APPROVED BY SENATE
12/03/2012

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ILLINOIS
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

Proposal to the General University Policy Committee

TITLE OF PROPOSED CENTER OR INSTITUTE:

Grainger Center for Electric Machinery and Electromechanics – Request to permanently establish the Center in the Department of Electrical and Computer Engineering in the College of Engineering.

DESCRIPTION OF THE CHARTER:

- Detail the charter or mission of the proposed center/institute.
- Discuss the center/institute's alignment with the strategic direction of the campus/college/school/department.
- Describe the center/institute's Public Engagement activities as they relate to the charter or mission, if any.

The Grainger Center for Electric Machinery and Electromechanics (CEME) was formed in September 1999, in the Department of Electrical and Computer Engineering with funding from the Grainger Foundation, to establish a position of leadership at the University of Illinois among university programs in the field of electric machinery and electromechanics, to nurture a new generation of engineers for contributions to rotating electric machines and electromechanics, to advance the technologies of electric machines and electromechanical devices, to conduct research that promotes the understanding of rotating machinery and involves students in experiences that enhance their knowledge, and to establish a network of collaborating universities and industries in the field.

Over the past almost thirteen years, the CEME has taken on a fourfold mission: education, research, economic development, and public service. Our primary contribution is in the field of energy, including long-term fundamental advances in electric machinery, transportation and vehicles, energy resources, and energy efficiency and reliability. CEME-supported education and research forwards economic development in Illinois directly through its graduates employed across Illinois and indirectly through its published research. CEME instructional development occurs through classroom lectures; laboratory classes; laboratory research carried out by undergrads, graduate students, post-docs and visiting scholars; and student and faculty publications and presentations at conferences and University seminars. The CEME nurtures large student team projects including the Solar Decathlon, the Future Energy Challenge, and the Formula Hybrid Team. These mostly undergraduate team projects are supported by faculty across multiple University departments and supervised by CEME graduate students. The Solar

Decathlon houses are open to the public, first in Washington, D.C. and then in Illinois, to encourage energy-efficient design for residential applications.

JUSTIFICATION:

- How does the formation of this center/institute fulfill needs not already met by other entities on campus/college/school/department?
- How will the center/institute help position the campus/college/school/department in a current or emerging field of inquiry?

The CEME is unique on the University of Illinois at Urbana-Champaign campus because both the Center and the Center Director are endowed by the Grainger Foundation to advance research in the field of energy through long-term research in electric machinery, transportation and vehicles, energy resources, and energy efficiency and reliability.

Electric machines consume nearly two-thirds of all global electricity and are essential in growth industries such as transportation, small portable devices, and wind and wave generation. Key elements of the relevant industry are centered in Illinois, and the CEME is strategically located as the regional hub for research in electric machinery. High-tech motor work is located in the Chicago and Rockford areas. Major Illinois industries applying CEME research include Motorola, Caterpillar, John Deere, Electro-Motive Diesel, and MPC Products. CEME student researchers and graduates have also taken their expertise throughout the Midwest to St. Louis—Bitrode and Emerson Electric; Indiana—Rolls-Royce in Indianapolis, P.C. Krause Consulting in West Lafayette, and Delphi in Kokomo; Milwaukee—Eaton and Rockwell Automation; and Detroit—Ford and General Motors. CEME research is also being applied by the Military at state and regional levels. The US Army Corps of Engineers Construction Engineering Research Laboratory in Champaign funds CEME research and employs CEME graduates. Negotiations for collaboration are ongoing with other branches of the US military, including the Naval Sea Systems Command (NAVSEA) whose main facility is located in Crane, Indiana. NAVSEA specializes in total lifecycle support in special and strategic missions and electronic warfare/information operations; Rolls-Royse's military applications; and the Power Systems group at Boeing. On the longer term, the CEME is pursuing discussions about the Illinois high-speed rail system and the auto industry, including Mitsubishi in Bloomington.

Two CEME-related start-up companies: PowerWorld and SolarBridge, along with the following eleven companies, are Power Affiliates: Ameren, Bitrode Corporation; City Water, Light & Power, Springfield, IL, Continental Automotive, Electrical Manufacturing & Coil Winding Association, Inc., Exelon, Flanders Electric, G&W Electric, MidAmerican Energy Company, S&C Electric Company, Sargent & Lundy Engineers. And, along with John Deere and Delphi, the CEME also has on-going relationships with National Instruments, Texas Instruments, and Google. All the Power Affiliates contribute to research in the Power and Energy Group (see below).

