Conn Center for
Renewable Energy Research
University of Louisville

IMPACT REPORT

2010 – 2020

UofL CONN CENTER FOR RENEWABLE ENERGY RESEARCH

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LOCAL INNOVATION, GLOBAL IMPACT

ABOUT CONN CENTER

The Conn Center for Renewable Energy Research conducts and facilitates R&D on potentially commercializable renewable energy and energy efficiency technologies.

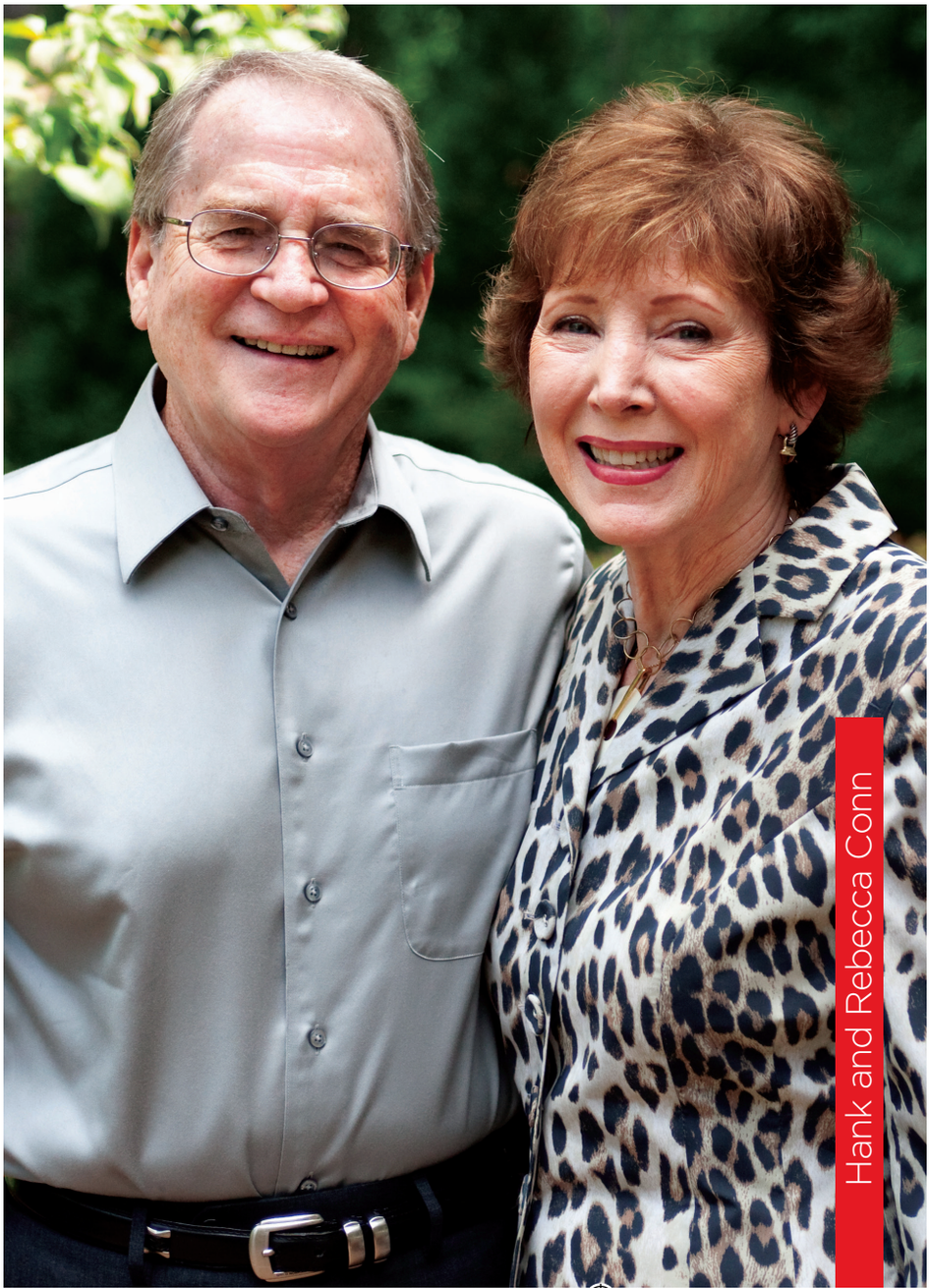
Drawing on strengths of academic discipline and commercial pragmatism, the center has earned a reputation for fostering the development of transformational science and accelerating the translation of technology concepts from the lab to pre-commercial scale.

Conn Center employs top-notch scientists and engineers as theme leaders for directing these research thrusts and to enable collaborations with faculty researchers and industry partners worldwide.

The University of Louisville established the Conn Center at the J.B. Speed School of Engineering in 2009 in honor of major donors Hank and Rebecca Conn.

Since 2009, Conn Center's research has advanced basic scientific knowledge, informed applied engineering know-how, and supported Kentucky's diversifying advanced manufacturing economy. The center provides analytical capabilities to materials and chemicals sector industries, research educational opportunities to PhD, masters, and bachelors students as well as outreach to middle and high school groups.

Through innovative R&D at an accelerated pace and development of Kentucky's workforce and renewable resources, the Center's ongoing goal is to seek outcomes that enhance global energy security, maintain US technological leadership, and improve high-tech manufacturing activity in Kentucky.



Hank and Rebecca Conn

FROM THE DIRECTOR

There is a growing demand to transform the Commonwealth's economy into a stable marketplace that can provide our citizens with high-paying jobs by expanding technology-oriented manufacturing. Since 1990, Kentucky has lost over 100,000 manufacturing jobs. Now is the time for us to attract technology industry segments that can yield the highest growth in capacity, quality, and global reach. Manufacturing of renewables and energy efficient technologies constitute vital markets that are poised for massive growth in the next five decades. However, such transformation of the region's economy cannot occur without local innovation, viable market, and committed investments. With Kentucky's unique blend of manufacturing and agricultural capabilities, we still have great potential and can sustain industries for many renewable energy and energy efficiency technologies.

The University of Louisville, the state, and the community made the choice to invest in the development of Conn Center for Renewable Energy Research. Hank and Rebecca Conn, as champions of energy, economy, and environmental stewardship, generously set the tone for the importance of this endeavor. The work performed at Conn Center is truly defining the future on a global scale. As we continue to develop our facilities, attract and train great minds, and create collaborations with industry partners, we are influencing how energy is captured, stored, and utilized for maximum benefit. Our country's energy challenges are well known. Our goal is to develop and promote renewable energy solutions that increase our society's ability to function with available resources without poisoning our world. It is essential to our way of life, and to our children's children's way of life, that we succeed.

