



ANNUAL REPORT FY20

Center for Clean Energy Engineering

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A Message from Our Center Director

This past year has been different to say the least, however that did not stop the growth at the Center for Clean Energy Engineering. Academic year 2019-2020 has been a productive year for us, with more students trained, more research projects conducted with a larger faculty. C2E2 is a group of faculty, students, and researchers that work to make the world a better place by discovering new materials and designing devices and systems to enable more efficient and environmentally friendly energy conversion and storage technologies. We educate next generation of energy professionals through our research and educational programs, such as the interdisciplinary Master of Science degree in Advanced Manufacturing for Energy Systems. We are very proud of our collaborative culture at C2E2. We believe impact of our research only gets better with our internal and external collaborators and we are looking to work with you as well.



Ugur Pasaogullari

Director, C2E2, Professor of Mechanical Engineering



ABOUT THE CENTER

The Center for Clean Energy Engineering (C2E2) is multi-disciplinary energy research center that facilitates education, training and outreach at UConn. The center provides an umbrella and platform for the development of scientific and engineering knowledge base and transformational breakthrough. This is accomplished in the development and validation of advanced energy system concepts and additionally in cost effective engineering and demonstration of the long term operation and reliability.

The Center for Clean Energy Engineering further serves as a nexus for the development to deployment activities involving fundamental and applied research in clean and efficient energy systems (from energy conversion and distributed generation technologies to utilization of fossil and non-fossil fuels to power distribution and management). Key to these activities is the utilization of foundational knowledge in the field of materials science, systems engineering, computational analysis, large scale demonstration and testing as well as training of 21st century scientists and engineers. With its expanded mission, C2E2 is in a leadership position to address and meet the emerging "Energy, Water and Climate" challenges at the national and global levels.

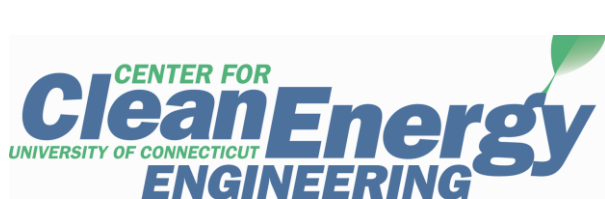
Center Mission: Our mission is to be recognized for world class education, research and training of scientists and engineers; regarding innovations in transforming "Science to Systems"; enabling industries and organizations in developing cost effective solutions for multi-disciplinary problems in a timely manner; and for providing guidance and leadership in solving global societal issues ranging from sustainable energy to environment.

C2E2 Organization

- Resident Faculty: 17
- Research Faculty: 2
- Affiliated Faculty & Research Support: 9
- Graduate (PhD and MS) Students: 60
- Technical and Administrative Staff: 6

Academic Department Affiliations

- Faculty & Students from:
 - Mechanical Engineering
 - Materials Science & Engineering
 - Civil and Environmental Engineering
 - Electrical and Computer Engineering
 - Chemical and Biomolecular Engineering
 - Biomedical Engineering
 - Computer Science & Engineering
 - Chemistry



CENTER GOAL

- C2E2's goal is to provide facilities and the collaborative environment to conduct world-class research in energy and related fields. C2E2 was founded in 2002 as the Connecticut Global Fuel Cell Center (CGFCC), focusing primarily on fuel cells, due to Connecticut's long history in fuel cell technology and large industry base. The center was renamed in 2009 due to a widened scope in Sustainable Energy as a result of the Eminent Faculty Initiative in Sustainable Energy approved in 2007. Today, C2E2 faculty still work in our traditional areas of fuel cells and other electrochemical systems (e.g. batteries, electrolyzers) as well as in combustion, power electronics, materials for renewable energy, separations and filtration, atmospheric computations (weather and chemistry) and clean fuels. C2E2 also supports faculty in other fields such as composites and composites manufacturing, and environmental resources



Providing facilities and the collaborative environment to conduct world-class research in energy and related field

- To enable sustained growth of externally funded research in areas related to energy at the University of Connecticut by providing a collaborative research environment and maintaining shared facilities which enables high quality research output. Our research outcomes are primarily measured in terms of scholarly contributions, and extramurally funding of research. Later sections of this report will show that C2E2 has shown consistent growth in both measurable outcomes.
- Continue to be the central umbrella housing and supporting the majority of the energy related activities in the School of Engineering. C2E2 has expanded in the last few years with new faculty to the university (Biyikli (ECE), Matheou (ME), Jankovic (MSE), Carbone (ME), Bliznakov (C2E2, CBE)) and existing faculty who started working with C2E2 (Lu, Sung, Zhao, (ME), Wagstrom, Willis (CBE)). C2E2 also has expanded its facilities by acquiring new space in the new Engineering and Science Building (ESB).

C2E2's externally funded research has seen continuous growth in the last five years. All metrics related to external funding, the number and total value of proposals, awards, and research expenditures have steadily increased.

Advanced Energy Materials, Processes & Systems

- Improving the efficiency and durability while reducing the cost of high- and low-temperature fuel cells and other power conversion

Combustion Science and Technology

- Creating novel techniques for chemical conversion of fuels; improving the quality of emissions and increasing the efficiency of existing methods of conversion.

