University of Kentucky

Power and Energy Institute of Kentucky

2021 Annual Report

Our Team

UK Faculty and Staff with Primary Department Affiliations

Top Row (left to right): YT Cheng (CME), Don Colliver (BAE, KIAC Director), Aaron Cramer (ECE), Paul Dolloff (ECE, EKPC), Zongming Fei (CS)
Second Row: Jiangbiao He (ECE), Larry Holloway (ECE), Dan M. Ionel (ECE, PEIK Director), Nicholas Jewell (ECE, LG&E and KU), Yuan Liao (ECE, Director of PEIK Graduate Certificate)
Third Row: Jeffrey Seay (CME, Paducah), Dusan Sekulic (ME), Simone Silvestri (CS), Vijay Singh (ECE), Joseph Sottile (MNG, ECE, Director of PEIK Undergraduate Certificate), Jason Souders (PEIK Coordinator).

PEIK Supporters

PEIK gratefully recognizes the support of the following:

PEIK also gratefully recognizes the support of: EKPC, Etap, GE,CMTA, Kentucky Power (AEP), Kentucky Energy and Environment Cabinet, Honda of America, Toyota, IEEE Power and Energy Society Lexington Chapter, Kentucky Association of Electric Co-ops (KAEC), ABB, Black and Veatch, Electric Power Research Institute (EPRI), Sargent and Lundy, S&C Electric, Schweitzer Engineering Labs, and Texas Instruments.

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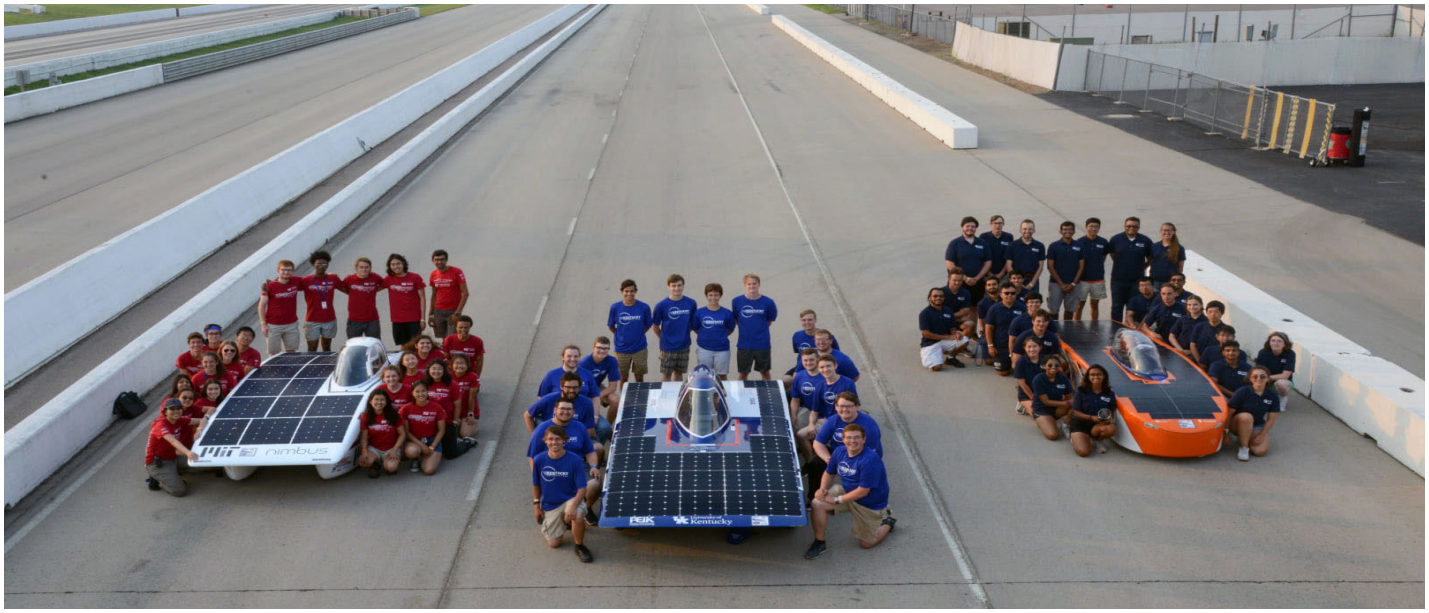
Awards & Recognitions

PEIK Sponsored UK Solar Car Team are National Champions!



The University of Kentucky (UK) Solar Car team are now national champions after claiming 1st place in the track-style 2021 Formula Sun Grand Prix (FSGP) race this past July 30th-August 1st. In the photo, the team and their car, Gato Del Sol VI, are placed in their final podium positions ahead of the second and third placed groups from MIT and University of Illinois Urbana-Champaign. Other team participants from the US included large colleges of Engineering such as University of California Berkeley, Georgia Tech, and Minnesota. The Formula Sun Grand Prix (FSGP) is an annual track competition that is held on grand prix or road style closed courses for custom-designed and built solar electric vehicles to test them in overall reliability, vehicle handling, energy efficiency and strategy. UK's current car, Gato Del Sol VI completed first the 250 laps accounting for 625 miles in this year track race.

The UK Solar Car Team are also national vice-champions for the American Solar Challenge (ASC), which took place August 3rd-8th, having completed the approximately 970-mile road race fully under the car's own power. The UK team also received the "Most Improved" award for continuous development in design, construction, and racing of solar PV electric vehicles over the past 10 years. These are outstanding achievements in the long-standing tradition of the UK Solar Car team that provides hands-on experience with engineering design and development for power and energy generation and efficient vehicle operation. The PEIK logo is proudly displayed on the UK Solar Car and its continued support is gratefully acknowledged.

Awards & Recognitions

PEIK Faculty, Don Colliver, Named Co-chair of New ASHRAE Task Force for Building Decarbonization

PEIK faculty, Biosystems Engineering faculty Professor, Don Colliver, has been appointed co-chair of the ASHRAE Task Force for Building Decarbonization. Twenty five states, many US cities (including Louisville, KY), and many countries have set goals for carbon reduction. Buildings contribute 40% of all carbon emissions. This international task force is charged with developing information to give guidance to countries on how to achieve their carbon reduction goals.

Don Colliver, ASHARE Fellow and Presidential Member ('02-03) and Director of the Kentucky Industrial Assessment Center, also served for ten years as Chairman of the Advanced Energy Design Guide Steering Committee consisting of AIA, ASHRAE, ISENA, USGBC and DOE that produced ten books with over 650,000 copies in circulation. Dr. Colliver's research interests include Solar Energy, Sustainable Design and Construction, Climatic Design Conditions, and Energy Auditing.

Founded in 1894, ASHRAE is a global professional society of 55,000 members with 199 chapters worldwide. It is committed to serve humanity by advancing the arts and sciences of heating, ventilation, air conditioning, refrigeration and their allied fields. As an industry leader in research, standards writing, publishing, certification and continuing education, ASHRAE and its members are dedicated to promoting a healthy and sustainable built environment for all, through strategic partnerships with organizations in the HVAC&R community and across related industries.

Electrical Engineering and PEIK Faculty Dr. JiangBiao Awarded the 2021 Zucker Faculty Grant

Electrical Engineering and PEIK Faculty Dr. JiangBiao He, received the 2021 Zucker Faculty Grant for his proposal titled "'High-Reliability Electric Propulsion Drives based on Digital Twin Technologies". This new project aims to enhance the reliability of electric propulsion drive systems with digital twin technologies, a virtual multi-physics modeling representation that serves as the real-time digital counterpart of a physical propulsion system. The electric propulsion drive is the core component in electric transportation systems, including electric vehicles, airplanes, and ships, and improving the reliability of the propulsion drives will be of paramount importance. Contributions from this project will establish a cost-effective, accurate and robust reliability improvement framework for modern electric propulsion systems.

The Myron Zucker Faculty Grant Program was established within the IEEE Foundation by the IEEE Awards Board in 1987. It is administered by the IEEE Industry Applications Society through its Zucker Grant Committee. Every year, only two research projects are selected from the global Industry Applications Society that has more than 14,000 members

Rosemary Alden and Donovin Lewis, EE SPARK and PEIK Students Awarded Prestigious National Science Foundation Graduate Research Fellowships

Rosemary Alden and Donovin Lewis, electrical engineering, PEIK and SPARK Lab students, have been awarded National Science Foundation Graduate Research Fellowships (NSF GRF). The two students are featured in the center of the photo during a recent celebratory ZOOM friendly meeting with their SPARK Lab group. The NSF GRF is very competitive and attracts typically more than 12,000 applications annually for all topics of science and engineering. This year, only 48 fellowships were awarded nationwide for electrical engineering. The NSF GRF provides student stipend, tuition, and research support for the duration of the doctoral studies.

