Chijioke Ekechi
R. Tyler Hughes
Steven Lam
Nicholas Lawson
Tyler Marcum
Tyler W. McCormick
J. Will Meacham
Brandon Miller
Brandon Neiman
Khushi Patel
Leonardo Ramon
Devin Roland
George Rucker
Joseph Staller
William Stump
Devin Threet
Jeff Webster
Zachary Wisniowski

Degree and Major

M.S. ECE
M.S. CSC
M.S. CSC
M.S. CEE
M.S. CEE
M.S. CEE
M.S. ECE
M.S. CEE
M.S. CHE
M.S. CEE
M.S. ECE
M.S. ECE
M.S. ME
M.S. ME
M.S. ECE
M.S. ECE
M.S. CEE
M.S. ME
M.S. CHE
M.S. ME
M.S. ECE
M.S. ME
M.S. ME
M.S. ME
M.S. CEE

Ph.D. Graduate StudentsDegree and Major

Webster Adepoju	Ph.D. ECE
Atef Bondok	Ph.D. ECE
Chikezie Emeghara	Ph.D. ECE
Thomas Hines	Ph.D. CSC
Utkarsh Kavimandan	Ph.D. ECE
W. Luke Lambert	Ph.D. CSC
Rajesh Manicavasagam	Ph.D. CSC
Tyler Marcum	Ph.D. ECE
M. Rayhan Ahmed Mithu	Ph.D. CSC
Mohamed Shaban Mohamed	Ph.D. CSC
Abdul Salam Mohammad	Ph.D. CHE
Ebrahim Nasir Esfahani	Ph.D. ECE
Reza Nouri	Ph.D. ME
Babajide Onanuga	Ph.D. CHE
Vinit Prabhu	Ph.D. ME
Hajar Taheri Afarani	Ph.D. CHE

FWS & UASDegree and Major

William McCarty

B.S. ME

Dawood A. Issa

B.S. LIST

Daniel S. Holman

B.S. CSC

Rachel N. Debaar

B.S. ME

Michael Ezelle

B.S. ME

FWS: Federal Work Study

UAS: University Academic Service

2021-2022

Undergraduate Student	Sponsor	Program	Faculty Advisor
Ann Brewer	Center for Energy Systems Research	Free energy calculation on human beta defensin translocation through bacterial lipid membranes for paper to be presented at AIChE meeting in fall 2021	Dr. Liqun Zhang
Katelyn Carpenter	Tennessee Board of Regents	SERS Project: Building Pathways into Civil and Environmental Engineering for First Year Students	Dr. Daniel VandenBerge
Ryan Colon	Department of Defense via Mississippi State University	SimBRS II TO008 - Adaptive and Reconfigurable Sensor Elements and Networks for Monitoring Critical Infrastructure and Maneuver Corridors	Dr. Charles Van Neste
Austin Day	United States Air Force via SPS	Hypersonic Onboard Power and Thermal Management System (Phase 2)	Dr. Rory Roberts
Jackson Dittert	Department of Energy	The Structure of Neutron-Rich Deformed Nuclei Studied via Beta Decay	Dr. Mustafa Rajabali
Caleb Eldridge	Department of Energy	The Structure of Neutron-Rich Deformed Nuclei Studied via Beta Decay	Dr. Mustafa Rajabali
Michael Ezelle	Tennessee Valley Authority	Smart Grid	Mr. Robert Craven
Miguel A. Fuentes Garcia	University of Florida Transportation Institute	Atmosphere Independent Bipropellant Consuming Additively Manufactured Solid Oxide Fuel Cells (SOFCs) for Assured On-Orbit Space Power	Dr. Shirin Noei

UNDERGRADUATE RESEARCH PROJECTS, continued SM-11

2021—2022

Undergraduate Student	Sponsor	Program	Faculty Advisor
Brian Hawkins	Tennessee Valley Authority	Development of Laser-Based System for Maintenance of Ice Condensers	Dr. Ahmad Vasselbehagh
Brian Hawkins	Tennessee Valley Authority	Thermal Treatment of Nuclear Plants' Ice Condensers Using Laser, Phase II	Dr. Ahmad Vasselbehagh
Zachary Hinchman	Department of Energy	The Structure of Neutron-Rich Deformed Nuclei Studied via Beta Decay	Dr. Mustafa Rajabali
Daniel Holman	Tennessee Valley Authority	Smart Grid	Mr. Robert Craven
Carson Kennedy	Tennessee Board of Regents	Building Pathways into Civil and Environmental Engineering for First Year Students	Dr. Daniel VandenBerge
Vadim Kholodilo	National Aeronautics and Space Administration (NASA)	Quasi-Wireless Capacitive (QWIC) Surface Power for Adaptive and Reconfigurable Sensor Elements on Space Infrastructure	Dr. Denis Ulybyshev
Aaron Kindred	National Science Foundation	MRI: Development of a high resolution neutron detector for decay and reaction studies with exotic nuclei/Arts & Sciences Match	Dr. Mustafa Rajabali
Braden Long	Department of Energy	The Structure of Neutron-Rich Deformed Nuclei Studied via Beta Decay	Dr. Mustafa Rajabali
Logan Malotte	Tennessee Board of Regents	Building Pathways into Civil and Environmental Engineering for First Year Students	Mr. Daniel VandenBerge