Energy Storage and Power Management

- The storage and conversion of energy obtained from fossil fuels, biofuels, fuel cells, solar, wind, and hydroelectric sources for distributed generation applications through the development of enabling technologies for the “smart grid.”

Fuels and Fuel Processing

- Improving hydrogen production, catalysis, and heat integration for fuel reformation; improving waste heat recovery and reducing CO₂ emissions in coal refineries; thermochemical and hybrid cycles; gasification and extracting energy from sources of organic material such as coal, petroleum, biofuel

Renewable Energy and Resources








- Developing innovative technologies behind solar photo catalysis, wind, and electrochemical conversion; hydroelectric and water filtration

INDUSTRIAL PARTNERS

<p>CT Industrial & Academic Partners: United Technologies Corporation, Pratt & Whitney, FuelCell Energy, Skyre, Northeast Utilities, Energize Connecticut CT, Sustainable Innovations, Proton Energy Systems, Alstom Power, Habco Inc., nzymSys, PCI Energy Services LLC., DSTAR, Sonalysts Inc., Yardney Water Management Systems, Mystic Innovations Group, Yale University, many more.</p>		<p>Research Laboratory Partners: Oak Ridge National Laboratory, Argonne National Laboratory, Pacific Northwest National Laboratory, Savannah River, National Research Council Canada, Research Center Juelich – Germany, Institute of Nuclear Energy Research Taiwan, Council for Scientific & Industrial Research India, and others.</p>
	<p>National and International Industrial and Academic Partners: Cadenza, Giner, Praxair, Northrop Grumman, Siemens, LG Fuel Cells, Fraunhofer, Alstom Power, Conoco Phillips, ENI, Cabot, Corning, Nissan Automotive, Toyota, Eldor, GE, Cummins, Harvard, MIT, Technion, WR Grace, UMass Amherst, WPI, Boston Univ., Univ. of Pittsburgh, Univ. of Wyoming, UC Irvine, Univ. of South Carolina, Ohio State Univ., Dalian, POSTECH, Tokyo Institute of Technology, Indian Institute of Science, and many more.</p>	
		<p>Federal Agency Partners: United State Department of Energy (DOE), National Science Foundation (NSF), United States Army, Office of Naval Research (ONR), Defense Advanced Research Projects Agency (DARPA), National Aeronautics and Space Administration (NASA), United States Department of Agriculture (USDA), United States Air Force, and others.</p>


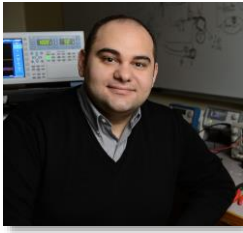








ORGANIZATION

C2E2's operations are mainly supported by funds from the School of Engineering through the Eminent Faculty Initiative in Sustainable Energy and through the share of indirect costs from the Office of Vice President for Research. C2E2 also has received funds from the Provost's Office for support of certain initiatives as well as additional funds from the Office of Vice President for Research, and the School of Engineering for the Summer Undergraduate Fellowship in Sustainable Energy program.

Center Leadership		
 Ugur Pasaogullari C2E2 Director & Professor Mechanical Engineering	 Terry Barber-Tournaud Program Director	
Administrative Support		
 Sheila Ciccone Administrative Specialist	 Amy Smith Financial Assistant 2	
Building Management & Safety		
 Peter Menard Laboratory Manager Center for Clean Energy Engr.	 Garry Barnes Laboratory Technician Engineering Science Building	 Mark Biron Laboratory Technician Center for Clean Energy Engr.

FACULTY

C2E2 core faculty is defined as faculty with research space at C2E2 managed facilities, and faculty whose research is mainly administered by C2E2.

Core Faculty		
 <p>Alex Agrios Associate Professor Civil & Environmental Engineering</p>	 <p>Ali Bazzi Associate Professor Electrical & Computer Engineering</p>	 <p>Necmi Biyikli Assistant Professor Electrical & Computer Engineering</p>
 <p>Stoyan Bliznakov Associate Research Professor Chemical & Biomolecular Engr.</p>	 <p>Francesco Carbone Assistant Professor Mechanical Engineering</p>	 <p>Jasna Jankovic Assistant Professor Materials Science & Engineering</p>
 <p>Tianfeng Lu Associate Professor Mechanical Engineering</p>	 <p>George Matheou Assistant Professor Mechanical Engineering</p>	 <p>Radenka Maric Vice President of Research & Professor Chemical & Biomolecular Engineering</p>
 <p>Sung-Yeul Park, Associate Professor Electrical & Computer Engineering</p>	 <p>Ugur Pasaogullari Director, C2E2 & Professor Mechanical Engineering</p>	 <p>Prabhakar Singh Professor Materials Science & Engineering</p>

Core Faculty (continued)		
 <p>Chih-Jen (Jackie) Sung Professor Mechanical Engineering</p>	 <p>Ioulia (Julia) Valla Associate Professor Chemical & Biomolecular Engineering</p>	 <p>Kristina Wagstrom Assistant Professor Chemical & Biomolecular Engineering</p>
 <p>Xinyu Zhao Assistant Professor Mechanical Engineering</p>		
Research Specialist	Postdoctoral Fellows	
 <p>Leonard Bonville</p>	 <p>Ashish Aphale</p>	 <p>Pawan Kumar Dubey</p>
	 <p>Gholamreza Mirshekari</p>	 <p>Muhammad Anisur Rahman</p>

AFFILIATED FACULTY

C2E2 affiliate faculty is defined as faculty who has occasional collaboration with C2E2 core faculty as a Co-PI in C2E2 affiliated grants, or who has occasional research grant administered at C2E2.

