Today, you have more ways to use energy. At Duke Energy, we’re doing more too. More innovative technology, like ways to fix outages before they happen, for more reliable service every day. So no matter how much you do, we’re always here... with power for your life.

We are leading a coalition of companies developing a smarter grid using innovative, responsive technology for greater reliability and customer value.

www.duke-energy.com/More
EPIC partners,

It is my pleasure to reflect on 2017, another eventful year for EPIC. Having joined EPIC in July, 2017, I have been busy entrenching myself in the mission and work of the Center and guiding our faculty and staff in pursuing exciting research opportunities. With the vantage point of a newcomer to EPIC, I am honored to be working with high-caliber faculty who are driving innovative research, talented students who are learning valuable skills to prepare them for the workforce, and state-of-the-art labs capable of handling a broad range of testing. This trifecta of resources is an unrivaled resource for students and industry.

In this 2017 Annual Report, you will find a summary of the accomplishments of EPIC and its faculty over the 2016-2017 academic year. You will also find details about the next chapter for EPIC - EPIC 2.0. With the ever increasing needs of the energy industry, EPIC is poised to be a leader in education, research & development, and economic development.

I hope you enjoy reading this report and that you gain further insight into EPIC’s capabilities to envision how our resources can be an asset to the energy industry as we work to solve complicated issues.

Dr. Micheal Mazzola
Executive Director
Duke Energy Distinguished Chair in Power Engineering Systems
ABOUT UNC CHARLOTTE

Founded in 1946, the University of North Carolina (UNC) at Charlotte is North Carolina’s urban research university and has the second largest undergraduate enrollment among the University of North Carolina system’s 17 institutions and is the largest institution of higher education in the Charlotte region. It leverages its location in the state’s largest city to offer internationally competitive programs of research and creative activity, exemplary undergraduate, graduate and professional programs, and a focused set of community engagement initiatives.

UNC Charlotte maintains a particular commitment to addressing the cultural, economic, educational, environmental, health, and social needs of the greater Charlotte region. 2017-2018 enrollment exceeded 29,000 students, including over 5,400 graduate students. The University has seven academic colleges, and offers 77 Bachelor, 61 Master and 21 Doctoral degrees. The William States Lee College of Engineering, located on the Charlotte Research Institute Campus, has paired with the Energy Production Infrastructure Center (EPIC), to create programs, courses and energy concentrations within multiple departments that enhance technical skills and engineering.

ABOUT EPIC

The Energy Production and Infrastructure Center (EPIC) was formed through private and public funding in response to the need to supply well-educated and highly trained engineers qualified to meet the demands of the energy industry and to provide sustainable support for applied research. Offering a collaborative industry/academic partnership, EPIC produces a technical workforce and advancements in technology for the global energy industry while supporting the Carolinas’ multi-state economic and energy security.

With a sophisticated research center, EPIC provides education and applied research opportunities to students with energy related interests. Our industry-education partnerships unite students, faculty and industrial partners to collaborate on interdisciplinary research and learning with a special focus on energy research and education.

EPIC’s energy curriculum teaches students project management, collaborative teamwork, risk analysis and leadership skills. Our facilities assist the energy industry, training the next generation of energy professionals who will deliver new and creative solutions for the energy community.
EPIC SUPPORTED STUDENTS

EPIC supports both undergraduate and graduate students by providing research assistantships and scholarships. Students play a major role in assisting faculty members with research projects and through their work are able to gain valuable experience, making them more attractive to employers upon graduation.

Undergraduate students continue to receive strong support from EPIC, but with the expiration of scholarships the amount provided decreased 32% over FY2016. However, the average amount of scholarships provided per student increased almost 5% from $10,023 to $10,496 in FY2017.

Graduate research, assistantships, and scholarships are key components to attracting talented students interested in pursuing advanced studies. EPIC provides Graduate Research Assistantships to graduate students (PhD and Masters) to support faculty-led research. These students analyze data and work on higher level tasks to complete the project scope. Combined, graduate students received over $800,000 in grants, scholarships, and assistantships from EPIC Direct Hires, an increase of 36% over 2016. The average amount of grants per graduate student also increased 16% from $6,740 in FY2016 to $7,819 in FY2017.