UNDERGRADUATE RESEARCH PROJECTS, continued SM-11

2021—2022

Undergraduate Student	Sponsor	Program	Faculty Advisor
William McCarty	Tennessee Valley Authority	Smart Grid	Mr. Robert Craven
Emma Mitchell	National Science Foundation	MRI: Development of a high resolution neutron detector for decay and reaction studies with exotic nuclei/Arts & Sciences Match	Dr. Mustafa Rajabali
Richard Mitchell	National Science Foundation	MRI: Development of a high resolution neutron detector for decay and reaction studies with exotic nuclei	Dr. Mustafa Rajabali
Richard Mitchell	Department of Energy	The Structure of Neutron-Rich Deformed Nuclei Studied via Beta Decay	Dr. Mustafa Rajabali
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	The Structure of Neutron-Rich Deformed Nuclei Studied via Beta Decay	Dr. Mustafa Rajabali
Andrew Moore	Tennessee Board of Regents	Building Pathways into Civil and Environmental Engineering for First Year Students	Dr. Daniel VandenBerge
Andrew Moore	Tennessee Department of Transportation	Load Rating of Girder Stringer Floor Beam Bridges (state portion)	Dr. Craig Henderson
Dakota Moye	Department of Energy	The Structure of Neutron-Rich Deformed Nuclei Studied via Beta Decay	Dr. Mustafa Rajabali

UNDERGRADUATE RESEARCH PROJECTS, continued SM-11

2021—2022

Undergraduate Student	Sponsor	Program	Faculty Advisor
Luke Olson	Tennessee Valley Authority	Development of Laser-Based System for Maintenance of Ice Condensers	Dr. Ahmad Vasselbehagh
Luke Olson	Tennessee Valley Authority	Thermal treatment of nuclear plants' ice condensers using laser Phase II	Dr. Ahmad Vasselbehagh
Brandon Patel	United States Air Force via SPS	Hypersonic Onboard Power and Thermal Management System (Phase 2)	Dr. Rory Roberts
Isaac Sandoval	Department of Defense via Mississippi State University	SimBRS II TO008 - Adaptive and Reconfigurable Sensor Elements and Networks for Monitoring Critical Infrastructure and Maneuver Corridors	Dr. Charles Van Neste
David Schafer	United States Air Force via SPS	Hypersonic Onboard Power and Thermal Management System (Phase 2)	Dr. Rory Roberts
Ryan Senz	Tennessee Valley Authority	Smart Grid	Mr. Robert Craven
Chrystopher Shaward	Tennessee Board of Regents	Building Pathways into Civil and Environmental Engineering for First Year Students	Dr. Daniel VandenBerge
Alex Tharpe	Department of Energy	High Power Density Carbon Neutral Electrical Power Generation for Air Vehicles	Dr. Rory Roberts
Michael Tidwell	Department of Defense via Mississippi State University	SimBRS II TO008 - Adaptive and Reconfigurable Sensor Elements and Networks for Monitoring Critical Infrastructure and Maneuver Corridors	Dr. Charles Van Neste

UNDERGRADUATE RESEARCH PROJECTS, continued SM-11

2021—2022

Undergraduate Student	Sponsor	Program	Faculty Advisor
Kyle Wendt	Tennessee Concrete Association (TCA)	Going Beyond ACI 332: Commercial/ Residential Enhanced Durability Concrete: Phase III The Effect of Limited Curing	Dr. Lewis K. Crouch
Cody White	Department of Defense via Mississippi State University	SimBRS II TO008 - Adaptive and Reconfigurable Sensor Elements and Networks for Monitoring Critical Infrastructure and Maneuver Corridors	Dr. Charles Van Neste
Pierce Wooten	Tennessee Valley Authority	Development of Laser-Based System for Maintenance of Ice Condensers	Dr. Ahmad Vasselbehagh
Pierce Wooten	Tennessee Valley Authority	Thermal treatment of nuclear plants' ice condensers using laser Phase II	Dr. Ahmad Vasselbehagh