- **Michael Accorsi**, Senior Associate Dean, School of Engineering; Professor, Civil & Environmental Engineering
- **Emmanouil Anagnostou**, Director, Eversource Energy Center; UConn Alumni Associate Distinguished Professor; Eversource Energy Endowed Chair in Environmental Engineering
- **Mehdi Anwar**, Professor, Electrical & Computer Engineering
- **George Bollas**, Director, UTC-IASE; Associate Professor, Chemical & Biomolecular Engineering
- **Hadi Bozorgmanesh**, Professor of Practice, School of Engineering
- **Yupeng Chen**, Associate Professor, Biomedical Engineering
- **Yongku Cho**, Assistant Professor, Chemical & Biomolecular Engineering
- **Avinash Dongare**, Associate Professor, Materials Science & Engineering
- **Martin Han**, Associate Professor, Biomedical Engineering
- **Rainer Hebert**, Associate Professor, Materials Science & Engineering
- **Jeongho Kim**, Associate Professor, Civil & Environmental Engineering
- **Yu Lei**, Professor, Chemical & Biomolecular Engineering
- **Anson Ma**, Associate Professor, Chemical & Biomolecular Engineering
- **Jeffrey McCutcheon**, Associate Professor, Chemical & Biomolecular Engineering; Executive Director, Fraunhofer USA Center for Energy Innovation
- **Syam Nukavarapu**, Associate Professor, Biomedical Engineering
- **Krishna Pattipati**, Board of Trustees Distinguished Professor, UTC Professor in Systems Engineering, Electrical & Computer Engineering
- **Ranjan Srivastava**, Professor and Dept. Head, Chemical & Biomolecular Engineering
- **Steven Suib**, Director, Institute of Materials Science; Board of Trustees Distinguished Professor, Chemistry
- **Brian Willis**, Professor of Chemical and Biomolecular Engineering
- **Liang Zhang**, Associate Professor, Electrical & Computer Engineering