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<td>KIT Students</td>
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Embracing our heritage

You have known us as AREVA. We changed our name. We changed our brand. But the passion of our people remains constant. We continue to improve the safety and performance of nuclear power plants around the world, while investing in the growth of our communities.

www.framatome.com/us
In cooperation with The Williams States Lee College of Engineering, The Belk College of Business, and industry partners, EPIC provides a series of undergraduate and graduate energy concentration and degree programs. The energy concentrations require a set of core and elective courses. Undergraduate students take four to six core courses and choose from a list of additional elective courses. The UNC Charlotte MBA is a 37 credit-hour program. To obtain the energy concentration, students are required to take four specialized courses divided into required and elective courses.

EPIC continued to make efforts to broaden awareness of the availability and importance of energy concentrations across the university. Overall, since it’s inception, energy concentrations have seen a 97% increase in participation from 91 to 179. The number of Graduate students pursuing a Masters degree with an Energy Concentration have steadily increased from 33 in 2014, to 68 this past year. Engineering Technology saw the largest increase and more than doubled the number of students pursuing an energy concentration. With an ongoing focus to attract students to this program, EPIC looks to continue this upward trend.
Interest in energy-related courses is strong and enrollment has grown dramatically since the 2013/2014 academic year, when there were 1,729 students enrolled. Now with 2,400 students enrolled in energy-related courses within the College of Engineering, EPIC has seen more than a 38% increase since that first year. In the 2016/2017 alone, enrollment increased by over 26% for Undergraduate students and over 70% for Graduate students over the previous year.

More and more businesses are headed our way, to North Carolina. With some of the lowest energy rates in the country, easy access to anywhere in the world and a reliability rating of 99.98%, can you really blame them? They’re finding out we’re big enough to provide the best possible value, yet small enough to keep that good ol’ Southern hospitality alive. And the quality of life isn’t too bad either.
The Lee College of Engineering’s Senior Design Program brings together students and industrial partners in a collaborative research environment. As they tackle real-world engineering projects, the students and their industry supporters are afforded unlimited possibilities for learning and achievement.

Our engineering and engineering technology students develop critical skills while working in multi-disciplinary teams tackling problems in Electrical, Computer, Mechanical, Systems and Civil engineering technologies.

EPIC is particularly interested in the number of students who participate in energy related Senior Design projects.

The Fall 2016 Expo was held on December 9, with 294 students participating. There were 56 completed projects showcased, 17 of which were energy related.

The Spring 2017 Expo was held on May 4, with 116 students participating. There were 26 completed projects that were showcased, 8 of which were energy related.

In addition, 26 posters were displayed for projects that will be completed in Fall 2017.

In FY2017, 31% of all senior design projects were related to energy, a remarkable achievement for the EPIC Public/Private partnership and a highlight of the strength of the energy industry in the area served by UNC Charlotte.
Together… Shaping the Future of Electricity

EPRI is proud to collaborate with EPIC on their crucial work of developing energy engineers for the future.

Congratulations to EPIC on another successful year!
As EPIC looks ahead to our next phase the focus will turn to developing an extramural-funded research program that is “additive” to the existing departmental activities. This will be accomplished by:

- Focusing on corporate engagement by completing research deliverables on an industrial client’s schedule.
- Seeking government leverage from corporate funds.
- Empowering 6 EPIC Assistant Directors of Research (ADoR).
- Supporting each ADoR with full time staff that reports to an ADoR.
- Recruiting faculty from UNC Charlotte and outside institutions onto cross-cutting, multidisciplinary, large research projects.
- Benefiting workforce development by growing the energy concentration, supporting senior design, and recruiting graduate students with the help of the EPIC Affiliates.
High Bay (Core)
Dr. Youngjin Park (Manager)

Flexible Energy (Core)
Dr. Soma Essakiappan (Manager)

Photovoltaic
Dr. Aba Ebong

Duke Energy Smart Grid (Core)
Vacant (Manager)

EPIC ASSISTANT DIRECTORS OF RESEARCH
Strategic Development & Faculty Liaison – Dr. Badrul Chowdhury, ECE & SEE
Energy System Management - Dr. Rob Cox, ECE
Energy and Power Conditioning – Dr. Madhav Manjrekar, ECE
Energy and Environment - vacant
Energy Infrastructure – Dr. David Young, CEE (EPIC Assoc. Director)
Large Energy Manufacturing – Dr. Tony Schmitz, MECH
EPIC AFFILIATES PROGRAM

UNC Charlotte’s Energy Production and Infrastructure Center (EPIC) with input from its External Advisory Board developed the EPIC Affiliates Program (EPIC AP), a membership program for industry and government partners that wish to collaborate with EPIC. There are three membership levels: GigaWatt, MegaWatt and KiloWatt.