The CEME will be contributing funds for advanced energy features of the new ECE building. This "beyond" LEED Platinum design is 230,000 gross square feet. It is projected to become the

largest zero net energy building in the US and a model for sustainable buildings at the University, State, and National levels.

PROPOSED STRUCTURE:

- Describe the direct reporting line(s) of the proposed center/institute. How will the center/institute be situated in the organization's hierarchy?
- Describe the proposed organizational structure and how the structure will permit the center/institute to meet its stated objectives.
- Describe the staffing needs of the center/institute and plans for the leadership of the center/institute.

The CEME is an autonomous entity within the Power and Energy Systems (PES) area of the Department of Electrical and Computer Engineering (ECE). PES comprises the CEME, the Power Systems Engineering Research Center (PSerc), and, to a significant degree, the Trustworthy Cyber Infrastructure for the Power Grid Effort (TCIPG), which is supported by a large grant from the US Departments of Energy and Homeland Security. ECE faculty in the Power and Energy Systems area provide guidance to both centers and TCIPG. Each center has its own director, and the director of PSerc is also a Co-PI of TCIPG. An Associate Director, a Coordinator, and a Staff Engineer report to the CEME Director. The Director holds the titles, "Grainger Endowed Director's Chair in Electric Machinery and Electromechanics," and "Professor and Director of the Grainger CEME." The CEME Director reports to the ECE Department Head, who reports to the Dean of the Engineering College.

ACADEMIC IMPLICATIONS:

- List affiliated faculty and staff.
- Will tenure-stream faculty hold appointments in the unit? If so, describe the structure of the appointments.
- Describe any plans for the center/institute to offer courses or academic programs.

Professor Philip Krein is the Director of the Center and Grainger Endowed Director's Chair Professor. His research interests include dynamic performance, control, and design of high-performance electric machines and large-signal analysis and control of power electronic systems.

Assistant Professor Alejandro Domínguez-García is the Associate Director of the Center and a Grainger Associate. His research interests lie at the interface of system reliability theory and control theory, with special emphasis on applications to power electronics, electric power systems, and safety-critical/fault-tolerant aircraft, aerospace and automotive systems.

Kevin Colravy is the CEME's research engineer. Kevin has worked at the University of Illinois as a research engineer in areas of electron microscopy, X-ray diffraction, and micro/nanofabrication. He now manages all the Grainger CEME labs and assists with student projects.

Professor Paul Kenis, Department Head of Chemical Engineering, collaborates with the CEME in the fabrication of fuel cells and microreactors for advanced energy applications.

Professor Kyekyoon (Kevin) Kim, Director of the Thin Film and Charged Particle Research Laboratory, collaborates with the CEME in the fabrication of gallium nitride–based power devices.

Professor Thomas Overbye is a Grainger Associate and works in the area of power system operations and simulation. He is interested in visualization tools for all aspects of electric power and is developing visualization tools that illustrate dynamic magnetic fields in motors.

Assistant Professor Robert Pilawa-Podgurski works in the area of power electronics and integrated circuits, with an emphasis on renewable energy, energy harvesting, and CMOS power management.

Professor Peter Sauer is a Grainger Professor of Electrical and Computer Engineering. His research interests include all aspects of electric machines and their interactions in power systems.

Joyce Mast, Program Administrative Assistant, is the Center Coordinator. She edits technical papers and coordinates and documents Center activities.

The CEME annually supports about 15 graduate students and 30 undergrads doing research in the Grainger Laboratory. In academic year 2011-12, more than 300 different students were enrolled in the following CEME-related courses: ECE 330 Power Circuits and Electromechanics, ECE 333 Green Electric Energy, ECE 431 Electric Machinery, ECE 464 Power Electronics, and ECE 469 Power Electronics Laboratory. In some years a post-doc and/or visiting scholars are CEME-supported. Graduate students in various groups and departments of the University, including Power and Energy, Electromagnetics, Microelectronics, Mechanical Science and Engineering, and Chemical and Biomolecular Engineering are supported. CEME funds have been part of start-up packages for three new faculty members (Professors Chapman, Domínguez-García, and Pilawa-Podgurski. Associate Professor Patrick Chapman, former Associate Director of the CEME, is now an Adjunct Professor at the University of Illinois and Co-Founder, Chief Technology Officer and Vice President of SolarBridge). Large student activities receiving CEME support include the CEME Collaborative Network, which supports two to three external research proposals annually at the rate of $20,000 per proposal; the Solar Decathlon held in Washington, DC (2006-7, 2008-9, and 2010-11) and 2012-13 to be held in China — RA appointments, equipment, and faculty advising; the annual Formula Hybrid team competition in New Hampshire — general funds as needed, equipment, faculty advising, and some years, travel expenses for the Director or post-doc advisor; the annual Engineering Open House — supplies and advising; the graduate student-organized and led Power and Energy Conference in Illinois (PECI) held annually since 2009 — student support, all printed matter, supplies, some equipment, and advising by the Director and Coordinator; the University of Illinois IEEE Power Electronics Society/Power and Energy Systems joint student chapter — CEME-supported students have taken leadership roles. A textbook for ECE 330, *ECE Power Circuits and Electromechanics* by Professor Emeritus M. A. Pai, was developed and published. This textbook has been reprinted and revised three times. Plans are in place for a new edition with additions by