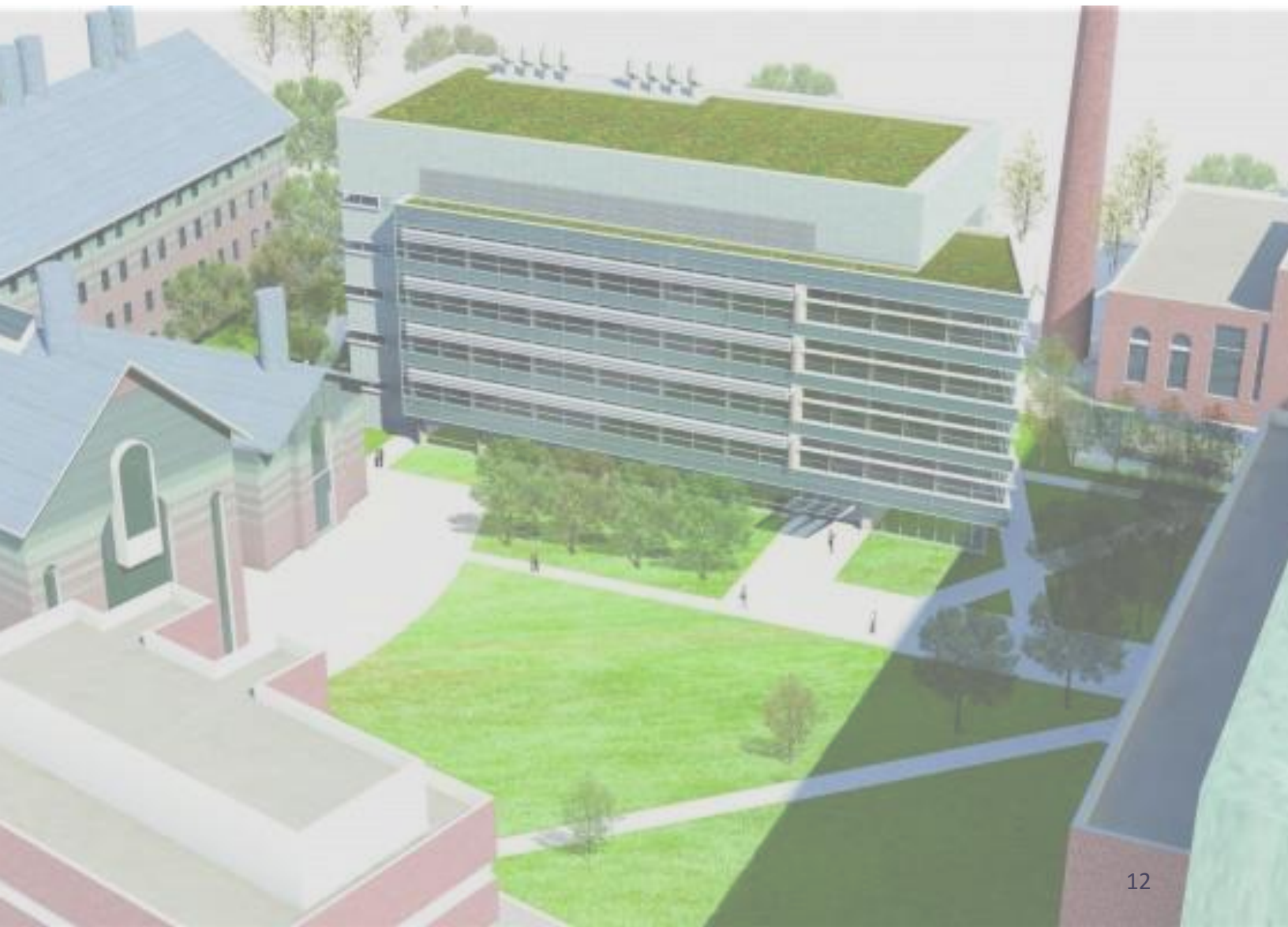
FACILITIES AND SHARED LABORATORIES

Three locations make up the research facilities for C2E2.

The Longley building and the C2E2 building on the Depot campus and the 5th floor of the new Engineering Science Building (ESB). C2E2's building is a dedicated 16,000 sq. ft. facility that house 11 resident researchers and over 55 students who share facility resources and equipment. The 5th floor of NESB also operates as shared laboratories. There are currently more than 11 research groups and over 80 students working in this 15,000 sq. Ft. research space.

C2E2 technical staff support these facilities, they are responsible for maintaining equipment, assisting with test setups, and ensuring that proper safety measures are followed.

In its facilities, C2E2 maintains a large array of shared equipment to support research ranging from energy conversion to power management to materials characterization and diagnostics



C2E2 RESEARCH FACILITY



Mark Biron, Pete Menard & Garry Barnes, C2E2 & ESB laboratory support personnel

C2E2 is a dedicated 16,000 square foot facility, located on the University of Connecticut Depot Campus just five minutes from the main Storrs campus. The building offers a mix of flexible and functional office and laboratory space designed to meet the needs of research and education. The C2E2 facility features four high bay areas, each of which is approximately 1,000 sq. ft. with over 24-foot ceilings.

Each high bay has access to compressed air, water, an exhaust system and 220/480 volt electrical bus. Four physical lab areas border the high bays. These laboratories include sinks, vent hoods, bench top experimental workspace and are on average 850 sq. ft. In addition, each lab area has access to compressed air, water and 110/220/440-volt power supply. The full laboratory area is equipped with distributed hydrogen gas flow.

Each laboratory has individual gas detection sensors and digital read out panels interconnected to the Universities fire department. C2E2 provides complete resources for cell/stack assembly, cell and electrode characterization, electrochemical testing and diagnostics for single cells, multi-cell stacks and large FC systems. Equipment is also available for prototype manufacturing, cell assembly, materials characterization, fuel cell testing and diagnostics.

Each of the C2E2 laboratories are supported with technical staff who ensure the safe operations of the research conducted in the facilities.

INSTRUMENTATION


Selected pieces of equipment available at the Center are:

- ❖ Bruker D5005 X-ray Diffractometer
- ❖ FEI Quanta 250 FEG field emission scanning electron microscope
- ❖ Retsch PM 400 Planetary Ball Mill
- ❖ Automated 30 cm² capacity Reactive Spray Deposition (RSDT) System
- ❖ 3 Solartron/Analyzers
- ❖ Systemic automation screen printer
- ❖ Arbin 50 W Fuel Cell Test Stand for PEM fuel cells
- ❖ Diablo D3163A, 5000A Real-time gas analyzer
- ❖ Lynntech Industries Model FCTS MTK Liquid Fuel Cell Test Stand
- ❖ 4 Teledyne/Scribner Associates Model 890 Fuel Cell Test Stands
- ❖ Avtron Freedom portable 105 kW load bank with Data Collection Capability
- ❖ Advanced Measurements, Inc. 6 cell 50 W solid oxide fuel cell test stand
- ❖ Solartron Model Chas 08, modulab 8 slot chassis, Model FRA ModuLab
- ❖ Varian Inc. Micro GC
- ❖ Netzsch STA 449 F3 Jupiter Simultaneous Thermal Analyzer
- ❖ Micromeritics ASAP 2020 Automatic Chemisorption Analyzer BET
- ❖ Ecochemie PGSTAT302N Autolab potentiostat, equipped with the BA bipotentiostat and frequency response analyzer modules.
- ❖ 8 High temperature furnaces of tube type
- ❖ Pine Instrument Analytical Rotator
- ❖ 4 Pine Instrument Rotating Ring Disk Electrodes – Pt, Au and glassy carbon interchangeable disks, each with Pt ring.
- ❖ Nicolet iS10 FT-IR Spectrometer with both transmission and ATR capability
- ❖ Purelab Ultra deionized water system
- ❖ Labconoco single user glove box
- ❖ MBraun single user glove box
- ❖ Vacuum Oven
- ❖ Convection Oven
- ❖ 1700 Degree furnaces
- ❖ Custom built physical vapor deposition reactor