The main focus of EPIC AP is energy workforce development. By bringing together industry, students, faculty, and research experts in disciplines of electrical and computer, civil and environmental, mechanical, and systems engineering the EPIC AP aims to drive advancements in the energy fields as it educates a new generation of energy professionals.

After a year of operation, the EPIC AP has 10 members at the conclusion of FY2017. Through EPIC AP these members funded $139,000 worth of energy related projects, worked with students and faculty, and participated in recruiting and networking events. EPIC faculty collaborated with Atom Power, Duke Energy, and Siemens on seed projects ranging from solid state protection devices, to hardware based security architectures for smart grid, and advanced 3D metrology for large-scale manufacturing. Nine Senior Design student teams worked on projects proposed and mentored by Atom Power, Duke Energy, EPRI, Framatome and Siemens.

Through the Program, Affiliates participated in events organized by UNC Charlotte, the College of Engineering (COE), EPIC, and EPIC AP. Events included the COE Annual Fall Picnic, UNC Charlotte’s Spring Career Fair, the Affiliates Energy Career and Networking Fair, and the Affiliates Annual Meeting. The EPIC Energy Seminar Series also hosted speakers from the Affiliates throughout the academic year, giving them the opportunity to present to students, faculty and other industry partners.

Looking forward to 2018, the EPIC AP is actively working to create incentives to attract more students to the energy industry, such as financial incentives, student mentor-ships, freshmen and sophomore student engagement, and networking events with Affiliates. At the same time the program is exploring ways to engage students with innovative ideas, help them nurture them, expand on them and ultimately bring them to fruition.

EPIC AP’s goal for 2018 is to improve collaboration between its members, connect more Affiliates with excellent engineering students and graduates and provide a platform for successful networking and recruiting events, that ultimately promote the Program’s main focus of energy workforce development.

EPIC AFFILIATES

GigaWatt Members

MegaWatt Members

KiloWatt Members
KIT EXCHANGE

On April 1, 2017, EPIC welcomed 10 graduate students from Karlsruhe Institute of Technology (KIT) in Karlsruhe, Germany as they took part in a six-month research exchange program. KIT is one of the largest and most prestigious research and education institutions in Europe and is known for its high quality of research work around the world. This partnership is a result of a “Memorandum of Understanding” signed in 2013, between KIT and EPIC, with the purpose of building a trans-Atlantic energy bridge and aims to link academic and research initiatives of the two institutions around key energy issues. Four UNC Charlotte students will spent six weeks in KIT over the summer as part of the exchange.

KIT Projects at EPIC:

**Wideband Current Sensors for High Frequency Power Electronics Applications** (Babak Parkhideh)
Investigate contactless integrated current sensing techniques needed for next generation high voltage power electronics systems.

**Power System Modeling, Integration and Application** (Yamilka Baez)
Develop models of the power grid in which solar and wind is integrated, and create hardware in the loop models that demonstrate how the power grid behaves with and without solar and wind integration.

**Development of a multi-model short term electricity price forecasting system using advanced artificial intelligence and data analytic techniques** (Umit Cali)
Investigate the determining drivers of well-performing electricity price forecasting systems and development of a multi-model short-term electricity price forecasting system using advanced artificial intelligence and data analytic techniques.

**Evaluations of DC and AC Distribution Architectures in Data Centers** (Tiefu Zhao)
Study and compare the most important factors (reliability, efficiency, protection and cost) together to comprehensively evaluate the emerging architectures and challenges in data centers.

**Distribution Systems with Increased Situational Awareness** (Valentina Checchi)
The project aims at increasing situational awareness of the electric power distribution system, especially relevant with the increasing presence of distributed energy resources, including renewable generation, energy storage and plug-in EVs.

**PV Integrated Grid Modeling and Control with Energy Storage for High Penetration of PV Farms** (Sukumar Kamalasadan)
Design PV integrated model with energy storage and develop optimization and control architecture for energy storage integrated grid with higher penetration of renewable energy.

**Stationary Fuel Cell Integration and Controls** (Weimin Wang)
This project is for the development of an energy dispatch controller to improve management of fuel cell and other distributed energy resources integrated into building systems.