Professors Domínguez-García and Pilawa-Podgurski. The total enrollment for ECE 330 for academic year 2011-2012 was 292.

BUDGET AND FUNDING STRATEGY:

- What is the proposed time period for existence of the center/institute?
- Detail an initial budget.
- Describe the funding strategy, including any internal or external support, and if applicable, plans for replacing internal fund support with external funds.

The CEME was founded in September 1999. Because it is endowed (see below), there is reason to believe that it will continue in perpetuity. The Grainger CEME receives no State or University funds. It was originally funded for three years by The Grainger Foundation. The Grainger Foundation permanently endowed the Center in 2003 following the initial three years, and substantially increased the endowment in 2007. A separate endowment totally funded by the Grainger Foundation in 2003 supports The Grainger Endowed Director's Chair in Electric Machinery and Electromechanics. The expenditures for 2010-11 are summarized below. Current annual endowment income allocation is about $524K.

2010-2011 Grainger CEME Budget Report
Center activity was held close to a sustainable level in 2010-2011. The surplus, $30,056, is 6% of operating expenses. External project funding leverages the endowment support, so the actual level of Center activities is substantially higher than this report suggests. With the global economic downturn in 2008, endowment income is rising very slowly – just 1.1% during the year. Our engineer-in-residence program supported two short-term visitors, and a long-term visitor with external support is also participating. Equipment expenditures are charged against the quasi-endowment principal, although surplus carried over is covering equipment costs for the time being.

Center activities are leveraged with project support from several other sources, notably the Office of Naval Research, the Global Clean Energy Program (GCEP) at Stanford University, and industry sponsors. Future project support is expected from the Department of Energy and other sponsors. The budget summary addresses only the internal Center funding and financial activity. This year, about 54% of non-equipment expenses were in the form of direct support for undergraduate, graduate, and post-doctoral students, both at Illinois and through our collaborative network schools. An additional 13.3% of funds cover support of student projects through costs of supplies, student travel to conferences and meetings, and machine shop technician assistance. The Center supports the salary and benefits of our Center Coordinator and the salary for our Research Engineer. Costs associated with the Director and other faculty-related expenses are not borne by the Center operating budget, as the Director position is endowed separately. The endowment support began in 2001.

The budget plan for 2010-11 was to target expenditures of about $525,000, moving toward a sustainable level based on projected income. The CEME seeks to keep clerical and office expenses below 15% of the total. Actual expenditures, including equipment, totaled $499,593, about 5% below the target. Clerical and office expenses were 13.6% of the total. The surplus carries over for the future. The cash balance at the end of the fiscal year was positive at

$150,737. The expected income for 2011-2012 is also $525,000, and the budget target is to balance expenses. The cash balance is about 29% of the planned annual expenditure. Equipment expenditures in 2010-11 totaled $13,817. This figure is relatively low because we were anticipating delivery of a new set of custom lab machines for instructional purposes. The vendor has been delayed, and these will not be booked until 2012-13. Other equipment items include an expansion of lab spaces and facilities to support experimental work by Professor Domínguez-García.

Operating expenditures (actual)

	2010-2011
Student direct support	$208,627
Grad assistants $161,000	
Undergrads $47,627	
Research engineer	74,449
Clerical and office expenses	67,860
Computer system support	17,475
Student project support	64,736
Collaborative network	40,967
Engineer-in-residence	11,662
Equipment	13,817
Total	$499,593

Operating cash flow

	2010-2011
Beginning balance, July 1, 2010	$120,681
Endowment support	529,649
Less operating expenses (left)	499,593
Ending balance, June 30, 2011	$150,737

OUTCOMES:

- Describe the criteria and outcomes that will be used to demonstrate the quality and effectiveness of the center/institute.