CENTER HIGHLIGHTS

Traineeship Grant




UConn | SCHOOL OF ENGINEERING

MASTER OF SCIENCE IN
**ADVANCED
MANUFACTURING
FOR ENERGY
SYSTEMS (AMES)**

ACCEPTING APPLICATIONS NOW FOR FALL 2020

C2E2 was awarded a traineeship grant from the Advanced Manufacturing Office (AMO) at the US Department of Energy in 2018 (PIs: Pasaogullari, Valla, Dongare, Zhang, Accorsi). This grant addresses workforce training needs in the early-stage technology area of advanced materials and process technologies.

 www.energy.uconn.edu/AMES
More information at ames@uconn.edu

Faculty Spotlight

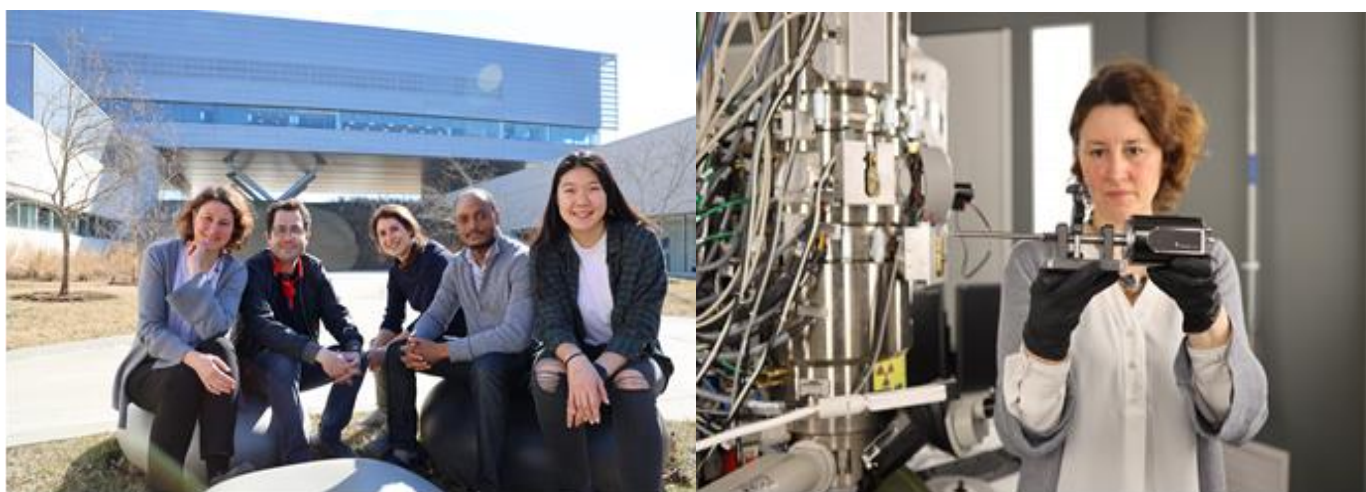
Professor Jasna Jankovic is one of the newest faculty members who joined C2E2 in January 2018. Dr. Jankovic started her career in a petroleum refinery and achieved her master's degree in Chemical at the University of British Columbia (UBC). Exposure to the oil industry inspired her change in interest to fuel cells, a renewable alternative. She wanted to focus on clean energy to contribute to society and give back to future generations. Her specific focus was proton conductive ceramics for intermediate temperature fuel cells.

Dr. Jankovic credits UConn for the cutting-edge technology and facilities that aid her research. UConn enables this incredible research by providing analytical equipment in the Institute of Material Science (IMS), high tech equipment at the Innovation Partnership Building (IPB) and testing facilities at the C2E2. Furthermore, the powerful collaboration with industry and government labs at UConn is an integral part of research success.