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 2021-22 Actual			FY 2022-23 Proposed			FY 2023-24 Requested		
	Matching	Appropriations	Total	Matching	Appropriations	Total	Matching	Appropriations	Total
Expenditures									
Salaries									
Faculty	\$ 411,227	\$ 385,395	\$ 796,622	\$ 110,750	\$ 397,561	\$ 508,311	\$ 88,350	\$ 294,498	\$ 382,848
Other Professional	\$ 32,718	\$ 80,115	\$ 112,833	\$ 6,000	\$ 213,382	\$ 219,382	\$ 6,000	\$ 141,815	\$ 147,815
Clerical/ Supporting	\$ -	\$ 84,178	\$ 84,178	\$ -	\$ 87,523	\$ 87,523	\$ -	\$ 87,523	\$ 87,523
Assistantships	\$ 286,370	\$ 239,333	\$ 525,703	\$ 160,000	\$ 165,530	\$ 325,530	\$ 172,000	\$ 170,500	\$ 342,500
Hourly Students	\$ 91,363	\$ 44,578	\$ 135,941	\$ 23,500	\$ 66,660	\$ 90,160	\$ 18,000	\$ 36,388	\$ 54,388
Total Salaries	\$ 821,678	\$ 833,598	\$ 1,655,276	\$ 300,250	\$ 930,656	\$ 1,230,906	\$ 284,350	\$ 730,724	\$ 1,015,074
Fringe Benefits	\$ 105,872	\$ 150,136	\$ 256,008	\$ 22,150	\$ 171,991	\$ 194,141	\$ 108,706	\$ 231,290	\$ 339,996
Grad Tuition/Fees	\$ 177,044	\$ 161,806	\$ 338,850	\$ 112,000	\$ 165,090	\$ 277,090	\$ 79,118	\$ 158,236	\$ 237,354
Total Personnel	\$ 1,104,594	\$ 1,145,540	\$ 2,250,134	\$ 434,400	\$ 1,267,737	\$ 1,702,137	\$ 472,174	\$ 1,120,250	\$ 1,592,424
Non-Personnel									
Travel	\$ 57,625	\$ 2,500	\$ 60,125	\$ 42,360	\$ 35,794	\$ 78,154	\$ 15,000	\$ 10,000	\$ 25,000
Software	\$ 9,600	\$ 4,339	\$ 13,939	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
Books & Journals	\$ 1,250	\$ -	\$ 1,250	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
Other Supplies	\$ 155,376	\$ 31,268	\$ 186,644	\$ 23,220	\$ 136,120	\$ 159,340	\$ 25,000	\$ 50,000	\$ 75,000
Equipment	\$ 485,114	\$ 55,333	\$ 540,447	\$ 38,770	\$ 64,815	\$ 103,585	\$ 35,000	\$ 5,000	\$ 40,000
Maintenance	\$ -	\$ 1,469	\$ 1,469	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
Scholarships for Service	\$ 3,200	\$ -	\$ 3,200	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
Consultants/Subcontracts	\$ 362,907	\$ 3,214	\$ 366,121	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
Renovation	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
Seminars/Workshops/Con	\$ 46,114	\$ -	\$ 46,114	\$ -	\$ -	\$ -	\$ 45,451	\$ -	\$ 45,451
Total Non-Personnel	\$ 1,121,186	\$ 98,123	\$ 1,219,309	\$ 104,350	\$ 236,729	\$ 341,079	\$ 120,451	\$ 65,000	\$ 185,451
GRAND TOTAL	\$ 2,225,780	\$ 1,243,662	\$ 3,469,442	\$ 538,750	\$ 1,504,466	\$ 2,043,216	\$ 592,625	\$ 1,185,250	\$ 1,777,875
Revenue	NOTE: Actual Matching Funds do not include Indirect Costs of \$431,921 for FY 2021-2022.								
New State Appropriation	\$ -	\$ 1,030,100	\$ 1,030,100	\$ -	\$ 1,077,500	\$ 1,077,500	\$ -	\$ 1,185,250	\$ 1,185,250
Carryover State Appropriation	\$ -	\$ 640,528	\$ 640,528	\$ -	\$ 426,966	\$ 426,966	\$ -	\$ -	\$ -
New Matching Funds	\$ 2,225,780	\$ -	\$ 2,225,780	\$ 538,750	\$ -	\$ 538,750	\$ 592,625	\$ -	\$ 592,625
Carryover from Previous Matching Funds	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
Total Revenue	\$ 2,225,780	\$ 1,670,628	\$ 3,896,408	\$ 538,750	\$ 1,504,466	\$ 2,043,216	\$ 592,625	\$ 1,185,250	\$ 1,777,875
NOTE: Carryover funds of \$426,966 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;									

JUSTIFICATION FOR 2023-2024 APPROPRIATIONS REQUEST

The Center for Energy Systems Research (CESR) is requesting a 10% increase in anticipation of additional expenses during 2023-2024. The increased expenses include additional cost for personnel appointments of the second Research Assistant Professor, and funding for additional undergraduate and graduate students to participate in the research activities of the CESR.