To do this, we need to keep growing. Additional recruitment and retention of outstanding faculty members, research scientists and engineers, and students as well as continued commitments at the community, state, and federal levels will ensure that the Conn Center becomes a preeminent center for renewable energy research. Most importantly, we will continue to work to move ideas from the lab to the marketplace seamlessly and share our discoveries with the world.

"Conn Center provides critical research, collaboration, and education for the development of advanced manufacturing in Kentucky."

Mahendra K. Sunkara, PhD
Director, Conn Center for Renewable Energy Research
Professor, Chemical Engineering
Distinguished University Scholar

CENTER WEBSITE
www.conncenter.org

MORE RESEARCH NEWS
www.uoflenergymaterials.org

LEIGH ANN CONN PRIZE FOR RENEWABLE ENERGY
www.leighannconnprize.org

CONN CENTER SENIOR LEADERSHIP

Mahendra Sunkara // PhD, Director
Andrew Marsh // MFA, Assistant Director, Program Officer, Leigh Ann Conn Prize for Renewable Energy
Eunice Salazar // MBA, Unit Business Manager
Gamini Sumanasekera // PhD, Energy Storage Theme Leader
Jacek Jasinski // PhD, Materials Characterization Theme Leader
Thad Druffel // PhD, PE, Solar Manufacturing Theme Leader, Endowed Chair in Renewable Energy Research
Jagannadh Satyavolu // PhD, Biofuels Theme Leader, Endowed Chair in Renewable Energy Research
Joshua Spurgeon // PhD, Solar Fuels Theme Leader
William Hank Paxton // PhD, Research Engineer
Arjun Thapa // PhD, Research Scientist, Energy Storage R&D Manager
Madhu Menon // PhD, Computational Scientist

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CENTER'S RESEARCH IMPACT DURING OUR EVOLUTION TO VIABILITY

BEGINNING

Materials and energy research at University of Louisville grew from humble beginnings. Prior to the announcement of Conn Center, there was a small, concerted effort to establish core facilities to advance materials research. The objective was to support budding enthusiasm for developing and applying targeted, highly functional nanomaterials in renewable energy devices.

In 2008, a pivotal meeting occurred between UofL J.B. Speed School of Engineering and Business School alumnus Mr. Hank Conn, Kentucky's Cabinet Secretary for Energy Dr. Len Peters, UofL President Dr. James Ramsey, and Speed School Dean Dr. Mickey Wilhelm. In Frankfort, House Bill 2 followed, which resolved to establish a renewable energy research center in the Commonwealth of Kentucky.

In 2009, Mr. Hank Conn, Governor Steve Beshear, Secretary Len Peters, and President James Ramsey made an announcement of the establishment of a renewable energy research center at University of Louisville. That announcement brought a sense of purpose for researchers and put a clear vision toward renewable energy economy and energy future for the region. It was also announced that the center would be led by chemical engineering professor – Dr. Mahendra Sunkara – founding director for the UofL Institute for Advanced Energy Materials – Renewable Energy (IAM-RE), an accomplished researcher with Department of Energy (DOE) and National Science Foundation (NSF) funding in renewable energy topics.

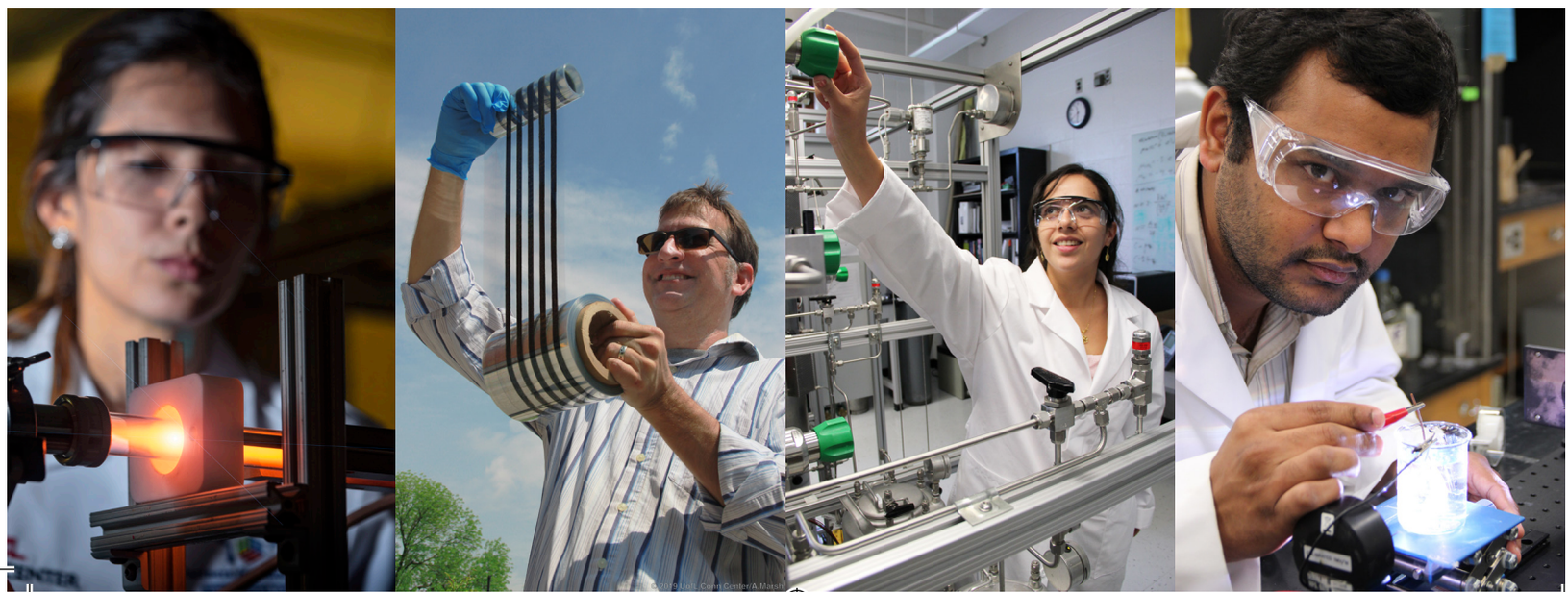
At the time, there were very few energy research centers focused on renewables established within academic settings. As a result, there was little precedence on how such centers should be structured to yield good results.

MODEL

A university research center can be as small as a single faculty laboratory with one staff member to a center employing hundreds of researchers and faculty. Many academic research centers are virtual, functioning to coordinate programming and technical support services while encouraging faculty to work on a common research goal. Success with a virtual model depends heavily on existing and well-established faculty in energy research.

Prior to 2009, UofL had very few faculty with energy research funding from the DOE or NSF and little impact on both basic and applied energy research. It became apparent that the center needed to expand the existing materials research facilities and establish new core facilities focused specifically on energy research. Most importantly, the center would take ownership of accomplishing progress with renewable energy research and bring faculty and industry together to accelerate such progress.