Rosemary, who grew up in Nicholasville, KY, is an L. Stanley Pigman Scholar, a national IEEE PES Scholarship Plus Initiative recipient, the Chair of the IEEE PES & IAS Student Chapter at UK and received many other awards and recognitions. She has been an NSF REU student for the last year and has been an Undergraduate Research Fellow in the SPARK Lab since 2018. Donovin, who grew up in Paducah, KY, is the recipient of William C. Parker, Kentucky Educational Excellence, and national IEEE PES Plus scholarships, the electrical engineering lead of the UK Solar Car Team and received many other awards and recognitions. He has been a NASA REU student for the last year and has been an Undergraduate Research Fellow in the SPARK Lab since 2019.

Rosemary and Donovin are both University Scholars Program (USP) students and are scheduled to graduate with a BS in May. They plan to intern over the summer with the National Renewable Energy Laboratory (NREL) and the Oakridge National Laboratory (ORNL), respectively, on their main research topics of smart homes and grids and electrification of transportation, before continuing their USP at UK in the fall with PhD studies and research in the SPARK Lab.

In the photo, among the other SPARK students, at the lower right corner is Akeyo Oluwaseun, who recently graduated with a PhD and now works on the analysis of renewable energy integration with Sargent & Lundy, one of the world's largest power systems consulting firms. Next to him is Damien Lawhorn, who is a NASA KY Graduate Fellow and is scheduled to soon defend his PhD dissertation before moving to Houston to work in collaboration with the NASA Johnson Space Center as part of the Space Exploration Systems Group within Jacobs Engineering. Short bios for all the SPARK students are available at https://sparklab.engr.uky.edu/people. All students are advised by Dr. Dan M. Ionel, Professor of Electrical Engineering, the L. Stanley Pigman Chair in Power, and the Director of the SPARK Laboratory and of the PEIK Institute at the University of Kentucky.

Damien Lawhorn, EE and PEIK Student Completed NASA Graduate Fellowship Research and Received PhD in Electrical Engineering

Damien Lawhorn, an electrical engineering (EE) PhD student and a NASA KY Graduate Fellow, has successfully defended his dissertation. His PhD advisor was Dr. Dan M. Ionel, EE Professor and L. Stanley Pigman Chair in Power, Director of the SPARK Lab and of the PEIK Institute. The UK Ph.D. committee included Drs. Aaron Cramer, Gabriel Dadi, James Lumpp, and Joseph Sottile.

Damien, who was born and grew up in Liberty, Casey County, KY, graduated with a BS in EE from UK in May 2017. He continued directly for PhD studies at UK, initially as a L. Stanley Pigman graduate scholar, and since January 2018 as a NASA KY Graduate Fellow on three consecutive research projects assignments on topics of electric power components and systems for aircraft. He spent the summers with the NASA Glenn Research Center (GRC), contributing as an intern to the development of motor drives for NASA's first all-electric aircraft, the X-57 Maxwell, as well as to advancements toward MW hybrid-electric propulsion systems. During the academic semesters, Damien's research took place at UK in the SPARK Lab and funding was provided by NASA KY grants for which Drs. Ionel, Cramer, and Lumpp, served as PI and Co-PIs, respectively.

Damien is a founder and a leading member of the Kentucky Organization of Robotics and Automation (KORA), a multidisciplinary student-led club, which has competed in a NASA driven national competition, and Executive Committee member of the UK IEEE PES and IAS student chapter. Upon PhD graduation, he will move to Houston to work in collaboration with the NASA Johnson Space Center on advanced electronics projects as part of the Space Exploration Systems Group within Jacobs Engineering.

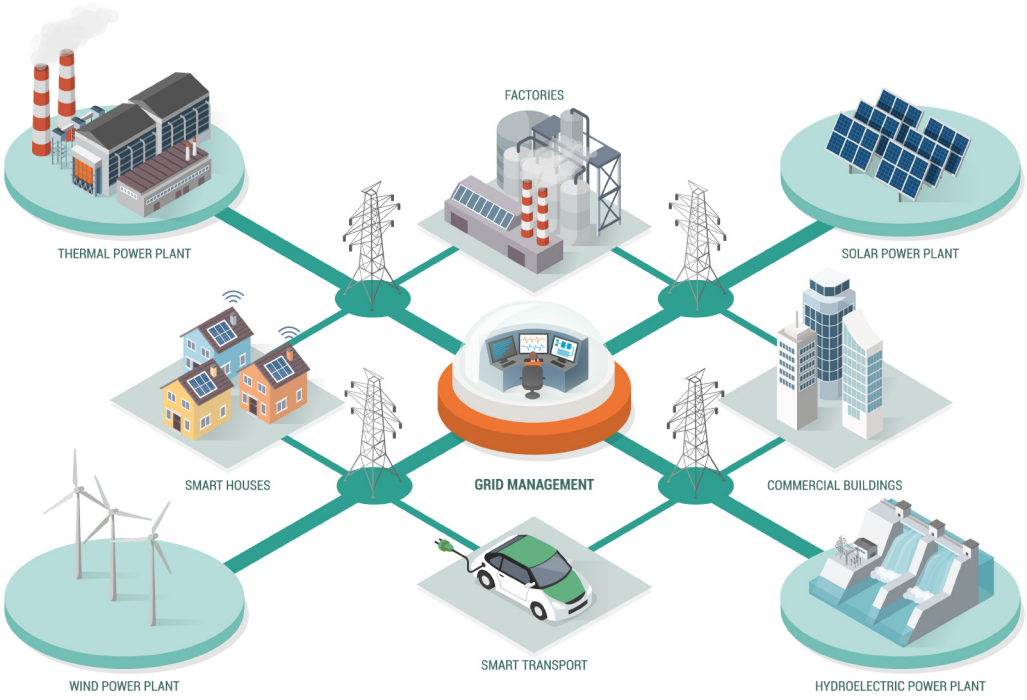
Due to pandemic restrictions the PhD defense was held online, and the public section of the presentation was attended by internationally distinguished academics, colleagues and friends, and family. The full PhD dissertation will be available online from the UKnowledge repository. Examples of Damien's research concepts and results include those from the journal paper "Multi-objective Optimization for Aircraft Power Systems using a Network Graph Representation", recently published in IEEE Transactions on Transportation Electrification.

Rosemary E. Alden Received IEEE PES GM Poster Award and Started EE PhD Program at UK

Rosemary E. Alden, a recent Electrical Engineering (EE) Bachelor and Science (BS) and undergraduate PEIK certificate graduate, received the Undergraduate Student Award - Second Prize at the 2020 IEEE Power and Energy Society (PES) General Meeting (GM). The conference, which is the flagship annual event of PES, one of the largest societies within IEEE, typically gathers more than 2,500 participants. This is the second year in a row Rosemary has been awarded at IEEE PES GM for her undergraduate research work. As per her IEEE mentors, this is nothing short of a record for an extremely competitive international event.

The award-winning poster, “Artificial Intelligence-based Short Term Electric Load Forecasts for Smart Homes including HVAC, EWH, and PV Components ”, has an author’s version posted on the publications page of the SPARK website. The research covered was conducted as part of an NSF REU supplement on a collaborative NSF project led at University of Kentucky (UK) by CS and ECE and PEIK faculty, Drs. Simone Silvestri and Dan M. Ionel, and at Marquette University by Dr. Cris Ababei.

Rosemary, who grew up in Kentucky, was a University Scholars Program student integrating her BS and PhD studies at UK, where she was a L. Stanley Pigman Scholar and received many student awards and recognitions. In the spring, she has awarded a most prestigious National Science Foundation (NSF) Graduate Research Fellowship, one of the only 48 granted this year nationwide for EE. Over the summer, she had a remote internship with the National Renewable Energy Laboratory (NREL). Rosemary will continue her PhD studies at UK, where she found an excellent academic environment, and continues to be directly advised by Dr. Dan M. Ionel, FIEEE, ECE Professor, L. Stanley Pigman Chair in Power, SPARK Lab and PEIK Director.



Donovin D. Lewis is Received the Otis A. Singletary Graduate Fellowship and Started EE PhD Program at UK

Donovin D. Lewis, a recent Electrical Engineering (EE) Bachelor of Science (BS) and undergraduate PEIK certificate graduate, was awarded the Otis A. Singletary Graduate Fellowship for the 2021-2022 academic year. This fellowship honors Otis A. Singletary, the eighth president of the University of Kentucky (UK), who advocated for increased student participation in university affairs and developed greater trust and respect between students and university administration. The award was established by the Board of Directors of the University of Kentucky Athletics Association and is the highest attainable graduate fellowship offered by the UK Graduate School.

Over the summer, Donovin, continued to serve as the electrical chief engineer for the UK Solar Car team who became national champions for the Formula Sun Grand Prix and national vice-champions for the American Solar Challenge, as covered in recent PEIK and UK news. Donovin's leading technical contributions benefited greatly of the technical knowledge on electric vehicles, and reliability of power electronic systems gained as part of two NASA REUs in the previous academic year at UK.