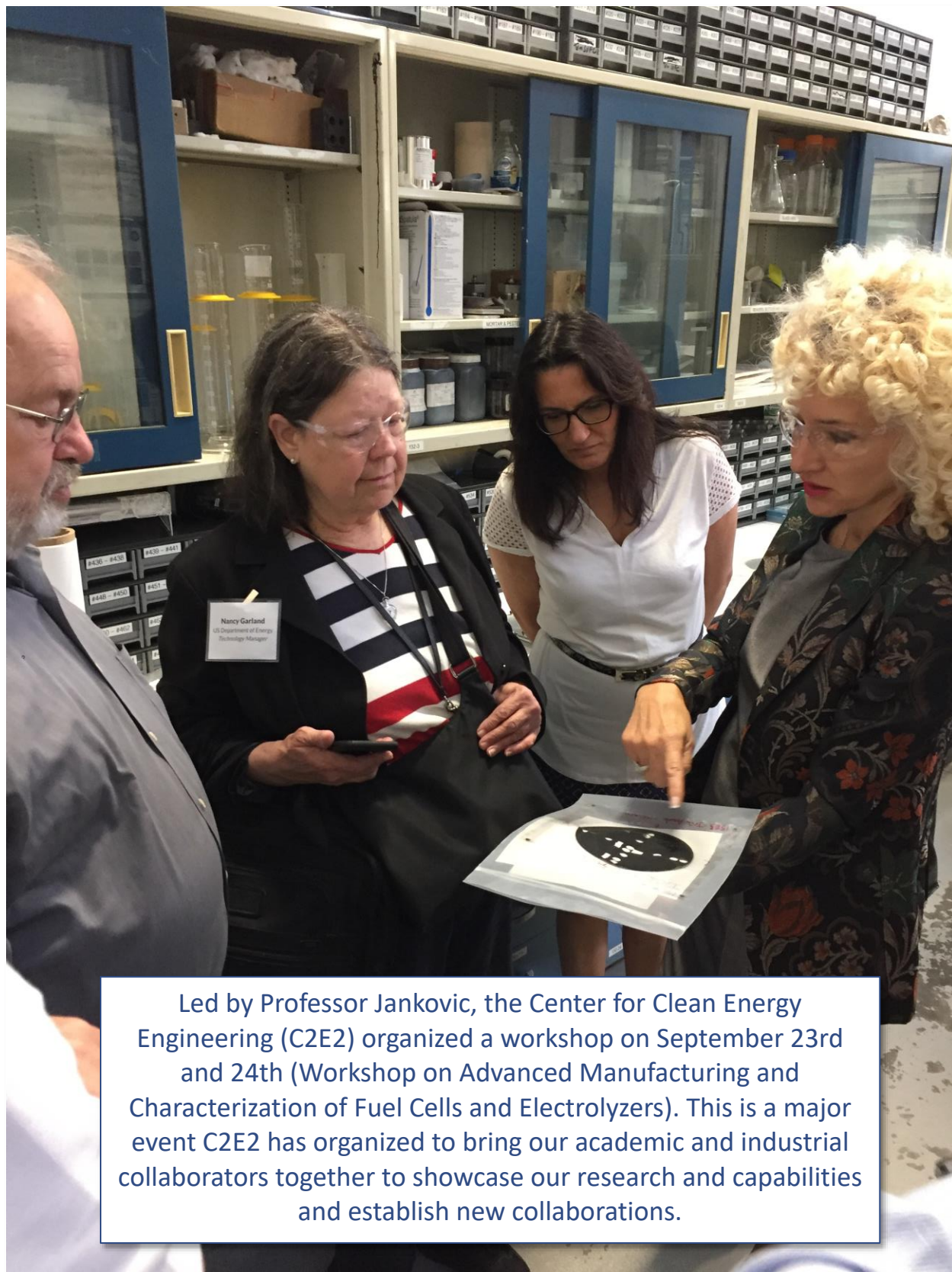
"if you are passionate about science and engineering, or anything else for that matter - just go for it. Nothing can stop you. Don't be shy to ask for help and do help others along the way"

The Jankovic group, which includes two Ph.D., two master's and 7 undergraduate students, focuses on fuel cells and batteries. More definitively, the development of materials and characterization using microscopy as well as bio-inspired designs have been the main research focus.

Professor Jankovic is noted for her drive and involvement with Research Experience for Undergrads (REU) and Research Experience for Teachers (RET) which provides lab experience to undergraduate students and high school teachers to burgeon interest in Clean Energy



Clean Energy Workshop



Led by Professor Jankovic, the Center for Clean Energy Engineering (C2E2) organized a workshop on September 23rd and 24th (Workshop on Advanced Manufacturing and Characterization of Fuel Cells and Electrolyzers). This is a major event C2E2 has organized to bring our academic and industrial collaborators together to showcase our research and capabilities and establish new collaborations.

Collaborations & Program Awards

UConn and Technion Collaborate on the Development of New Materials for Clean Energy Technologies

The University of Connecticut's Center for Clean Energy Engineering (C2E2) and Technion, Israel Institute of Technology are collaborating on the development of platinum free fuel cell catalyst. They have had a relationship for 2 years under the UConn-Technion Energy Collaboration Initiative

UConn and Technion are recognized leaders in energy engineering and education, and both institutes are committed to advancing global adoption of clean and efficient energy technologies.

which enables the exchange of faculty and students. This initiative has become the base that has allowed UConn and Technion to collaborate on a number of topics associated with the development of new materials and approaches to reduce precious metal content in anion exchange membrane fuel cells (AEMFCs). Dr. Radenka Maric, UConn's Vice President for Research, Innovation and Entrepreneurship, Dr. Dario Dekel, Technion's Associate Professor and Dr. S. Pamir Alpay, UConn's Associate Dean for Research and Industrial Partnerships are working on advanced concepts that will provide novel solutions in energy research and catalysis.