After investigating several research center/institutes, a model was established upon a shared vision and mission, a detailed technical agenda, and the objective to hire research theme leaders to rapidly advance the research agenda. Mentoring and focused hiring of new faculty across engineering and sciences departments was planned to strengthen each of the research themes. A top-notch technical advisory board was assembled to guide these efforts, comprised of top executives from GE Appliances, Brown Forman, Clariant, LG&E, commonwealth Cabinet Secretaries for Energy and Economic Development, academic deans of engineering and sciences, and Mr. Hank Conn.



VISION & STRATEGY

The technical advisory board established a set of technical themes – solar, energy storage, biomass/biofuels and energy efficiency – consistent with federal funding priorities and regional industry interests. The board embraced a vision to create a nationally recognized center of excellence on renewable energy research with scientific relevance and societal impact. As part of the center's strategic plan, objectives and targets were incorporated to advance research in all chosen directions.

PHASE ZERO: 2010-2015 PULLING TOGETHER

With a model, advisory board and director, vision and mission for the center, work began to create the business and administrative structure and hiring of theme leaders despite limited baseline resources. Irrespective of the changing circumstances in the university's upper administration, the center continued to make progress with temporary and partial hiring of theme leaders. Projects were developed with clear agendas for longer timelines, faculty and students were engaged, and some external funds were attracted for the chosen agenda.

Specifically, Conn Center absorbed the IAM-RE core materials effort, including energy materials research by Sunkara and A&S Physics professor Dr. Gamini Sumanasekera, and acted to establish significant energy research and administrative personnel. Dr. Jacek Jasinski and Ms. Rodica McCoy were instrumental in enabling advanced materials characterization as the first core facility for Conn Center. Dr. Paul Ratnasamy, retired director of the National Chemical Laboratory in India, was hired as a distinguished researcher for a 3-year term to kick start biofuels research and commercialization. Mr. Andrew Marsh, an accomplished artist, writer/editor, and administrator, was hired as Assistant Director in 2010. Dr. Thad Druffel also came in 2010 to establish research efforts on flexible solar cells and a core facility supporting roll-to-roll manufacturing.

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Established multi-disciplinary basic and applied research in 15 specialized laboratories with 7 PhD theme leaders

In 2012, Dr. Jagannadh Satyavolu, a food systems industry veteran, was hired to investigate biomass and industrial waste streams in Louisville and Kentucky and establish pilot scale facilities for biomass and biofuels. In 2013, Ms. Eunice Salazar was hired into the Unit Business Manager track to orchestrate financial accountancy. Dr. Robert Hickman, an entrepreneur and semiconductor device engineer, served a 3-year term to start up power electronics research. To support across themes, Dr. Hank Paxton was hired as a Research Engineer. Dr. Joshua Spurgeon was recruited in 2014 to broaden and strengthen efforts on solar fuels. With the continued help of Dr. Sumanasekera, Dr. Arjun Thapa was hired to help expand core facilities on electrode coatings, pouch cell fabrication and testing for Li-ion and related batteries as part of the energy storage theme. Dr. Madhu Menon, a computational materials scientist, was hired to accelerate progress with discovery and development of new materials for energy applications. Finally, Dr. W. Mark McGinley, endowed professor of infrastructure research in civil engineering and faculty co-director of the 2013 and 2020 solar decathlon teams, currently serves as theme leader for Energy Efficiency.

During this period, the center also mentored, recruited, and provided resources for several young faculty – Dr. Moises Carreon (ChemE), Dr. Delaina Amos (ChemE), Dr. Gerold Willing (ChemE), Dr. Heather Rypkema (A&S Chem), Dr. Eric Berson (ChemE), and Dr. Sam Park (MechE).

PHASE ONE: 2015-2020 GATHERING MOMENTUM

In 2014, Speed School Dean Neville Pinto secured baseline funding of $1M per year to support Conn Center. During next five years, Conn Center led targeted hiring of seven junior faculty members, including Dr. Farshid Ramezanipour (A&S Chem), Dr. Jinjun Liu (A&S Chem), Dr. Noppadon Sathisuksanoah (ChemE), Dr. Hui Wang (MechE), Dr. Gautam Gupta (ChemE), Dr. Michael McIntyre (ECE), and Dr. Badri Narayanan (MechE). In addition to hiring of junior faculty, the center also engaged senior faculty on campus, including Dr. Mark McGinley (Civil), Drs. Craig Grapperhaus, Robert Buchanan, and Frank Zamborini (A&S Chem), Drs. Bruce Alphenaar and Shamus McNamara (ECE), and Dr. Glen Prater (MechE).

During this period, the theme leaders put together and expanded necessary core facilities, well-defined research challenges, and small group teams for research projects and proposals. They developed IP and led entrepreneurial activities by founding startups to advance translational R&D and commercialization. As a result, interest in Conn Center's research


Gamini Sumanasekera


Jacek Jasinski


Rodica McCoy


Paul Ratnasamy


Andrew Marsh


Thad Druffel


Jagannadh Satyavolu

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agenda has grown considerably. Many large-scale industries and investors have started interacting with the startups on the technologies originated at Conn Center. By the end of 2020, the center had the largest number of externally funded research grants by small groups from US Department of Energy and National Science Foundation. There has been considerable research progress in all chosen themes, described below.

ADVANCED ENERGY MATERIALS

Focus has been placed on developing various scalable processes for making nanowires, large single crystals and films of III-V materials, and materials with compositions that are not easily accessible for existing techniques. These materials form the essential building blocks for designing new catalysts, visible solar absorbers, lithium ion and related battery technologies, and power electronics. Innovative use of plasma excitation of gas phase has been the key contribution from this theme toward materials processing.

Engaged over 50 PhD faculty across 5 engineering and 4 scientific disciplines

This basic technology concept has been used to create a startup, Advanced Energy Materials, LLC, through appropriate licensing. The company has accelerated the scale-up of materials processing and their use in creating unique catalyst and adsorbent products. Success with scale-up of plasma-based processing schemes is a unique achievement and allows development of plasma catalytic approaches for conversion of methane, carbon dioxide, water, and air into carbon neutral fuels and chemicals. Significant progress can be expected in the next five years with distributed chemical processing, electrifying the chemical processing industry, and sustainable production of platform chemicals.

In this theme, a significant discovery was made of dilute anion alloyed III-nitride materials as visible light absorbers. These could be used both for solar photovoltaics and photoelectrochemical cells. In the next five years, this theme will focus on making rapid advances necessary for making a global impact in this area.

It is imperative that we accelerate discovery of new materials and processes to make progress in realistic time frames with next generation energy technologies. This theme emphasizes developing high throughput synthesis, dynamic characterization methods, and machine learning/modeling techniques to understand genomic aspects of materials and processes.