Donovin, who grew up in Kentucky, was a University Scholars Program student integrating his BS and PhD studies at UK, where he was the recipient of a William C. Parker Scholarship and received many student awards and recognitions. In the spring, he has been awarded a most prestigious National Science Foundation (NSF) Graduate Research Fellowship, one of the only 48 granted this year nationwide for EE. Recently, Donovin started collaboration with the Oak Ridge National Laboratory (ORNL) on topics of electrification of transportation, electric vehicle charging and power system integration. He continues for PhD at UK, where he found an excellent academic environment, and continues to be directly advised by Dr. Dan M. Ionel, FIEEE, ECE Professor, L. Stanley Pigman Chair in Power, SPARK Lab and PEIK Director.

Awards & Recognitions

IEEE PES National Scholarships Awarded to Electrical Engineering and PEIK Students

Two EE and PEIK undergraduate students, Hope Anderson and Steven Poore, have been each competitively awarded a 2021/2022 national IEEE Power and Energy Society (PES) Plus Initiative Scholarship. Hope (second from the left in photo) and Steven (second from right in photo) are both L. Stanley Pigman Scholars and recipients of the E.On for PEIK Scholarship. They are studying towards their BS in electrical engineering and pursue the PEIK certificate. Their research on electric power engineering topics is supported this year through an NASA REU and an NSF REU, respectively.

These IEEE awards continue the success enjoyed in recent years by UK and PEIK students. Also included in the photo are Evan Jones (right in photo) and Donovin Lewis (left in photo), both Ph.D. EE students and mentors to Hope and Steven. Evan and Donovin have previously received the IEEE PES national scholarship as undergraduate students at the University of Kentucky (UK), where they have continued for graduate studies. Evan is currently a Department of Education (DoEd) GAANN Fellow and Donovin is an Otis A. Singletary Fellow and a National Science Foundation (NSF) Graduate Research Fellow. All four students conduct research in the SPARK Lab within PEIK and are advised by Dr. Dan M. Ionel, IEEE Fellow, ECE Professor and L. Stanley Pigman Chair in Power.

Best Paper Award at the 2021 ICRERA for SPARK and PEIK Researchers

The paper “Power Factor and Reactive Power in US Residences - Survey and EnergyPlus Modeling,”, authored by SPARK and PEIK researchers from University of Kentucky (UK), has received a Best Paper Award at the 10th edition of the International Conference on Renewable Energy Research and Applications (ICRERA).

The research covered in the paper benefited of support from the Department of Energy through the ENAGE project led by the Electric Power Research Institute (EPRI). A growing number of electronic loads for modern appliances are present in residential electric power distribution systems. It has become increasingly more important to consider the power factor (PF) of residential communities with a view at opportunities for energy savings. Following a survey based on literature and publicly available information, the paper proposes a procedure for the calculation of an equivalent PF employing experimental data provided smart meters. Also included in the paper is a proposed simulation technique employing the widely used EnergyPlus software for building energy modeling.

The authors of the award-winning paper are featured in the photo from left to right: Dr. Abdullah Al Hadi, Postdoctoral Researcher; Hope Anderson, ECE Undergraduate Research Fellow and NASA REU student; Dr. Dan M. Ionel, ECE Professor and L. Stanley Pigman Chair in Power; and Evan S. Jones, PhD student and GAANN Fellow. The authors’ version of the paper manuscript is available on the SPARK Lab website.

PEIK Success Metrics for the Last 3 Years

Undergrad power and energy course enrollments at UK

4,000+

Undergrad PEIK certificate core Global Energy Issues course enrollments

500+

Undergraduate PEIK certificates issued

130+

Graduate PEIK Certificates issued

10+

Continuing education training course, seminar, and workshop events

40+

PDH (Professional Development Hours) credits issued free of charge

450+

E.On endowment, on behalf of Kentucky Utilities, student scholarships for PEIK awarded

75+

PEIK Progress

PEIK promotes, coordinates, and supports power and energy courses and curriculum at UK, including graduate and undergraduate certificates in power and energy. PEIK, which was established in 2010 with a $2.5M DOE grant for energy workforce development, builds upon UK's strengths across multiple engineering disciplines. The Institute has more than 12 affiliated faculty from diverse academic departments with extensive research, education, and industrial expertise. Dr. Dan M. Ionel, Professor and L. Stanley Pigman Chair in Power, currently serves as the Director of PEIK. PEIK educates the next generation of power engineers. PEIK fosters partnerships with industry and utilities, and with other academic and research organizations.

Undergraduate Certificates

In 2021, UK awarded 45 students with the Undergraduate Certificate in Power and Energy. This certificate program consists of a series of foundational courses supplemented by a broad array of elective courses related to power and energy developed to prepare the students for a successful career in industry and the electric utilities. The list of majors for the students who were issued the certificate this year includes Chemical and Materials Engineering, Electrical Engineering, Mechanical Engineering, and Mining Engineering. A total of 130 students have received the Undergraduate Certificate in Power and Energy over the last three years. Dr. Joseph Sottile is the Director of the Undergraduate Certificate in Power and Energy prorgam. For more information on the Undergraduate Certificate visit the PEIK Undergraduate Certificate Webpage.

Scholarships in Power & Energy

The UK College of Engineering has awarded 19 E.ON Scholarships for PEIK to eligible students who demonstrated strong interest in power and energy studies. These annual scholarships that continue to be supported by the endowment established years ago at UK by E.ON, on behalf of Kentucky Utilities, provide recipients between $2,000 and $3,000 annually and may also grant an additional $2,000 for use on a power and energy related study abroad trip during the school year or the following summer.

Louisville Gas and Electric and Kentucky Utilities (LG&E and KU) continue to be strong supporters of UK and PEIK teaching, research, and outreach programs. For more information about Power and Energy scholarships visit the PEIK Scholarship Webpage.

Graduate Certificates

Over the last two years, 2020 and 2021, UK College of Engineering awarded 12 students with graduate certificates in Power and Energy and the online Power Systems graduate certificates. The graduate certificate in Power and Energy provides students with state of the art knowledge in power and energy areas and shows the graduates dedication to this area of study. Graduate certificates are offered to MS students and PhD students. Dr. Yuan Liao is the Director of the Graduate Certificate in Power and Energy program.

For more information about the graduate certificate visit the PEIK Graduate Certificate Webpage.

PEIK Awarded 19 Power and Energy Scholarships

The UK College of Engineering awarded 19 E.ON Scholarships for PEIK to eligible students who demonstrated strong interest in power and energy studies. These annual scholarships continue to be supported by the endowment established years ago at UK by E.ON, on behalf of Kentucky Utilities Company (KU). The scholarships provide recipients between $2,000 and $3,000 annually and may also grant an additional $2,000 for use on a power and energy-related study abroad trip during the school year or the following summer.

KU and Louisville Gas and Electric Company (LG&E and KU) continue to be strong supporters of UK and PEIK teaching, research, and outreach programs. For more information on the Undergraduate Certificate in Power and Energy scholarships, visit the PEIK website [PEIK Undergraduate Certificate Webpage] and [PEIK Scholarship Webpage].

The photo used for illustration was taken during a 2018 on-campus PEIK seminar. Lonnie Bellar, Chief Operating Officer for LG&E and KU, presented during the in-person event, which attracted a very large audience of students and regional professional community.

PEIK Reported Success with Many Undergraduate Certificates Issued

Over the last academic year, 2020-2021, UK awarded 45 students with the Undergraduate Certificate in Power and Energy (PEIK). The program leading to the certificate consists of a series of foundational courses supplemented by a broad array of elective courses related to power and energy developed to prepare the students for a successful career in industry and the electric utilities. The PEIK certificate program has been initiated in 2010 with funding from the Department of Energy (DOE) and continues its growing activity with direct support from UK, industry, utilities, and private donors.