The project is focusing on fuel cells, an integral part of the clean energy initiative. Fuel cells use hydrogen and a catalytic layer to produce sustainable energy without the emittance of harmful greenhouse gases. The current catalytic layer is incredibly expensive since it is made from a noble metal raw material. The team has developed unique ideas on AEMFCs which will allow the

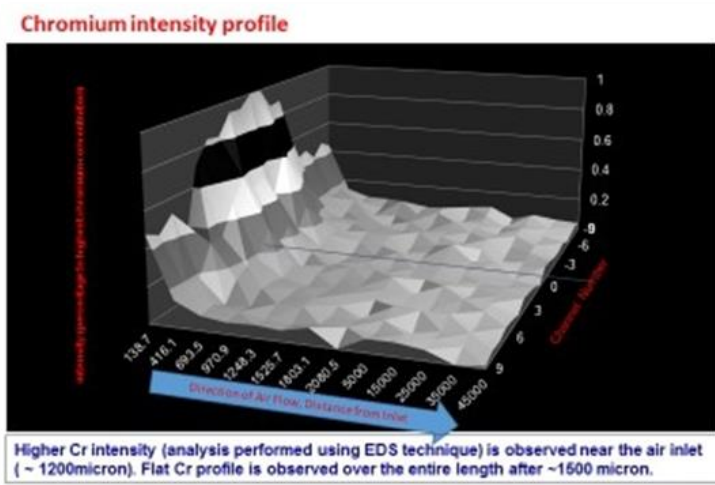


costly platinum to be substituted with a ceramic and a very small amount of palladium and ultimately replacing it entirely with a nickel-iron catalysts.

This project uses a unique reactive spray deposition technology (RSDT), a technology pioneered by Dr. Maric for the synthesis of the novel materials systems.

UConn submitted a \$500,000 proposal to the National Science Foundation (NSF). Similarly, Technion applied for a proposal from the U.S.-Israel Binational Science Foundation (BSF). Seed money provided by Technion-Satell Foundation allowed the teams to work together seamlessly on this proposal.

Solid Oxide Fuel Cells Basic Research – A Solution to the Chromium Vapor Problem



In a project supported by the Fossil Energy office at DoE, Dr. Singh's group have discovered materials that act as getters for Cr vapors, which originates from stainless steel components in high operating temperatures. A DoE research highlight shows Dr. Singh found that a compound consisting of strontium oxide (SrO) and nickel oxide (NiO) is effective. This compound also is desirable due to its stability, reaction product morphology, and ease of formation and processing.

In his C2E2 laboratory, Dr. Singh's group developed a thermodynamic model, which indicated constituents from the alkaline earth and transition metal groups would be useful. An SrO containing compound was selected because it is also stable against hydrolysis and the capture of water vapor at lower temperatures as well as high temperatures, conditions that occur during thermal cycling and shutdown.

UConn Partners in \$100M DOE Innovation Hub on Water Technologies – C2E2 Faculty McCutcheon leads UConn's participation in NAWI

U.S. Secretary of Energy Rick Perry announced that the National Alliance for Water Innovation (NAWI), a research consortium including the University of Connecticut, has been awarded a five-year, \$100-million Energy-Water Desalination Hub to address water security issues in the United States. The hub will focus on early-stage research and development for energy-efficient and cost-competitive desalination technologies and for treating nontraditional water sources for various end uses.

Prof. McCutcheon anticipates that NAWI will tap into UConn's expertise in areas like membrane technology, waste water treatment, computational development, and systems design, to create a stable and resilient water supply for agriculture, industry, and communities.



George Matheou Connects Engineering into Art and Nature

C2E2 faculty Matheou curates Fluid Dynamics in Art and Nature exhibit at Benton.

According to C2E2 faculty Prof. Matheou, the intersection between the arts and sciences are actually extremely important. This notion became the inspiration behind his art exhibit called *Fluid Dynamics in Art and Nature* at the William Benton Museum of Art. The exhibit, which began on August 23, 2019, explores the similarities between art and science through artists' works and computer simulations of natural phenomena that depict fluid flow.



Matheou observes his exhibit at the William Benton Museum of Art

The exhibit aims to “*promote creativity, critical thinking, and self-learning*”.



C2E2 faculty, Jasna Jankovic leads a project that seeks to develop an artistically designed portable renewable energy device, named UConn STEAM Tree, and then to explore human social reactions to the presence of the tree. The tree will service as a multidisciplinary research instrument, teaching tool, and most importantly a beautiful, functioning clean energy-harvesting power source that would promote social interactions and understanding through public engagement. The project is currently funded by an internal grant to a team consisting of faculty from Arts (C. Sancomb), Ecology & Evolutionary Biology (C. Jones), Urban & Community Students (S. Maddern) in addition to Engineering (J. Jankovic, S.Y. Park)

OUTREACH ACTIVITIES



C2E2 hosted *CT Science 4 Kids*, a grant received in collaboration with Kate Farrar of the Connecticut Women’s Education and Legal Fund which offer middle school students from 5 school districts a CT State Department of Education Inter-District Cooperative Grant entitled: ***CAPT-ivating Kids III: Innovate and Educate.***

The goals of this program are:

- Reduce racial, ethnic, and economic isolation as 300 students from the diverse communities of Bristol, Hartford, New Britain, Meriden, and Wolcott participate in a sequence of activities to develop a greater understanding, appreciation, and acceptance for diversity.
- Provide inquiry driven “hands-on’ laboratory and field investigations linking science, technology and society so as to improve science, social studies and math competencies aligned with the Connecticut Core Standards (CCS) and Next Generation Science Standards (NGSS).
- Provide activities that engage teachers, students and parents in strategies that acquaint underrepresented student groups with career pathways in STEM
- Prepare students for the new/planned (Spring 2019) NGSS-CT Assessments

UConn’s Pre-College Global Engineering

UConn Pre-College Summer Global Engineering students visited our center. These students were interested in learning about the many engineering disciplines and the research that is performed at our center. They heard from C2E2 graduate students on how they selected their career path and about the research they are doing in pursuit of their Ph.D



These young engineers will spend their last year of their studies abroad during which time they will complete an engineering internship in their field of specialty in the language and culture of their host country.

SCHOLARLY PUBLICATIONS

In the reporting period, more than 300 archival journal publications have been published by C2E2 faculty in highly reputable journals, including Science, Nature Communications, Energy and Environmental Science and Proceedings of National Academy of Sciences.

	2015	2016	2017	2018	2019
Journal Articles	41	43	74	104	71
Conference Proceedings	31	20	47	29	11
Total Citations	1010	722	1126	847	136



RESEARCH FUNDING

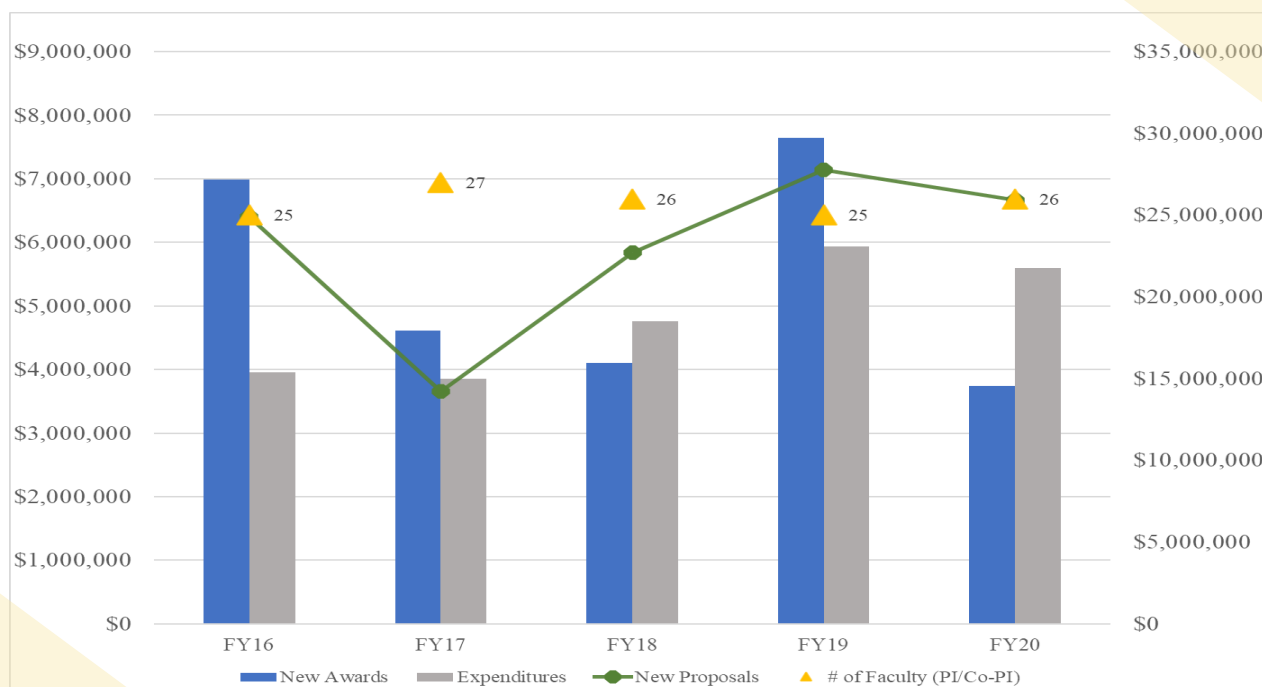
In the reporting period (FY16-FY20), C2E2 faculty has submitted 364 proposals with a total request of \$115,555,652 from diverse sources, including federal, industry and state. 95 of these proposals were funded with a total budget of \$27,083,855.

As of the beginning of FY20, C2E2 manages 82 active grants with a total value of nearly \$24M.

Research Expenditures-Externally Funded (FY 2016-FY2020)

	FY16	FY17	FY18	FY19	FY20	Total
Direct Costs	\$3,017,182	\$2,700,832	\$3,479,125	\$4,323,232	\$4,100,940	\$17,621,311
Indirect Costs	\$936,391	\$1,147,694	\$1,280,605	\$1,609,236	\$1,502,725	\$6,476,651
Total Expend.	\$3,953,573	\$3,848,526	\$4,759,730	\$5,932,468	\$5,603,665	\$24,097,962

*Active Grants only include awarded budgets to date and not total budgets, cost share is not included. Preproposals and concept papers are not included in the proposal submitted.





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