The highest priority of the Grainger CEME is students and their impact in CEME-related areas over the long term—ten to twenty years after graduation. Metrics that confirm student activities and support include: 1) Percentage of budget providing direct student support; 2) Number of students enrolled in CEME-related classes and involved in CEME activities and research; 3) Innovation demonstrated through patent disclosures, publications, and start-up companies; 4) participation and leadership in major international forums related to CEME topics; 5) Leveraging of other funds; and 6) mentoring and development of new faculty.

The impact of CEME-supported graduates in CEME-related fields ten or more years after graduation is broad and deep. For example, of eleven CEME-supported students completing either an M.S.E.E. or a Ph.D. and graduating between 2000 and 2002, four are in academia: two as faculty members at Texas A & M, a third as a research associate at Virginia Tech, and the fourth holds both a special appointment to the graduate faculty of the School of Electrical Engineering at Purdue University (one of the CEME's collaborating universities) and is Director of Engineering Services of a major engineering consulting firm with contracts from the US Department of Defense. Another graduate is a researcher for the Malaysian defense department. A Spanish graduate is a self-employed consultant in northern Spain specializing in research, design, development, technical viability analysis, power electronics, digital signal processing, embedded control, LED-based lighting systems and software development. A graduate from the east coast funds his own company, Sustainability Research, by working for a company

specializing in sustainable and integrated water systems (including contracts with USAID). Three CEME graduates are leaders in industrial innovation. The first is an electrical engineer in oil well drilling. She played a key role in electronic design and development of the next generation down-hole tools in well logging and formation evaluation. The second designs high-voltage power systems for a firm in Chicago, and the third, a senior systems architect in electronics doing research and development in advanced sensing, electronic system architecture, and nonlinear and distributed model control of conditioning systems in agricultural equipment manufacturing, works in downstate Illinois.

CLEARANCES:

A letter of support from the unit to which the proposed center/institute will directly report must be included.

Proposal Sponsor: _____ Date: 7/24/2012

Contact Information:

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Andreas Cangellaris
Department Head

July 17, 2012

To Whom It May Concern:

Please allow this letter to serve as my full endorsement of the Grainger Center for Electric Machinery and Electromechanics Proposal that was submitted to the General University Policy Committee by Professor Philip Krein, the Grainger Endowed Director's Chair in Electric Machinery and Electromechanics.

The Center's primary contribution is in the field of energy, including long-term fundamental advances in electric machinery, transportation and vehicles, energy resources, and energy efficiency and reliability. The Grainger Center, formed in September 1999 in the ECE Department, is funded by the Grainger Foundation, and contributes in an exemplary manner to our mission of education, research, economic development, and public service.

In addition to instructional development that transpires through classroom lectures and laboratory classes, the Grainger Center cultivates large student team projects including the Solar Decathlon, the Future Energy Challenge, and the Formula Hybrid Team. For the most part, these projects include undergraduate students. The projects are supported by faculty across multiple University units and supervised by CEME graduate students. The University of Illinois' team of students won second place in the 2009 Solar Decathlon competition, an international contest where only 20 of the best teams are permitted to participate.

The Department of Electrical and Computer Engineering strongly supports the Grainger Center for Electric Machinery and Electromechanics.

Sincerely,

Andreas C. Cangellaris
Department Head
M.E. Van Valkenburg Professor of
Electrical and Computer Engineering

telephone 217-333-2301 • *fax* 217-244-7075

UNIVERSITY OF ILLINOIS
AT URBANA-CHAMPAIGN

Office of the Provost and Vice Chancellor
for Academic Affairs

Swanlund Administration Building
601 East John Street
Champaign, IL 61820

August 10, 2012

Nicholas Burbules, Chair
Senate Committee on General University Policy
Office of the Senate
228 English Building
MC-461

Dear Professor Burbules:

Enclosed is a copy of a proposal to permanently establish the Grainger Center for Electric Machinery and Electromechanics in the Department of Electrical and Computer Engineering in the College of Engineering. It now requires Senate review.

Philip Krein, Director of the Grainger Center will serve as primary contact for the proposal.

Sincerely,

Kristi A. Kuntz
Assistant Provost

KAK/nh

Enclosures

c: P. Krein
J. Mast