SOLAR MANUFACTURING R&D

The center's vision for solar energy conversion started with idea of making durable dye-sensitized solar cells and scale-up manufacturing of solar cells on flexible platforms using traditional and modern printing techniques. The capital expenditure necessary for putting up even a gigawatt solar factory is substantial, so the focus was placed on lowering the prohibitively high cost of cell production. Coming up with ways to manufacture solar cells in a distributed and scalable fashion provides a route for meeting the terawatt challenge.

Initially, efforts were focused on making dye-sensitized solar cells durable with efficiencies greater than 10%. This was accomplished using a glass platform. Significant progress was also made toward translating onto a flexible plastic platform. However, due to complexities involved with liquid electrolytes, proper sealing techniques, and expensive dye molecules, development of this technology beyond lab scale was shelved.

A breakthrough came from the realization that all existing solar panels use silver for their conductive strips. To decrease precious silver use as broad deployment of solar cells increases worldwide, copper as a cheaper option was proposed. However, there are several challenges with copper. It readily migrates into silicon or other solar materials, which reduces the effectiveness of cell.

As part of this theme, a copper ink was developed to create the conductive strips, one that not only prevents migration of copper but also is durable with exposure to air, temperature, and moisture. This technological innovation is the basis for a startup called Bert Thin Films, LLC. This startup generated resources through private investors, federal

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funding agencies, and state funding agencies and accelerated the development and demonstration of this technology, which is ready for commercial deployment.

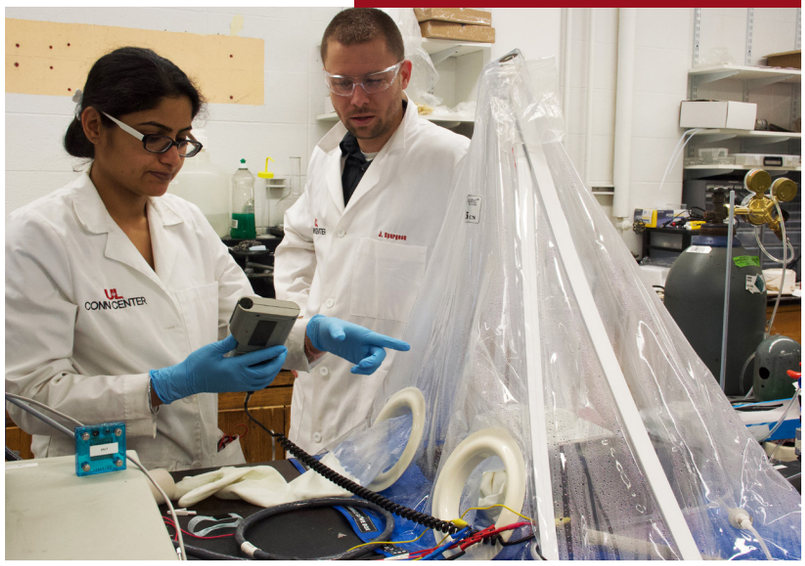
The vision for roll-to-roll and flexible cell manufacturing at Conn Center found its greatest ally with the development of perovskite solar cell technology. Although there were rapid advancements in small-scale solar cells made using these materials with all solid-state layers (without any liquid electrolytes), there are still many challenges with this technology. Perovskite materials tend to be moisture sensitive both during manufacturing and once in use. Several significant thematic breakthroughs were made, resulting in special sintering procedures and introduction of passivation layers to make perovskite solar cells with efficiencies greater than 18%. In fact, these cells have been made under normal atmospheric conditions using roll-to-roll coating techniques. The Solar Manufacturing R&D theme is making rapid progress with this technology toward commercial implementation.

Over 250 center publications at 5.498 average impact factor with 12,000 citations

Finally, this theme will focus its efforts toward integration of III-V materials into solar cell structures and develop unique roll-to-roll manufacturing. It is essential that progress is made to deploy inexpensive manufacturing techniques for making large solar panels, either through distributed production or in large factories, to address the terawatt challenge.

SOLAR FUELS

Solar energy can be used to create fuels and chemicals through two main routes. The first is to generate electricity and then use that electricity to make fuels. The second route is to convert solar energy directly to enable chemical conversions. In the first route, two approaches were implemented: plasma catalysis and/or electro-catalysis.



In terms of plasma catalytic approaches, there has been significant progress with processing methane to carbon and hydrogen in which the catalyst can be separated from the resulting carbon. Similar approaches are being implemented for sequestration of carbon dioxide by dissociating it into carbon and oxygen and/or converting it into polymerizable extended solids. Similar approaches are also being developed for upgrading methane to acetylene and ethylene while making hydrogen.

In the case of electro-catalysis, the thematic discovery was made of several new electrocatalysts to replace expensive precious metal-based materials. Their use was demonstrated with hydrogen evolution reaction, oxygen evolution reaction, and CO_2 conversion to formic acid and higher order compounds. Large-scale demonstrations with electrolyzers are being planned. In the next five years, the center expects to demonstrate these electrocatalytic processes using large-scale electrolyzers and translate this effort commercially through a startup.

Direct use of sunlight to produce chemicals and fuels can be highly cost effective, easy to use, and scaled up for addressing clean energy production and use. However, the challenges are so great that there has been slow progress toward economical commercial implementation of these materials and processes. Exploration continues in this direction with both new materials and device designs.

The center demonstrated a process for producing hydrogen from atmosphere by electrolysis of moisture using a cleverly designed electrochemical cell. This process enables production of hydrogen in a distributed fashion and its use to produce clean water simultaneously with electricity. This technology is ready for commercial implementation.

Although hydrogen production from water and natural gas presents a potential pathway for decarbonization, it still needs to be stored and transported. Natural gas presents the challenge of economic pyrolysis into useful carbon products and carbon-free hydrogen. One potential pathway is to produce hydrogen in the form of ammonia using air and water. This is something of great importance for enabling a carbon-free energy carrier infrastructure.

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BIOMASS AND BIOFUELS

Biomass conversion to fuels and chemicals also represents another pathway for decarbonization, energy independence, and sustainability. Currently, most chemicals and fuels are derived from fossil fuel sources. In addition, biomass and waste streams from industrial and agricultural sources offer a great potential for producing many platform chemicals and fuels. In the city of Louisville and the state of Kentucky there are several potentially high-value biomass streams of interest, including spent distiller's grain, soy hulls, industrial hemp, and kenaf.

The center looked at industrial waste streams and developed a robust anaerobic digestion process that could be implemented onsite at UofL for producing biogas toward electricity production. A 4 MW biogas-to-electricity production facility using industrial waste streams has been proposed, which is still being considered.