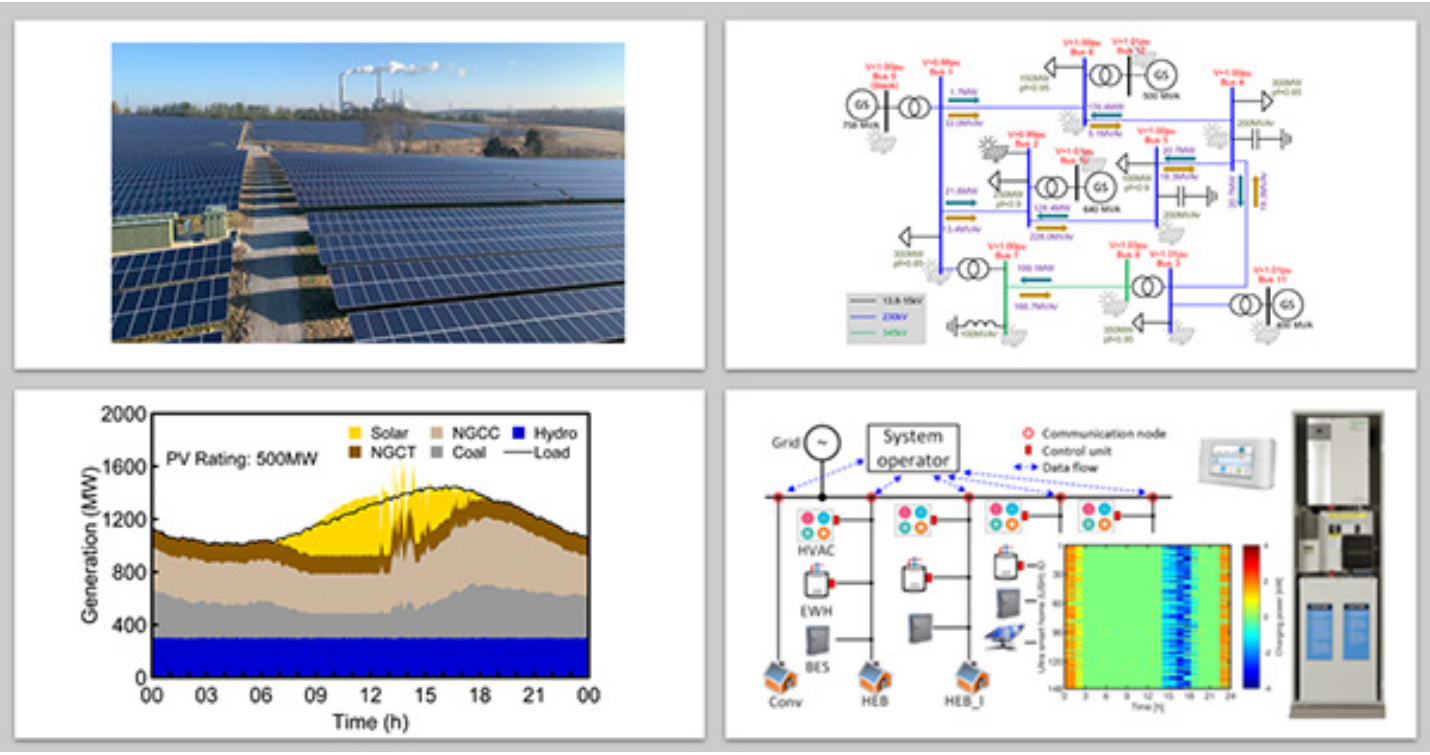
The photo used for illustration was taken at the UK December 2019 Commencement Ceremony before the COVID-19 pandemic. UK has returned to normal operations and is conducting classes mostly in person, with classrooms at full capacity.

The list of majors for the students who were issued the certificate this year includes Electrical and Computer Engineering, Chemical and Materials Engineering, and Mechanical Engineering. Dr. Joseph Sottile, ECE and MNG Professor, serves as the Director of the Undergraduate PEIK certificate.

PEIK Researchers Reported in Journals on Utility Sponsored Successful Projects for Renewable and Distributed Energy Resources Power System Integration

Two papers have been published in January in high-circulation and impact peer-reviewed open access journals: “Study of Renewable Energy Penetration on a Benchmark Generation and Transmission System,” in Energies, Vol. 14, and “Peak Reduction and Long Term Load Forecasting for Large Residential Communities including Smart Homes with Energy Storage”, IEEE Access, Vol. 9. The articles are available for open access from the Energies and IEEE Access websites, respectively. Authors’ manuscript versions are posted on the SPARK Laboratory website.

The success of the research reported and the papers greatly benefited of collaboration and support from large regional utilities Louisville Gas and Electric and Kentucky Utilities, LG&E and KU, and Tennessee Valley Authority, TVA. Authors and co-authors from the SPARK Lab within PEIK include Huangjie Gong, PhD candidate; Dr. Akeyo Seun, recent PhD graduate and now a Senior Engineer with Sargent and Lundy, LLC; Dr. Vandana Rallabandi, former postdoctoral researcher and now Lead Engineer with GE Research; and Dr. Dan M. Ionel, IEEE Fellow, ECE Professor and L. Stanley Pigman Chair, Director of the SPARK Lab and PEIK Institute.



Simone Silvestri, Computer Science and PEIK Faculty, Expanded NSF CAREER Award with REU Supplement

Dr. Simone Silvestri, Computer Science Assistant Professor and PEIK Faculty, has received a Research Experiences for Undergraduates (REU) supplement expanding on the prestigious NSF CAREER Award received in 2020. The award entitled "Energy Management for Smart Residential Environments through Human-in-the-loop Algorithm Design". In this award, Dr. Silvestri addresses the problem of reducing the energy consumption of the residential sector. This sector is responsible for more than 20% of the total energy consumption of the United States, and this amount has been constantly increasing for several decades. Smart residential environments (SREs) are a new paradigm that envisions homes equipped with smart appliances based on the paradigm of the Internet of Things. SREs offer tremendous potential to reduce the energy consumption of the residential sector; however, previous work in this context has largely overlooked the complexity of human behaviors and perceptions when interacting with such systems. In this award, Dr. Silvestri and his team take an innovative approach that merges computer science, electrical engineering, and social sciences to reduce the energy consumption of the residential sector through SREs.

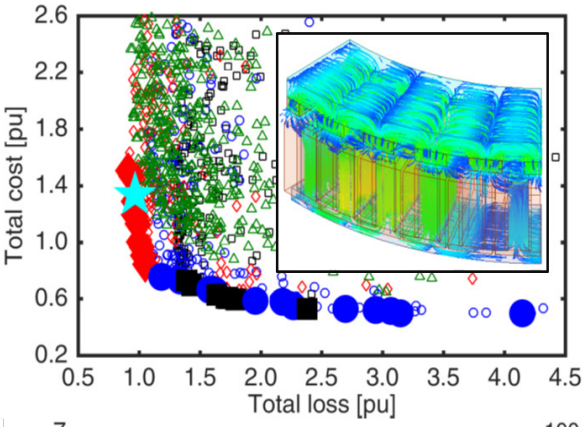
The REU supplement will allow Elanor Sudduth, a CS undergraduate student, to be actively engaged, later this summer and throughout the next academic year, in research alongside PhD students and their faculty advisors.

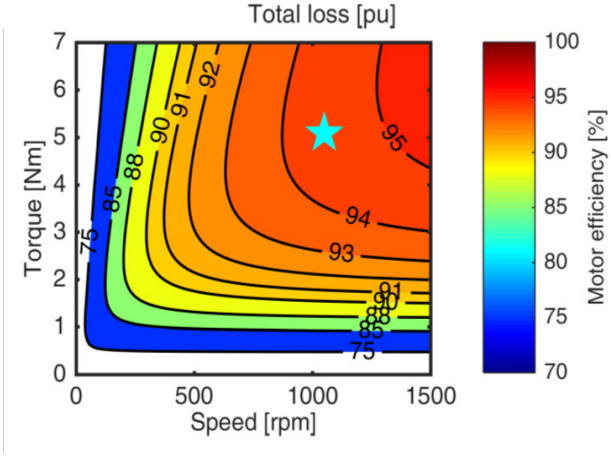
CS and PEIK Undergraduate Student, Jackson Codispoti, Reported on NSF REU Research in Transactions on Cyber-Physical Systems Paper

Jackson Codispoti, a Computer Science Senior and NSF REU student, will have a paper published in an upcoming edition of the Association for Computing Machinery's Transactions on Cyber-Physical Systems. This represents an outstanding achievement for such a junior researcher. PEIK and Computer Science professor, Dr. Simone Silvestri is Jackson's faculty advisor, and co-author to the paper, together with postdoctoral researcher Dr. Atieh R. Khamesi. The publication marks continued success with research supported by the NSF REU supplement that includes an expansion of Dr. Silvestri's NSF Career award received earlier this year.

The paper, "Learning from Non-Experts: An Interactive and Adaptive Learning Approach for Appliance Recognition in Smart Homes", focuses on the problem of appliance recognition from electric signatures collected by a smart outlet. The proposed approach combines stream based active learning and K-nearest-neighbor based classification to simultaneously learn the user engagement and the appliance signatures. Jackson led the design of the machine learning methods as well as the development of an Arduino-based smart outlet to collect the signatures.

SPARK Lab Extended Research on Electric Machines and Drives with Regal Beloit Company





The SPARK Laboratory, which is affiliated with the Power and Energy Institute of Kentucky (PEIK) and operates within the Electrical and Computer Engineering (ECE) Department at the University of Kentucky (UK) College of Engineering, has recently expanded its collaboration with Regal Beloit Corp. through the continuation of a multi-year sponsored research project. Regal, which is headquartered in Beloit, WI, is one of the largest electric motor manufacturers in the world, and a Fortune 1000 company with international operations and over 25,000 employees. The two organizations have very successfully collaborated over the last five years.

At UK, Dr. Dan M. Ionel, ECE Professor and L. Stanley Pigman Chair in Power, Director of the SPARK Lab and of the PEIK Institute, serves as the principal investigator (PI) for the project leading a team of students and postdoctoral researchers on topics of advanced analysis, simulation and optimization of special electric machines and power electronic drives. Example joint publications include: “Evaluating the Effects of Electric and Magnetic Loading on the Performance of Single- and Double-Rotor Axial-Flux PM Machines,” by Narges Taran, Greg Heins, Vandana Rallabandi, Dean Patterson, and Dan M. Ionel in IEEE Transactions on Industry Applications, Vol. 56, No. 4, doi: 10.1109/TIA.2020.2983632, pp. 3488-3497 (2020). This paper describes the design and demonstration of one of the highest efficiency ever reported electric motors for 3/4hp at 1,050rpm typical ratings (see photo). A collection of publications in authors’ manuscript versions is available from the SPARK Lab website.