**Low Cost Distributed Inverter for Solar Generation System** (Madhav Manjrekar)
This project is to construct a prototype Low Cost Distributed Inverter for solar PV panels and test it in the laboratory and in an actual solar power generation plant.

**Energy Water and Food Nexus-Study of the Catawba River Electric Power Plants** (Chris Hardin)
Project involves characterizing and compiling the water use, energy production and impact to agricultural irrigation for three main electric power plants in the Catawba River in North Carolina.

**Fault Detection and Identification using Network Data** (Badrul Chowdhury)
Power systems fault detection and identification, particularly high impedance faults from measured data on the network. Measured data includes sources like wireless sensors, smart meters, fault circuit indicators, etc.

**Building Energy Analytics** (Rob Cox)
Implementing analytics for building energy performance in several locations. One of the primary targets is a net zero energy retail location in Miami, Florida.
EPIC SPONSORED RESEARCH

EPIC Direct Hires are faculty members from various departments within the College of Engineering, who are experts in the power and energy field and have committed to maximize interaction among other faculty, students, staff and industry in the power and energy area. An EPIC Direct Hire participates and takes leadership roles in EPIC activities; contributes to EPIC interdisciplinary collaborative efforts to secure external funding; serves on EPIC graduate student and center committees; collaborates on scholarly articles originating from EPIC-affiliated research; and provides advice and input to EPIC initiatives and future directions.

In FY2016, 15 EPIC Direct Hires submitted proposals as the lead PI for research projects sponsored by public and private sources. They were awarded almost $3 million from various funding agencies (i.e., Department of Energy, Industry, National Science Foundation, and NC Department of Transportation). This funding represents a slight reduction from FY2016 of approximately $30,000.

A healthy realignment of external research continued in FY2017, reflecting an EPIC, College, and University priority on research that impacts the economy of Charlotte, North Carolina, and the Nation. EPIC had the largest change in funded research in Federal awards, which saw a 41% increase from $924,008 in 2016, to $1,303,530 in 2017. Funding from Industry increased over 16%. Since FY2012, EPIC Direct Hires have received awards of almost $17 million.

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EPIC DIRECT HIRE RESEARCH AWARDS BY YEAR

EPIC DIRECT HIRE 2017 RESEARCH AWARDS BY SOURCE

- Federal $1,303,530 (45%)
- Industry $929,646 (32%)
- Educational $70,000 (2%)
- Other $596,558 (21%)
Since 2002, SOS Int'l has helped keep the lights on by providing industry-leading training and compliance services to electric utilities.

Our team of experts hold an array of industry certifications. They understand the industry-specific challenges utilities face and provide detailed training and compliance services for the men and women that operate the power grid.

Over the years, we have provided high quality training for more than 16,000 students in North America and abroad.

Innovation continues to impact our growth as we work to develop advanced training content, incorporate human performance standards, and implement state of the art delivery methods.
The EPIC High Current and High Voltage Test Bed in the Flexible Energy Lab (G130) is now fully commissioned.

EPIC’s Tao Hong receives the Education Leadership Award by the Charlotte Business Journal and E4 Carolinas at the Charlotte Energy Leadership Awards.

UNC Charlotte EPIC students at the IEEE ECCE Energy Conversion Congress & Expo in Cincinnati, OH.

The UNC Board of Governors tours of the Duke Energy Smart Grid Lab with Dr. Mike Mazzola.

The Governors Association of Korea touring EPIC labs.

EPIC Staff bidding EPIC’s Beverly Guessford farewell.

Visitors to EPIC booth at DistribuTech.

The EPIC High Current and High Voltage Test Bed in the Flexible Energy Lab (G130) is now fully commissioned.

UNC Charlotte students on exchange to KIT.

The UTC Foundation, the charitable arm of the Utilities Technology Council (UTC), presented its inaugural grant to EPIC.

Graduate Research Assistant, Steven Dulin, was selected for a Foundation of the Association of Energy Engineers Scholarship and the Ronald C. Harrell Scholarship from the NC Society of Engineers.

Dr. Somasundaram Eswarippan monitors equipment during the solar eclipse.

KIT students getting some school spirit at the Spring 49er football game.

UNC Charlotte students at the 2017 Railway Challenge competition.

Bhaskar Mitra (r) and Pankaj Bhawmik (l) who won first and second place, respectively at the Duke University Energy Week Poster Presentation.
EPIC KEY HIGHLIGHTS

• KIT exchange – 11 German students arrived for 6 month exchange, 4 UNC Charlotte students went on a two-month exchange. Partnership continues to strengthen.