In collaboration with Brown Forman, center scientists analyzed spent distiller's grain as a resource for chemicals, developing a unique process for hydrolyzing hemi-cellulose and extracting hydrolysate containing about 6-10% xylose-based sugars. The main challenge is how to purify xylose without evaporating water. A thematic discovery yielded a cyclable compound to selectively extract xylose with highest purity from dirty and low concentration hydrolyzate streams. Upon this innovation was created a startup, Bioproducts, LLC, which further scaled up the process and is now working with potential customers for setting up plants. This technology of extracting xylose as a by-product enables many other economical biomass conversion strategies.

In conjunction with a South Carolina-based pilot operation, Integro Earth Fuels, the center developed a briquetting technology for converting biomass into bioCoal, which can be used for heat and power applications and replaces normal coal with many beneficial impacts. This technology uses simple modifications to the briquetting process to produce bioCoal with high hydrophobicity, density, and energy content similar to mined coal without any impurities. Conn Center established pilot briquetting facilities and supplied significant quantities for field-scale trials.

Next generation biomass conversion strategies include natural fibers for light weight automotive composites and construction materials as well as replacing fossil fuel-derived polymers and platform chemicals.

Attracted over $45 MILLION in research revenue

ENERGY STORAGE

Scalable storage is important for electrification of transportation and integration of renewables for personal, residential, and grid applications. Initial efforts focused on developing core competencies in lithium-ion and related battery technologies, including improvements in low cost and high energy density electrode materials for lithium-ion batteries. Using expertise in nanowire-based materials, the center developed several non-carbon-based anode material chemistries, such as tin/tin oxide nanowires, into durable and high energy density anodes. Following this, durability and high capacity with silicon and lithium molybdate nanowires have been demonstrated. In terms of cathode materials, increased durability and high capacity were demonstrated using titania coatings for sulfur and a full cell comprised of lithium molybdate and a sulfur cathode.

In the case of Ni-Mn-Co-oxide materials, center researchers developed a plasma process for creating complex oxides in a dry manufacturing environment. The resulting nanowire and complex oxide patents have been licensed to Advanced Energy Materials, LLC. ADEM developed the technique further and extended it for scalable manufacturing. Using scaled up processes for making titania nanowires, they developed a stable lithium titanate nanowire (LTO) anode technology. These battery material technologies have been demonstrated at scale using pouch cell fabrication and testing and are ready for commercial implementation. The energy density can be improved using metallic lithium anodes. Their safety can be improved with the development of high lithium-conducting solid-state electrolytes. In addition, the manufacturing of solid-state electrolyte materials and their integration into battery cell fabrication are important for meeting the storage on demand at scale challenge.

In terms of large-scale storage, the thematic interest lies in the development of low cost, scalable, and durable redox flow battery technology. The concept is based on using low redox couples (non-vanadium based) such as manganese. The center has been developing low cost, aqueous electrolyte-based redox flow battery chemistries involving metal ions for large-scale storage.

ENERGY EFFICIENCY

Reduction in energy consumption is important for reduction in power and energy demand. Energy savings can result in reduced greenhouse emissions and significant cost savings. In this theme, the center focused on low cost and energy producing houses through design and integration of solar power and energy storage. Center teams of faculty, students, staff, and volunteers participated in the 2013 US Department of Energy

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Solar Decathlon competition held in Irvine, CA and the 2021 Solar Decathlon Middle East competition held in Dubai, UAE.

There are many industry sectors that are energy intensive and responsible for large amounts of greenhouse gas emissions. Just within Kentucky and the surrounding region, these include cement manufacturing, steel production, aluminum smelters, and bourbon distilleries. Small improvements in energy efficiency can make a great impact on the reduction in greenhouse gas emissions and energy demand worldwide. In one initiative, machine learning and physical modeling/control were applied for developing smart manufacturing algorithms to reduce use of heat during cement manufacturing. The resulting smart manufacturing control platform will undergo a field trial at a cement manufacturing plant. The projected worldwide impact will be substantial even if just a modest 5% reduction in energy consumption is accomplished.

Engaged over 400 industry and academic users in Materials Characterization

There are many small- and medium-scale industries in the region that could utilize various energy efficiency measures. The center has initiated a US DOE-funded energy assessment center to help industry identify ways to reduce their energy consumption and greenhouse gas emissions. Through this effort over next 5 years, center faculty, staff, and students will be able to learn about challenges with energy efficiency and help implement solutions toward reducing energy demand and emissions. Deep decarbonization for all process, manufacturing, and energy industries worldwide is highly important over the next decade.

PHASE TWO: 2021–2025 TRANSLATIONAL IMPACT

The center vision for Phase II includes three key aspects that emphasize impact within the marketplace for energy, advanced materials, and manufacturing technologies, which conservatively holds a 2-4 trillion dollar investment potential within next 10 years. First and foremost, a center building is needed to co-locate all core facilities and laboratories for materials and energy research and establish new pilot facilities. This building will unify our disparate efforts across campus into a critical mass, one encompassing education, research, and commercialization. Second, the center plans to expand its core staff by hiring eminent scholars to lead its energy efficiency and energy storage themes. In addition, this period may also include cooperative targeted hiring of energy centric junior faculty in Speed School of Engineering, College of Arts & Sciences, and College of Business.

Third, it is of critical importance that the university establish a public-private commercialization entity to formalize the center's impact through successful technology translations. Termed as Renewable Energy, Business, Entrepreneurship, Capital, and Commercialization Accelerator (REBECCA), the goals are to 1) foster the successful translation of research innovations for chosen energy technologies and enable startup companies in a high-value and focused marketplace, 2) enrich the entrepreneurial ecosystem, and 3) transform academic research into an economic engine for Kentucky. REBECCA will bring together private investors and corporations to participate early in the process of technology acceleration. This includes Conn Center breakthroughs as well as innovations from across the state, the US DOE national labs and hubs, and universities across the nation. Viable products include solar panels, electrolyzers, photoelectrolyzers, chemical manufacturing, catalysts, energy storage technologies such as batteries, biofuels and biomass, and natural gas conversion to chemicals.

PHASE THREE: 2025–2030 MAGNIFYING THE IMPACT

The vision for Phase III is defined by explosive growth of large industrial partners for Conn Center and the expansion of an innovation park enabling over one hundred startups or relocated companies with over one thousand STEM-related jobs. Corporate engagement is foreseen as the means to grow the existing entrepreneurial ecosystem in Louisville, thus providing a continuum between researchers, their inventions, and the resources to effectively reach the marketplace. During this period, many of Conn Center's inventions would target ways of decarbonizing the majority of the energy, power, and fuel sectors. Return on investment from industry is anticipated to significantly fund much of this research.