PEIK Researchers Reported on Projects at IEEE Online Conferences

Power Energy Institute of Kentucky (PIEK) students from the ECE Department in the College or Engineering at University of Kentucky (UK), recent graduates, and researchers participated in this year edition of the International Conference on Electrification of Transportation, ITEC 2021, and presented the papers: Lawhorn, D., Han, P., Lewis, D., Chulaee, Y., and Ionel, D. M., "On the Design of Coreless Permanent Magnet Machines for Electric Aircraft Propulsion"; Gong, H., and Ionel, D. M., "Combined Use of EV Batteries and PV Systems for Improving Building Resilience to Blackouts".

In May, the group took part in the International Conference on Electrical Machines and Drives, IEMDC 2021, with papers and presentations: Kesgin, M. G., Han, P., Lawhorn, D., and Ionel, D. M., "Analysis of Torque Production in Axial-flux Vernier PM Machines of the MAGNUS Type; Zhang, Y., Lawhorn, D. L., Han, P., and Ionel, D. M., "Integrated AC to AC Converters for Single-phase Input to Two-phase Output Motor Drives"; Han, P., Heins, G., Zhang, Y., and Ionel, D.M., "Integrated Modular Motor Drives Based on Multiphase Axial-flux PM Machines with Fractional-slot Concentrated Windings".

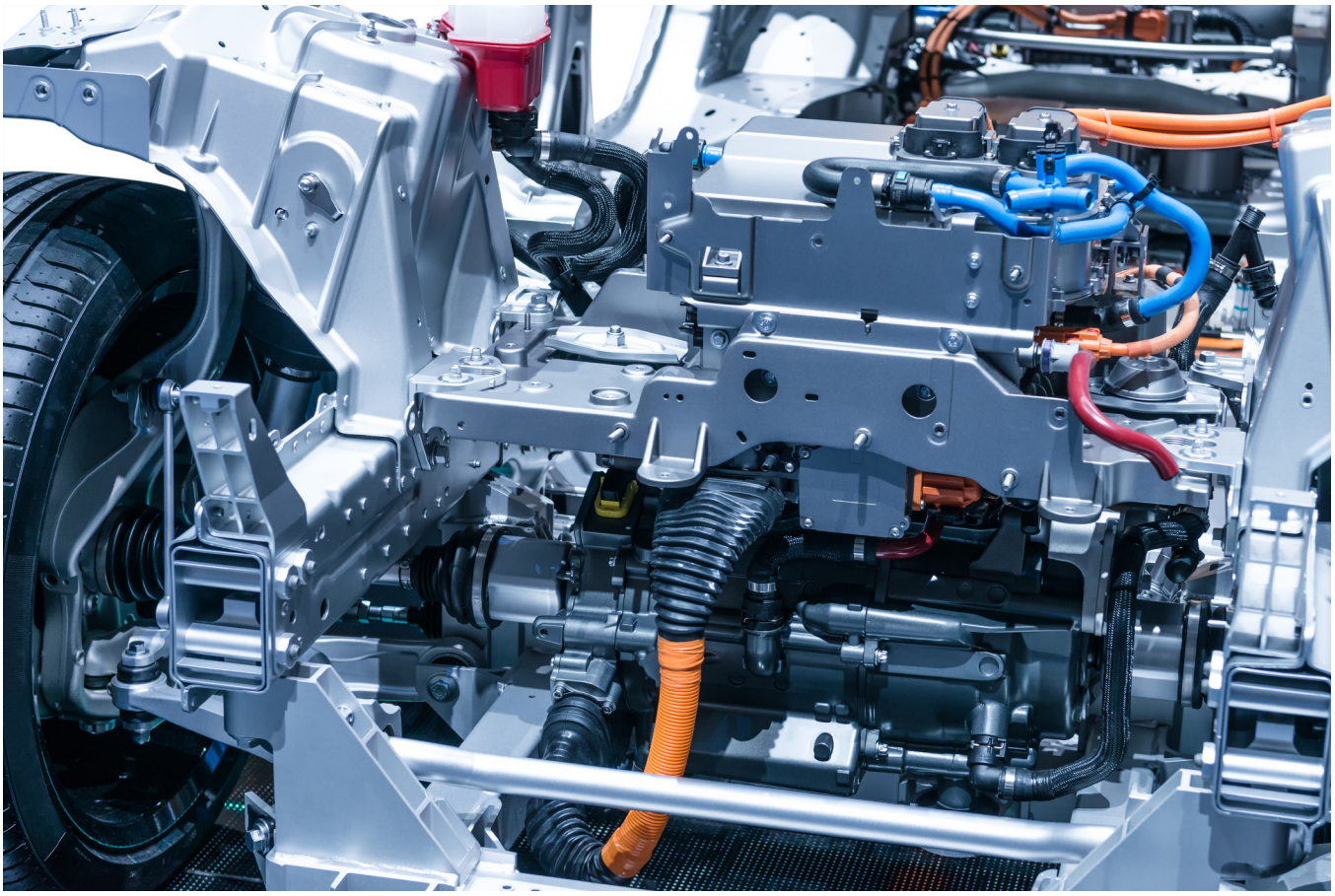
The papers cover main technical findings and the very good progress made on research projects sponsored by the National Science Foundation (NSF), National Aeronautics and Space Administration (NASA), Department of Energy (DOE), and directly by industry. Due to pandemic restrictions, the two large conferences organized by the IEEE took place online. Authors' manuscript versions of the papers are available online from the SPARK Lab website.

PEIK Presented on Research at IEEE PES GM Conference

Power and Energy Institute of Kentucky (PIEK) faculty, recent graduates, and students from the ECE Department in the College or Engineering at University of Kentucky (UK), participated in this year's edition of the IEEE Power and Energy Society (PES) General Meeting (GM), and presented the following papers and posters: Gong, H., Akeyo, O. M., Rooney, T., Branecky, B., and Ionel, D. M., "Aggregated Generic Load Curve for Residential Electric Water Heaters"; Alden, R. E., Ababei, C., and Ionel, D. M., "Artificial Intelligence-based Short-term Electric Load Forecasts for Experimental Smart Homes including HVAC, EWH, and PV Components"; Jones, E. S., and Ionel, D. M., "Co-simulation of Electric Power Distributions and Buildings with EnergyPlus and OpenDSS"; Bankes, G., Akeyo, O. M., and Ionel, D. M., "Large-Scale Solar PV and Battery Energy Storage Model Study on a Proposed Benchmark Transmission System"; Gong, H., Alden, R. E., and Ionel, D. M., "Home Energy Management System for Coordinated PV and HVAC Controls based on AI Forecasting".

The presentations reported on main technical findings and the very good progress made on research projects sponsored by the National Science Foundation (NSF), Department of Energy (DOE), Department of Education (DoEd), and directly by industry, A. O. Smith, and utilities, LG&E and KU, and TVA. The presentations were very well received, and Rosemary E. Alden was awarded a prize for her poster. Authors' versions of the manuscripts are available online from the SPARK Lab publications web page. Due to pandemic restrictions, the very large event, which typically attracts thousands of participants as the flagship conference of IEEE PES, took place online.

SPARK Lab Extended Research on Innovative Electric Machines with QM Power Company



The SPARK Laboratory, which is affiliated with the Power and Energy Institute of Kentucky (PEIK) and operates within the Electrical and Computer Engineering (ECE) Department at the University of Kentucky (UK) College of Engineering, has recently extended its collaboration with QM Power, Inc, a start-up company, the research of which is supported by substantial private investment and by the Department of Energy (DOE). The collaborative project focuses at UK SPARK on advanced large-scale optimization of innovative electric machines based on QMP patented concepts.

SPARK and QM Power have also collaborated for the last two years on another project supported by DOE for the development of an electric machines for electric vehicles with a record high specific power of 50kW per liter. Results from the successful preliminary testing of a laboratory prototype will be published in a joint paper and presented this October at the IEEE Energy Conversion Congress and Exhibition, which is the largest joint technical event of the IEEE Power Electronics and Industry Applications Societies.

Dr. Dan M. Ionel, ECE Professor and L. Stanley Pigman Chair in Power, Director of the SPARK Lab and of the PEIK Institute, will serve at UK as the principal investigator (PI) for the project leading a team of researchers. At QM Power, Drs. Madhav Manjrekar and Somasundaram Essakiappan will serve as the technical project leads, reporting to Mr. Tom Stepien, CEO of QM Power, Inc.