• EPIC was pleased to welcome the UNC Board of Governors, which included President Margaret Spellings, for a tour of the Duke Energy Smart Grid Lab. During their visit members were given a demonstration of how the lab uses real-time computer simulation data to learn how to best handle changes in loads from solar generation.

• 21 EPIC Energy Seminars were held Fall 2016/Spring 2017. We had 712 attendees, including students, faculty, the public, and those from industry.

• EPIC Transportation Energy Researchers and UNC Charlotte graduate students led by Dr. Shen-En Chen and Dr. Nicole Braxtan began work to help Rail Propulsion Systems (RPS) develop an innovative battery-powered engine, which can produce close to 8,000 HP, almost 5,000 more horsepower than the traditional engine.

• Dr. Mike Mazzola joined EPIC as the new Executive Director. Previously at Mississippi State University, Mazzola was the Associate Director for Center for Advanced Vehicular Systems.

• The UTC Foundation, the charitable arm of the Utilities Technology Council (UTC), chose EPIC for its inaugural donation of $7,500 for the outstanding Smart Grid technology and telecommunications work of the university.

• EPIC was featured across many media outlets including: Business North Carolina, Business North Carolina Energy Roundtable, Transmission and Distribution World, Appalachian Today, WBTV.

• EPIC’s Dr. Youngjin Park conducted field work in Puerto Rico as a member of the U.S. National Science Foundation-sponsored Geotechnical Extreme Events Reconnaissance (GEER) team in the aftermath of Hurricanes Irma and Maria. A report documenting geotechnical effects of these extreme events will be produced using their findings.

• EPIC’s Tao Hong received the Education Leadership Award by the Charlotte Business Journal and E4 Carolinas at the Charlotte Energy Leadership Awards! Dr. Hong is an Associate Professor in Systems Engineering and Engineering Management Department, and director of EPIC’s BigDEAL - Big Data Energy Analytics Lab.

• Nature presented EPIC researchers and their industry partners the ultimate intermittent solar power experiment - in the form of a total solar eclipse. The EPIC building houses a 25 kW-rated solar car port and power generated from this system is fed into the university power system. By treating the solar car port and the building as a miniaturized electric utility grid, they were ready to measure the impacts of intermittent solar power generation on the grid. EPIC researchers and industry partners will now study the data and contribute ways to ensure the grid is ready for future similar events.

• EPIC was honored to be included in the ASME Power & Energy Conference Technical Tours. This “sold-out” event provided 40 visitors from around the world an opportunity to visit and learn more about the work taking place at EPIC. This annual conference had over 3,000 attendees and EPIC had a strong presence with the tour, faculty serving as a session chair, student presentations, and a booth at the exhibition.

• A team of railway students from the Birmingham Centre for Railway Research and Education (BCRRE), partnered with UNC Charlotte, and Aegis Engineering Systems, to win second prize in the 5th Annual IMechE Railway Challenge. The integrated team, included UNC Charlotte visiting research students Austin Lukavsky and Nick Frayer.

• The EPIC High Current and High Voltage Test Bed in the Flexible Energy Lab was fully commissioned. The high voltage test kit is capable of performing test like insulation testing up to 100kV. The high current test setup is capable of generating currents up to 4000A in the device under test. Together these two capabilities provide much needed testing support to EPIC and UNC Charlotte faculty members in their research, and also to power equipment manufacturers.
EPIC EXTERNAL ADVISORY BOARD

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SAS

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Frank Yoho
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Executive Director

David Young
Associate Director

Yamilka Baez-Rivera
Duke Energy Smart Grid Laboratory Manager

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Lori Brown
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Robert Cox
Assistant Director, Energy Systems Management

Somasundaram Essakiappan
Duke Energy Suite Power Labs Manager

Christina Kapitopoulou
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Madhav Manjrekar
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Katherine Weaver
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It all starts here.

Across the globe, power is generated using Siemens equipment from Charlotte. Large gas turbines, steam turbines, and generators are manufactured and serviced at the Siemens Charlotte Energy Hub, using state-of-the-art equipment. Supporting our advanced manufacturing journey are many partners—customers, training partners, suppliers. By working together, we commit to a culture of safety and excellence, and we look forward to the region continuing its leadership in the energy industry.

siemens.com