Translated innovations with 30 patents and 117 invention disclosures, 13 technology licenses

FINAL COMMENTS & VISION 2035

As of 2021, it is clear that Conn Center has created a step change in energy and advanced materials research at University of Louisville in a very short period. The center makes demonstrable positive impact on academic prestige and has emerged as the university's largest non-medical research center. Its presence has enabled recruitment, retention, and mentoring of bright, young, and experienced faculty in energy research. It has spearheaded a new degree track - the Master of Science in Materials and Energy Sciences & Engineering - a multidisciplinary program designed to help professionals advance their careers, support the implementation of new energy technologies, and influence quality

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of life worldwide. Currently, the center remains vital in improving the spirit of entrepreneurship, job creation through small businesses, and engagement of large-scale regional industries.

The Intergovernment Panel on Climate Change has established a stringent requirement of greenhouse gas reduction with aggressive targets to avoid planetary environmental catastrophe by 2035. Such a timeline casts a sense of urgency on the development and translation of renewable energy technologies, energy efficiency measures, and carbon capture and utilization. To achieve significant decarbonization by 2035, the world will have to realize different ways of converting, storing, and using energy and fuels. Carbon-neutral and carbon-free fuels (hydrogen or ammonia), electrification of all sectors, and broad implementation of renewables are required. It is entirely possible that the entire system of centralized production of energy, fuels, and chemicals will shift toward distributed and on-demand production. Conn Center's vision over three phases of evolution enables the renewable energy economy and our future in a decarbonized world.

1 Created a one-year M.S. degree on Materials and Energy Science & Engineering

The aspirational vision and goals for Conn Center toward 2035 will require the involvement of many more faculty, students, dedicated research theme leaders, and increased public and private investments for acceleration of technologies to market. This support is essential to accelerate and strengthen the efforts of Conn Center toward making significant impact on the global environmental crisis and transforming our regional economy.

ENTREPRENEURSHIP

TRANSLATIONAL IMPACT: LOCAL, REAL, AND GROWING

Conn Center finds success by relying on the theme leaders to propel the center mission opportunistically by collaborating with faculty that share interests and need for fundamental discovery as well as industry to fuel the translation out of the laboratory. The organizational structure used currently by Conn Center is also being adopted by other larger schools, i.e., hiring research staff, such as at MIT, or even making tenure-track appointments, like those at Hawaii Natural Energy Institute. The rhythm for translation of fundamental discoveries is echoed through agencies such as DOE EERE, ARPA-E, and SETO, whose funding mechanisms are structured on the convergence of basic energy science acceleration in partnership with industry to accomplish this mission. Partnerships with industry also align degree programs at the university as their changing needs are understood.

The growth of renewables and their manufacturing are already playing a major role in the Commonwealth of Kentucky's economy. The Kentucky Cabinet for Economic Development's recruitment efforts over the last five years have targeted industries involved in renewable energy, with increasing reliance on Conn Center to provide the intellectual base for engagement. In this regard, Conn Center provides a capability for UofL to enable regional economic impact by 1) engaging with companies that want to relocate to Kentucky, and 2) enabling startups through innovation to create new high-tech industries. Conn Center will play an immense role in the next decade for UofL in terms of education, research, and innovation in this marketplace.

Engaging Industry. The center has a proven track record of working with existing companies to build manufacturing capacity for renewable energy and energy efficiency technologies. By capitalizing on these successes, connections, and lessons learned, the goal is to drive renewable energy and energy efficiency innovation in this region.

Kentucky Advanced Materials Manufacturing Corporation (KYAMMC) is a subsidiary of an established diamond manufacturing company that will site a large lab-grown diamond manufacturing facility near Louisville. This company is expected to invest over $300M over the next 5-6 years. Prior to such a large investment, they sought assistance from Conn Center to host and manage a 5-reactor manufacturing operation close to the university. KYAMMC relocated to draw on center expertise in reactor design and optimization that will transform their company.

Integro Earth Fuels, Inc. was a Greenville, SC-based company specializing in NuCoal, a wood waste/biomass to coal replacement product burned with or in place of coal by heat and power generators. This company

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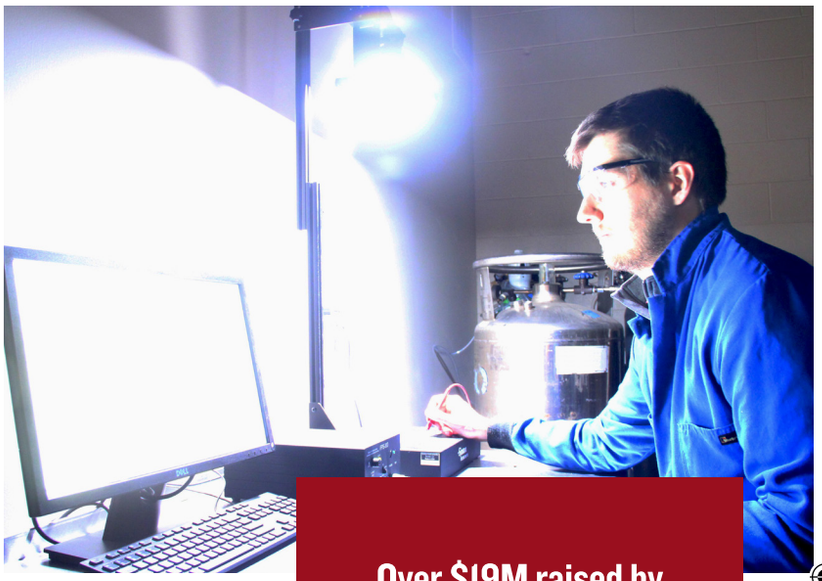
raised over $12M and established a pilot scale unit as well as R&D facilities at UofL to study the torrefaction and densification of wood and agricultural biomass sources. The UofL project was funded, in part, by a $256,890 grant over two years to Conn Center from the US Endowment for Forestry and Communities (Endowment) through its Consortium for Advanced Wood to Energy Solutions (CAWES) – a joint effort between the Endowment and USDA Forest Service.

Enabling Start-ups. The center has made a major impact on the research and development infrastructure and open innovation framework at the University of Louisville. Prior to the start of the center, there was very little research being conducted on materials and energy topics with limited impact on publications. The center continues to fulfill its mission of seeding commercializable technologies in the energy and advanced materials sector. To date, Conn Center's team played key roles in translating nine startup ventures from over 20 licensed technologies. Five of nine ventures have received federal and state funding (>$10M) and two raised private investments in excess of $5.0M in the last two years (2019 – 2021). Together, these startups account for 50 new jobs in the region and have attracted over 30 individual investors. In the last five years, these companies represented >90% of SBIRs/STTRs obtained from NASA, NSF, and DOE for the Louisville region.