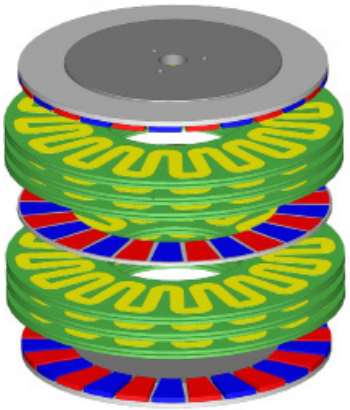
PEIK Researchers Particpated in the Online IEEE ECCE 2021 Congress and Report on Government and Industry Sponsored Research

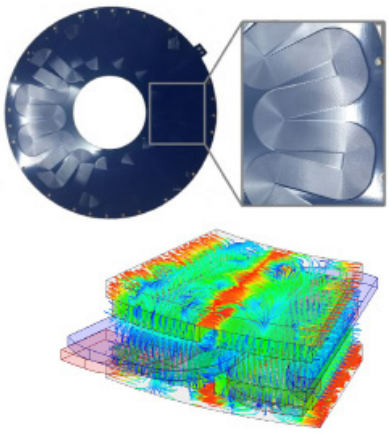
IEEE ENERGY CONVERSION CONGRESS & EXPO
Virtual Conference Oct. 10-14

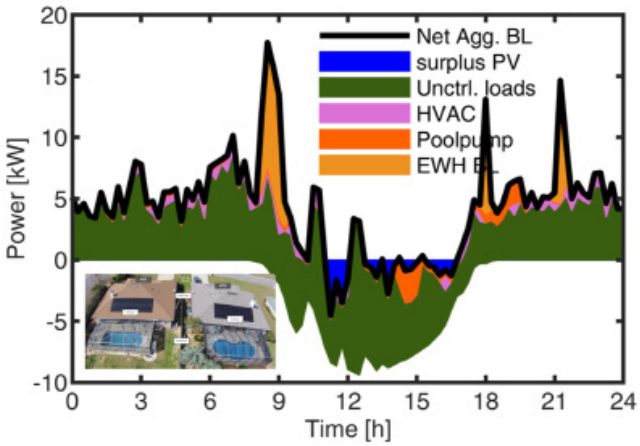
Power and Energy Institute of Kentucky (PEIK) and University of Kentucky (UK) College of Engineering faculty, Drs. Jiangbiao He and Dan M. Ionel, together with PhD students and candidates Yaser Chulaee, Majid Fard, Huangjie Gong, Murat Gurhan Kesgin, Pranoy Roy, and Yibin Zhang, participated in this year's edition of the large IEEE ECCE Congress. The papers presented, which were published in the conference proceedings, also include co-author contributions from other PEIK faculty, Dr. Aaron Cramer, and PhD students Evan Jones, Donovin Lewis, and recent graduate, Dr. Damien Lawhorn.

The research reported covers topics of special electric machines: ultra-high power density and coreless PCB axial flux, bearing currents, energy storage, smart buildings and grids, electric aircraft propulsion drives, and multiport converters for solar-wind hybrid renewable energy systems. Projects have been supported by the National Science Foundation (NSF), U.S. Department of Energy (DOE), U.S. Department of Education, NASA-KY EPSCoR, Ansys, Electric Power Research Institute (EPRI), Regal Beloit Corporation, and QM Power.

Drs. He and Ionel also served as session chairs on topics of transportation electrification, power electronics converters, and smart buildings and energy management systems, and Dr. He was a co-instructor for a 3-hour tutorial on "Hybrid Semiconductor Switches based Power Modules, Converters, and Systems". The Energy Conversion Congress and Exhibition (ECCE) is the largest annual joint event of the IEEE Industry Applications and IEEE Power Electronics Societies, which typically attracts approximately 2,000 attendees. The event was originally scheduled for Vancouver, Canada and was organized on-line due to pandemic conditions.





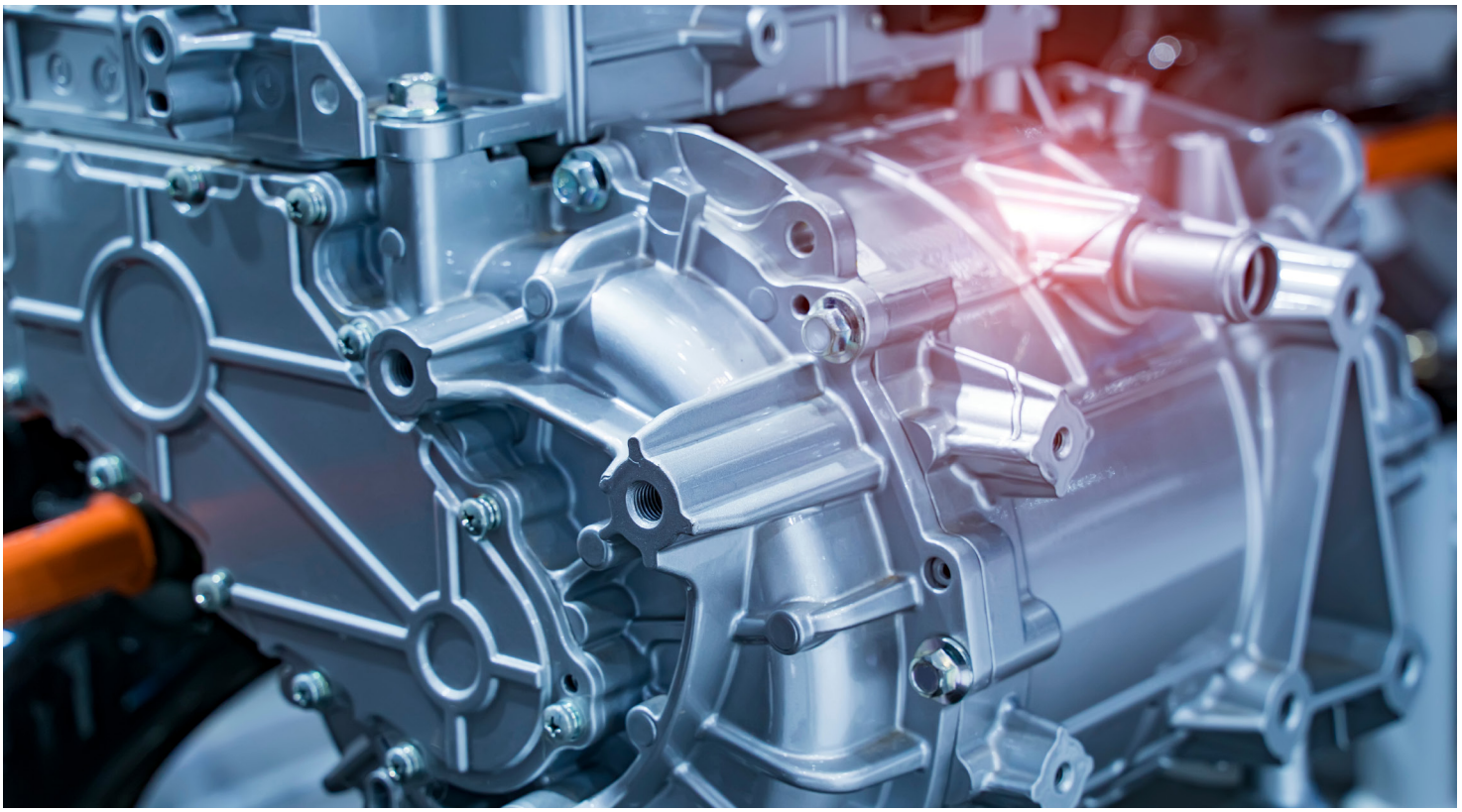


EE and PEIK Faculty JiangBiao He, Awarded New NSF Project to Research Smart Electric Motor-Drive Systems

JiangBiao He, PEIK Faculty and L. Stanley Pigman Faculty Fellow in the Department of Electrical and Computer Engineering, has received a new award from the US National Science Foundation (NSF). The project is titled "Collaborative Research: Smart Coils for AC Motors," and will be a collaboration with Kansas State University. It will be funded in the total amount of nearly $500,000 over three years. In this project, UK serves as the lead organization and He serves as the PI at UK.

Electric motors, generally powered by variable-speed drives, have been broadly used in electric vehicles, airplanes, robotics, industry automations and others. The new generation of fast-switching variable-speed drives induce significant insulation stress on the motor windings due to impedance mismatch and the associated high-frequency surge voltages. This project aims to develop smart coils' technology for AC motors, which adaptively changes the winding surge impedance by manipulating the high-frequency components of the line voltages output from the drives. This collaborative research can significantly impact mobile energy technologies such as electric vehicles, electric aircraft, and robotics, where high reliability and high energy efficiency of electric motor-drive systems is the high priority.

He joined the UK Department of Electrical and Computer Engineering in January 2019 after multiple years of industry R&D experience at GE Global Research and Rockwell Automation. His research interest includes power electronics, motor drives, renewable energy and smart grids.