1) Advanced Energy Materials, LLC
2) AliphaJet, Inc.
3) Bert Thin Films, LLC
4) BioProducts, LLC
5) Karuturi Kubed, LLC
6) IOP Technologies, LLP
7) ApiQ Semiconductors, LLC
8) Pascal Tags, Inc.
9) AdhviQ Technologies, LLC

Advanced Energy Materials, LLC (ADEM) licensed patents on nanowire-based materials production developed at Conn Center and established a production facility. ADEM scientists and engineers have further developed scale-up production technologies and demonstrated several catalyst and battery electrode materials for commercial implementations that are nearing launch. This company received over $6M in federal/state grants and raised $1.65M from angel investors in addition to $0.7M in debt financing for establishing a 0.5 ton/day pilot scale production plant. ADEM is currently working with targeted customers and strategic partners for implementing their catalyst and battery materials. They employ over 12 people and expect to see exponential growth when production starts in 2022. ADEM launched deep desulfurization products for commercial use – AdE-Sulfur and AdE-Scat. The former helps reduce sulfur levels down to 1 ppb and works with zero to low hydrogen, making it as useful for gasoline, diesel, natural gas and hydrocarbon feeds for fuel cells and chemical production.

Over $19M raised by ventures, with five receiving federal funding, and three raising private investment.

Beyond desulfurization, ADEM has developed a plascat technology (using renewable electricity) -based modular processing of natural gas, biogas, carbon dioxide, air, and water toward production of hydrogen, ammonia, and methanol. In addition, ADEM's catalysts have also been shown to enable conversion of biomass derived xylose to furans. These technologies have the potential to impact decarbonization of the processing industry as well as enabling hydrogen infrastructure and sustainable chemical manufacturing.

AliphaJet, Inc. and its sister company, Benefuel, established a 50 million gallon/year biodiesel plant with beef tallow as feedstock using a refurbished Koch plant in Nebraska. Their catalytic method was developed by Conn Center in 2010 and relies on a hydrogen-free way of removing oxygen, branded BoxCar™. This catalyst removes oxygen as CO_2, thus eliminating the need to co-locate fuel processing with an expensive hydrogen refinery. AliphaJet has successfully produced renewable jet biofuel using both plant-based oils and animal fats and can also produce renewable drop-in diesel fuel, gasoline, and other hydrocarbon molecules usually derived from fossil fuel oil.

Bert Thin Films, LLC (BTF) was founded in 2014 to commercialize a copper-based material for printable circuitry in solar cells. BTF has raised over $2M in funding from SBIR funds, $1M from a DOE Solar Energy Technologies Office grant, and an additional $2M in seed funding. The company spun out licensed technology from Conn Center, now employing 7 people (4 PhDs) and operating in a 4,000 square foot facility. The five-year plan of the company sees expansion to over 20 individuals with yearly revenue topping $17M.

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The company has utilized the analytical equipment at the center during the development of their product. BTF is currently working with several of the largest solar panel manufacturers in the world and has demonstrated superior material performance and durability.

Startups account for 50 new jobs in the region and have attracted over 30 individual investors.

AdhviQ Technologies, LLC was founded in May 2020 in rapid response to the COVID-19 pandemic to translate reusable N-95 mask technology developed jointly by Conn Center and ADEM. They established a bulk manufacturing capability for masks using existing materials for renewable energy applications and further developed a re-usable mask technology and filtration fabrics using nanofibers (both inorganic and electrospun).

Bioproducts, LLC licensed multiple patents on biomass conversion to value-added products developed at Conn Center and is currently in negotiations on commercial production of these products in countries around the world. Their products include Xylose (a diabetic friendly natural sugar), high surface area activated carbon, carbon neutral bio-coal, and modified fibers for composites and films. BioProducts develops processes specific to various undervalued biomass sources and integrates them for the economic production of value-added products. Customer value drivers included waste utilization, renewable carbon, carbon neutral energy source, and increased profits to farmers as well as socially beneficial natural products. Clients range from distilleries, sugarcane processors, industrial and CBD hemp producers, lumber operations, and government projects.

OUTREACH

INSPIRING AND ENGAGING NEXT GENERATION AND COMMUNITIES

Lab coats and safety glasses all around! Conn Center has created numerous opportunities for students to be involved in thematic research as well as in special initiatives and problem-solving challenges over the last decade.

Masters and PhD student involvement is vital to the center's work across themes. Students work on multiple publications and grant-funded research and define their own projects for dissertation and theses research based on Grand Challenges. The interactions between grad students and faculty are amplified by the center's theme leader research scientists, who are 100% focused on propelling research. Over 60 theses and dissertations have been completed in renewable energy and energy efficiency topic areas from across engineering disciplines as well as chemistry, physics, and biology. Center graduates have had excellent placement in national labs, materials production firms, and corporate R&D settings on the cutting edge of technology development and deployment. These include Intel, GM R&D, and Applied Materials as well as Sandia, Los Alamos, and Lawrence Berkeley national labs. In 2020, the center began offering its one-year Master of Science in Materials and Energy Science & Engineering, which is designed to prepare students for career tracks in industry such as semiconductors/opto-electronics, catalysts, and energy.

Over 60 Masters' theses and PhD dissertations completed in renewable energy and energy efficiency topic areas

COMPETITIONS, CONFERENCES, AND INTERNATIONAL SCHOLARS

The Conn Center conceived and delivered the Mickey R. Wilhelm Solar Flight Competition, a design-build-fly challenge for solar powered model scale aircraft, from 2011 to 2014 for over 100 students, staff, and faculty.

The center represented the university at numerous conferences and events, including annual Kentucky Governor's Conferences on Energy & the Environment, NAATBatt, and DOE ARPA-E Summits. The largest of these, the World Future Energy Summit in Abu Dhabi, UAE, reached over 20,000 participants.

My time at Conn Center gave me the real world experience to excel in the semiconductor industry. The problem solving and technical communication skills built with collaborators, vendors, mentees, peers, and advisors gave me the foundation for the working relationships I rely on now every day. Being exposed to the type of equipment in graduate school that I would work directly with in my career also gave an advantage in the workplace as it provided familiarity as I entered a new working environment. The technical speaking and troubleshooting using data and models at Conn Center gave me experience that also translated directly into my ability to solve complex technical problems in the field. Beyond the expertise I gained, I genuinely had a great time at Conn Center! It enabled me to visit new places, meet people of diverse backgrounds, and work on research that is meaningful to me.

– Harry "Ben" Russel, PhD, Chemical Engineering, Class of 2016

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The center developed numerous lectures, displays, and brochures to inform the public of center activities and breakthroughs.

The center has also hosted over 50 self-funded visiting scholars from 2010 to 2020 from international institutions to receive specialized training in renewable energy research. Partnering institutions include the Sheffield Hallam University in the United Kingdom; Universidad de los Andes in Bogotá, Columbia; University of Applied Sciences in Mannheim, Germany; ENSAIME National Engineering School Valenciennes, France; IMS Engineering College, India; Madurai Kamaraj University, India; Government College of Rajamahendravaram, India; National Institute of Technology in Tiruchirappalli, India; Gdansk University of Technology, Poland; University of Warsaw, Poland; Federal University of Technology, Nigeria; and National Center for Nanoscience & Technology in Bejing, China. Many of these scholars have reciprocated to invite Conn Center researchers to their home countries for conferences and lectures.