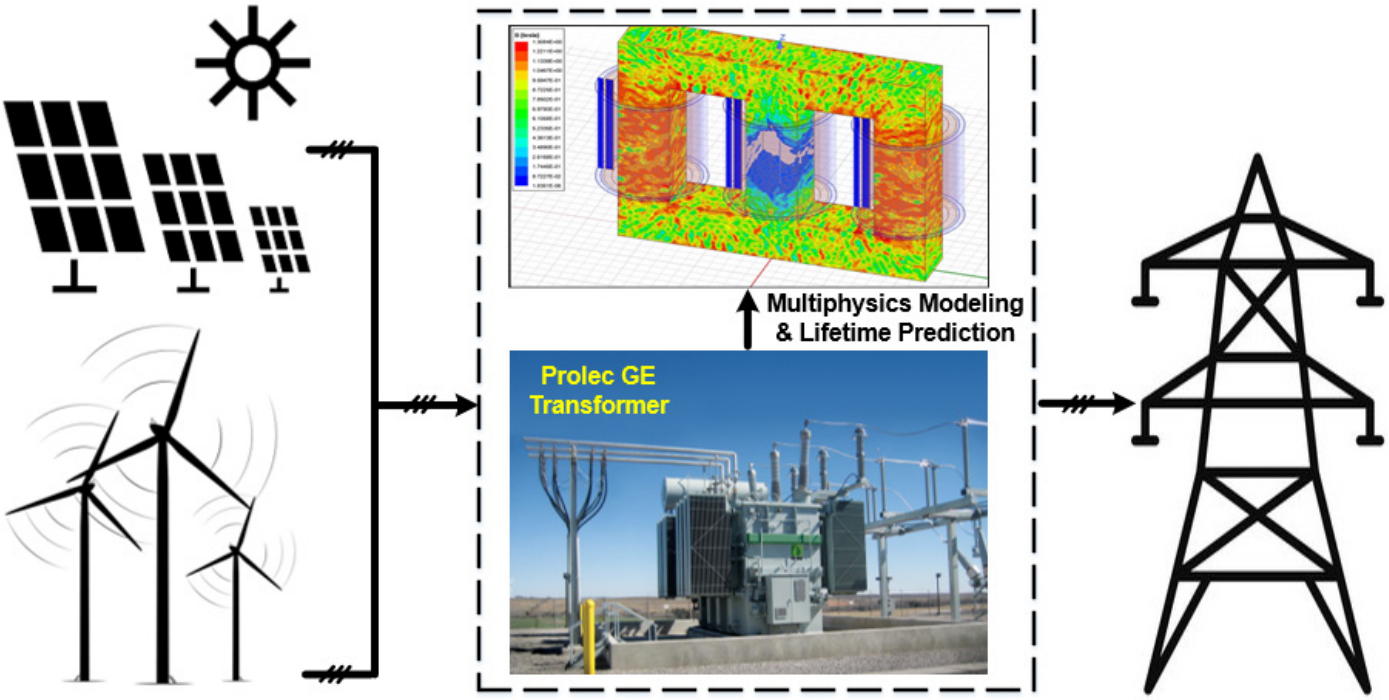
LG&E and KU, UK PEIK Collaborate on Studies for Large Scale Integration of Renewable Energy Generation

Louisville Gas and Electric Company and Kentucky Utilities Company (LG&E and KU) and the Power and Energy Institute of Kentucky (PEIK) at University of Kentucky have extended their collaboration on studies for integrating large solar PV power plants in the electric power systems. The two organizations have worked together in recent years on topics including renewable energy generation, transmission, and storage.

The research has benefited of the data provided by Kentucky's largest solar PV farm and the experimental results from the large electric battery, both of which are located at the EW Brown power plant facility. Joint publications in high-impact technical journals, such as IEEE Access, IEEE Transactions, and Energies include computational studies of PV penetration on benchmark systems, simulations and optimal design for very large grid connected PV systems, and experimental parameter identification for cells, modules, racks, and utility-scale batteries. One of the papers received a Transactions Paper Award from the IEEE Industry Applications Society Renewable Energy Systems Committee. Researchers from the two organizations are currently collaboratively developing new models for the electric power flow analysis and reliability assessment of generation and transmission systems such that increasing levels of renewable energy penetration may be integrated.

Dan M. Ionel, PEIK Director and L. Stanley Pigman Chair in Power, serves the PI project at UK, and Aron Patrick, Manager of Technology Research and Analysis at LG&E and KU, leads the collaborative project from utility perspective. The strategic partnership includes, apart from research, collaboration on academic curriculum, visits to electric power utility sites, and outreach to the professional and regional community with PEIK seminars by LG&E and KU experts and joint displays at large events, such as eDay at UK.

PEIK and EE Faculty Dr. JiangBiao He Awarded DOE Project to Research High-Reliability Large Power Transformers



Dr. JiangBiao He, Assistant Professor and L. Stanley Pigman Faculty Fellow with PEIK and the Department of Electrical and Computer Engineering, has received a new award from the US Department of Energy (DOE) Advanced Research Projects Agency-Energy (ARPA-E). The project, "Ultra-high-Performance nano-Liquid Insulation for upgrading Large Power Transformers (UPLIFT)," led by the industry partner, GE Research, will be funded in the total amount of $1.7 million over two years.

The new project, competitively awarded under the DOE Advanced Research Projects Agency-Energy (ARPA-E) program DE-FOA-0001953, seeks to improve the service lifetime of large power transformers, which are essential elements used in almost all electric power transmission-distribution systems. By collaborating with GE Research and Prolec GE, Dr. He will lead the research on lifetime prediction and multi-physics modeling of the large power transformers.

Dr. He joined University of Kentucky (UK) in 2019 and established a research program in power electronics, electric machines and drives, and electrification of transportations with project sponsors including NSF, DOE, and NASA. While with UK, he received the IEEE IAS Andrew W. Smith Outstanding Young Member Achievement Award in 2019 and the IEEE Myron Zucker Faculty Grant in 2021.

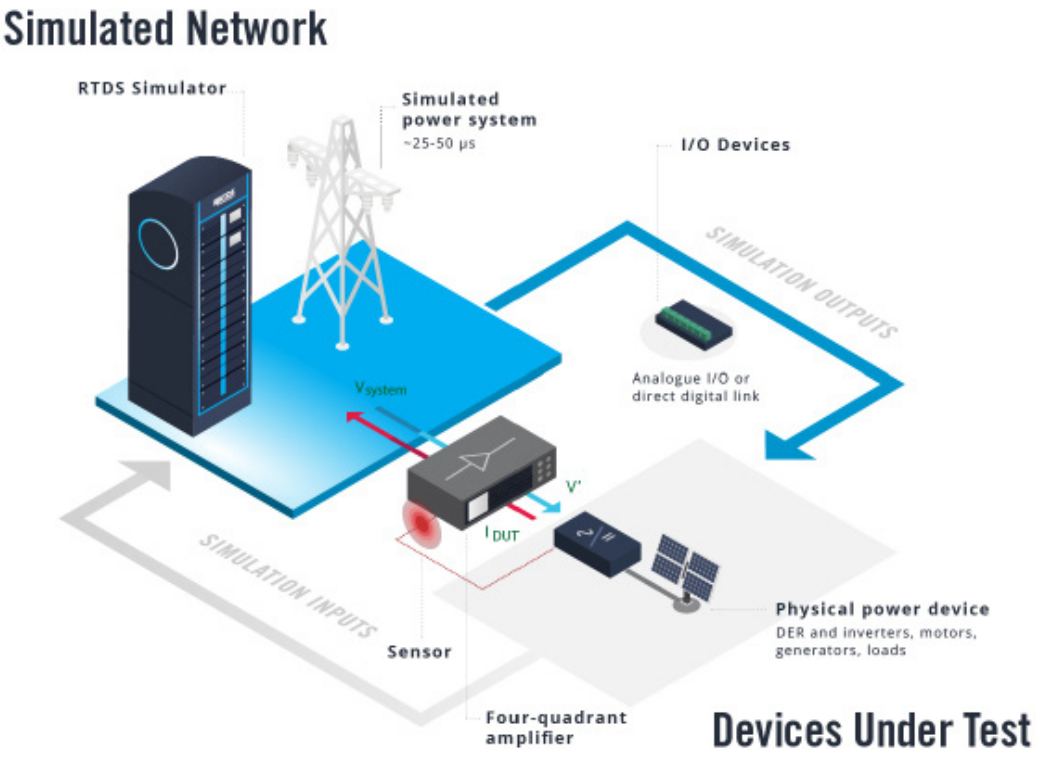
PEIK and EE Faculty Awarded a Department of Defense DURIP Award

PEIK and EE Faculty, Dr. Yuan Liao (featured in the photo) and co-PIs, Drs. Jiangbiao He, Aaron Cramer and Dan M. Ionel, have received a DURIP (Department of Defense University Research Instrumentation Program) award funded through the Office of Naval Research, totaling $876,408.00.

This project will be used to purchase critical research equipment including a real-time digital simulation system - RTDS simulator, Omicron protection testing system CMC 356 and amplifier CMS 356, and a power amplifier EGSTON CSU100.

The project team includes faculty members in PEIK, who have strong interests in research and education critical to the missions of DoD. The purchased equipment will empower investigators to perform research in modeling, simulation, diagnostics, protection and control of power components and systems, which are critical to the mission of the DoD.

The equipment will enhance existing defense-related research and enable investigators to pursue more future defense-related grants and educate more undergraduate and graduate students who have the expertise in power and energy area to meet the need for future defense labor force. The project team also plans to make the equipment available to researchers at other universities and the industry for broader impacts. The new equipment will greatly enhance the research and education infrastructure and capacity at the University of Kentucky, and as a result, the PEIK center will make a steady step toward establishing itself as one of the leading and key contributors to DoD research and education.



LG&E and KU's Aron Patrick Delivered PEIK Distinguished Speaker Online Seminar

On Wednesday, April 7, 2021, Aron Patrick, Manager of Technology Research and Analysis at Louisville Gas and Electric and Kentucky Utilities (LG&E and KU), was a featured presenter for a PEIK Distinguished Speaker online seminar. The presentation, "Kentucky's Clean Energy Successes, Opportunities, and Challenges", discussed Kentucky's success in meeting carbon emissions targets, as well as LG&E and KU's commitment to developing new clean energy technologies to go beyond current reduction goals. Based on available data, Kentucky has demonstrated reduced carbon dioxide emissions below the Obama-era Clean Power Plan targets for the year 2030, a full decade ahead of the proposed schedule. Emission reductions are expected to continue and accelerate into the future.

Mr. Patrick discussed the commitment of LG&E and KU, together with its parent company PPL, to reduce carbon dioxide emissions by 70% by 2040 and by 80% by 2050. Also reviewed were LG&E and KU's renewable energy infrastructure including hydroelectric plants, solar installations, and energy storage capabilities. The company has operated two hydroelectric facilities, Ohio Falls and Dix Dam, since the 1920s. In 2016, LG&E and KU built Kentucky's largest solar farm and installed its largest lithium-ion battery. The presentation covered LG&E and KU's expansion of solar offerings and concluded with a review of strategies for lowering costs and improving solar integration by utilizing the natural environment and incorporating native plants, pollinator habitats, and using sheep for vegetation management.

PEIK Faculty and UK Materials Science Professor Y.T. Cheng Discussed Electric Vehicles on NPR

PEIK faculty and Materials Science professor, Y.T. Cheng, recently appeared on local NPR station, WEKU, to discuss President Biden's electric vehicle goal. The goal, for electric vehicles to be 40 to 50 percent of vehicles purchases by 2030, would be quite an increase from the current number of 2%.

Dr. Cheng discussed several factors that could help increase the use of electric vehicles such as more government infrastructure and the declining cost of battery manufacturing. Finally, Dr. Cheng noted that the environmental impact of electric vehicle adoption will depend on where the electricity for the batteries is being generated.

Eastern Kentucky High School Students Attending the Pigman Scholars Camp at UK Visited with PEIK and SPARK

More than 50 high school students from across Eastern Kentucky had the opportunity to visit UK's campus for the first time during the Pigman Scholars Camp. The program, funded by L. Stanley Pigman and his wife Karen, is a four-day event that brings prospective students to UK's campus for tours, information sessions, and hands-on engineering activities. The Pigman Scholars Camp also encourages students to apply for an L. Stanley Pigman Scholarship if they pursue engineering studies at UK. The need-based scholarships are renewable up to four years and the annual amounts to be given range from $1,000 - $15,000. More details are available on the UK and College of Engineering websites.

In the group photo, taken at the entrance of the newly renovated Grehan building, Mr. and Mrs. Pigman are in the center at the top of the stairs. Their most generous contributions and donations for the power and energy program at UK include a chair endowment, the support for the national champion UK solar car team, advanced equipment for the new SPARKS labs in the Grehan building, support and mentorship of many students over the years. At the center on the ground row, from left to right, are three Pigman scholars and SPARK Lab students advised by Dr. Dan M. Ionel, L. Stanley Pigman Chair in Power and PEIK Director: Rosemary Alden, now an incoming PhD student and NSF GR Fellow, Evan Jones, a PhD student and DoEd GAANN Fellow, and Hope Anderson, a NASA REU undergraduate student. The three of them guided tours of the labs, meet with the young visitors, discussed, and shared from their own successful experience at UK.

More information can be found at the UK College of Engineering and UK websites.

PEIK Faculty and Chemical Engineering Professor, Jeffrey Seay, Developed Clean Cooking Fuel Device

Jeffrey Seay, PEIK Faculty and Chemical Engineering Professor at the University of Kentucky College of Engineering Extended Campus at Paducah (UK Paducah), has collaborated with partners in numerous countries, including Ethiopia, Senegal, Uganda and India, on research that has resulted in a device capable of converting waste plastic into clean fuel oil.

The Trash-to-Tank (3T) Processor is an open-source creation produced by Dr. Seay's nonprofit organization, Engineers for Sustainable Energy Solutions (ESES). The plastic-derived fuel oil (PDFO) yielded by the 3T Processor is clean, safe and easy to transport. ESES is working with Upcycle Africa Limited in Mpigi, Uganda, to train residents how to assemble and use the 3T Processor. In addition to being used as a cooking fuel, the 3T Processor can also produce diesel fuel for household or farm equipment.

While ESES is an independent nonprofit organization, numerous past and present UK students are involved in its mission. UK Paducah undergraduate researchers play a big role in enhancing the processor's performance. This technology, developed at the UK Paducah campus, will impact people around the world.

UK Entered Agreement with KU to Purchase Solar Power

UK Photo | Mark Cornelison | UK News | Shane Tedder and Meg Mills

The University of Kentucky (UK) has entered into an agreement with its electricity provider, Kentucky Utilities Company (KU), to purchase 44% of the output of a new 125-megawatt (MW) solar facility. KU and its sister utility, Louisville Gas and Electric Company (LG&E and KU), have now filed the contracts for the project with the Kentucky Public Service Commission. The facility is planned for McCracken County, near Paducah, and is expected to be online in 2025. Once operational, this solar facility will provide approximately one-third of the electricity consumed by the campus. Purchasing power from renewable sources also diversifies the mix of fuels the university relies on for electricity and this boosts the resilience of campus utility systems.

Integrating the operations of the campus with the academic experience of students and faculty is a high priority at UK. Utilization of the campus and campus operations as a classroom and lab is recognized nationally as a high-impact practice that enhances student success. This initiative is a strong example of this commitment. More details are available from the UKnow news and from the UK sustainability goals and initiatives webpage.

At UK, PEIK has an ongoing close collaboration with LG&E and KU on multi-year research projects for the integration of large solar PV in electric power systems. Joint studies were published in technical conference proceedings and journals on topics of renewable energy penetration, solar PV farms, and multi-MW battery operation for energy storage, including an IEEE award winning paper. The UK students, who pursue the PEIK certificate in power and energy, one of the largest of its kind in the UK College of Engineering, continue to benefit of scholarships established through the E.On endowment set up on behalf of Kentucky Utilities. Collaboration also includes teachings activities, classes with field visits, lectures and seminars by LG&E and KU experts, as well as joint participation in high impact outreach events. More details on the collaboration are available, for example, in this year's news featured on this PEIK website and in last year's annual report, which is available online.

L. Stanley Pigman Long-time Supporter and Advisor of PEIK Inducted in the UK Hall of Distinguished Alumni

L. Stanley Pigman, an entrepreneur from Wilmington, NC, and a longtime strong supporter and advisor of the Power and Energy Institute of Kentucky (PEIK), has been inducted into the University of Kentucky (UK) Hall of Distinguished Alumni. Mr. Pigman was a first-generation college student who studied at UK on an engineering scholarship and graduated in 1981 with a BS in Mining Engineering. He began his early professional career as a project engineer with a new mining company, Sierra Coal, a subsidiary of General Electric. Later in 1992, he joined two colleagues to form Sugar Camp Coal. Eventually, Mr. Pigman formed his own company, Pigman Coal Sales, providing sales services to an independently owned start-up company for a new mining project in western Kentucky. He built several more businesses that own and lease coal properties, then relocated his company headquarters to High Point, NC.

At UK, his generous support included the establishment of the endowment for the L. Stanley Pigman Chair in Power and for the L. Stanley Pigman Junior Faculty Fellow, sponsorship for the UK Solar Car, and donations for laboratory and SPARK group developments. Mr. Pigman and his wife, Karen, promote engineering and technology to high school students by supporting programs such as Project Lead the Way and, recently, by committing funding for 16 new high school chapters of the Kentucky Technology Student Association. The Pigman Scholars program at UK now provides scholarships for 70 undergraduate engineering students annually. The students who graduated with BS moved on to good careers in industry and utilities or some continued for PhD studies at UK, including those who were awarded prestigious fellowships from the National Science Foundation (NSF), the Department of Education (DoEd), and the National Aeronautics and Space Administration (NASA).

Mr. Pigman Pigman sits on the UK College of Engineering Dean's Advisory Council, the Mining Engineering Foundation, the President's Capital Campaign Committee and the UK College of Engineering Capital Campaign Committee. He was inducted in the UK College of Engineering Hall of Distinction in 2009 and was awarded a UK Honorary Degree of Humane Letters in 2017. The new induction in the UK Hall of Distinguished Alumni recognizes Mr. Pigman's significant contributions to the field of power and energy and for supporting various programs that provide better access to education in engineering.

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www.engr.edu/power

www.linkedin.com/company/power-and-energy-institute-of-kentucky

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