DEPARTMENT OF ENERGY 2013 SOLAR DECATHLON

In 2012-13, Conn Center supported 20 students for the 2013 DOE Solar Decathlon competition as they developed and built the 1000 square foot, solar powered "Phoenix House," with UofL and Ball State University faculty, staff, student, and volunteer support from over 100 people and fundraising at $600K. Phoenix House was built on campus and competed in California, winning the affordability portion and team favorite designation of the competition.

During the design phase of the competition, "Team Kentuckiana" identified the need for low-cost, solar-powered habitats for disaster relief. The team worked toward a quickly and easily deployed structure powered independently of the electric power grid. The home features a grid-compatible power system for net metering and can be linked with other homes to form local microgrids. Additionally, the house can also help address the pressing need for low-cost, energy efficient housing in rural areas where power access can be prohibitive. The team's housing system, which is designed to be comparable in cost to conventional manufactured housing and utilities, can be used in rural areas with greater efficiency and long-term equity.

PHOENIX HOUSE

Following the 2013 competition in Los Angeles, which reached over half a million people, the center coordinated the transformation of Phoenix House into an impactful university asset. After placement and zoning in the Speed School complex, the house was reimagined from its residential configuration, including completely refurbishing and adapting it to its current site and use as ADA compliant Conn Center business office, residential scale laboratory, and outreach demonstration, which opened in 2016. Assistant director and sculptor Andrew Marsh also developed an outdoor sustainability and sculpture installation as a complement to Phoenix House for use as common space and an outdoor laboratory demonstration site.

INDUSTRIAL HEMP TO ENERGY

Using this facility, Conn Center's biofuels theme became the driving force for hosting industrial hemp research at UofL as part of the Kentucky Department of Agriculture's Industrial Hemp Research Pilot Program in 2017, 2018, and 2019, undertaking planting, cultivating, harvesting, drying, and storage. This research on industrial hemp to energy, which is ongoing in materials and biofuels themes, has brought acclaim to Conn Center and UofL and involved over 10 faculty and 25 students and post-docs. Phoenix House continues to be utilized for further technology studies and testing of residential scale prototypes as well as for student outreach

When I was in 7th grade, I knew I wanted to do a research project that was not able to be done in my middle school classroom. So, I called a few professors at UofL asking if I could use their labs. Dr. Sunkara answered my call, set up a meeting with me, and introduced me to students working in the lab. Over the past 5 years, the graduate students and professors at Conn Center have been amazing mentors to me. From teaching me to use equipment to explaining complex scientific concepts, the individuals at Conn Center have been invaluable resources for me and my research.

My research project that I have been conducting for the past four years aimed to determine if plastics could be converted to porous carbon using a plasma reactor. I learned through my research that PET (with the addition of salt) can be converted to a carbon with high porosity in an environmentally friendly way. I had the opportunity to present different aspects of this project at many science fairs over the years and was ultimately named an International Science and Engineering Fair Finalist in 2020.

– Eliza Gallagher, Du Pont Manual High School, Class of 2021. BS Computer Science, Stanford University, (2026)

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in conjunction with the Campus Health Initiatives program. Its effective integration of engineering and architectural requirements and team building was directed by Dr. Mark McGinley, Professor of Civil Engineering at UofL.

2020 SOLAR DECATHLON MIDDLE EAST

In 2020-21, Conn Center director Mahendra Sunkara and Professor McGinley led "Team Desert Phoenix" in the Solar Decathlon Middle East competition in UAE, featuring faculty, staff, and students from the University of Louisville, American University in Dubai, Higher Colleges of Technology, and American University of Sharjah. Working collaboratively, Team Desert Phoenix undertook the challenge of designing, building, and operating a sustainable 1000-square foot solar-powered home for the decathlon showcase challenge in Mohammad bin Rashid Al Maktoum Solar Park in Dubai.

RENEWABLE ENERGY & ENERGY EFFICIENCY (RE3) WORKSHOPS

The center conceived and hosted a series of NSF-funded Renewable Energy & Energy Efficiency Workshops in 2011, 2013, 2015, and 2017. Each of these 3-day intensives featured over 100 talks from industrial, governmental, entrepreneurial, and academic leaders in the field as well as poster sessions for student researchers. The workshops encouraged, strengthened, and created partnerships among stakeholders at the state, regional, and national arenas, forging connections and fostering innovation and intellectual exchange amongst academic, small businesses, and entrepreneurial start-ups and mature industrial partners. Talks were recorded and disseminated free online for 2 years following each workshop.

SCIENCE FAIR MENTORSHIP AND RESEARCH SUMMER CAMPS

The center has opened its doors to over 250 high school students seeking mentorship for science fair competitions, pairing with faculty and center researchers on student-driven projects each year. As popularity in these mentored projects grew, the center created its Research Summer Camp series, which ran each summer from 2014 through 2017. The weeklong day camps for Louisville-area high school students offered the chance to learn principles behind cutting edge renewable energy research from the center's research scientists, then work in center labs on real hands-on projects using state-of-the-art analytical tools and research methods. At the end of the week, students gave their own research presentations for their science fair projects to jump start their progress toward state and regional competitions and spur further interest in higher education STEM studies.

In 2016 and 2017, the center collaborated with the Berea College's Gear Up Initiative and Partnership for Education with the Kentucky Highlands Investment Corporation to offer a second camp each summer to students from eastern Kentucky's Promise Zone, designated in Bell, Clay, Harlan, Knox, Leslie, Letcher, Perry, and Whitley counties. The highly competitive in-residence camp drew over 60 of the top high school science students from Appalachia, introducing them to university life and renewable energy research concepts. Many of these campers have taken up STEM studies as they embark on their university education.

EVENTS & ACCOMPLISHMENTS

High School Student Science Fair Mentoring // 2010 – current
Solar Flight Competition // 2011 - 2014
Renewable Energy & Energy Efficiency (RE3) Workshops // 2011, 2013, 2015, 2017
Conn Fellows // 2012
US Department of Energy Solar Decathlon Competition // 2012 - 2013
Research Summer Camp // 2014 - 2016
Wastestock Symposium // 2015
Biomimicry Symposium // 2015
Research Summer Camp Promise Zone // 2016, 2017
Winner's Circle RoboJockey FIRST Team // 2016
Solar Decathlon Middle East Competition // 2020, 2021

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Leigh Ann Conn Prize for Renewable Energy.

The University of Louisville Leigh Ann Conn Prize for Renewable Energy recognizes outstanding renewable energy ideas and achievements with proven global impact. It highlights the university's growing prominence in renewable energy, embracing the excellence of the most accomplished practitioners of translational research to marketplace entrepreneurialism. The university organized the prize in 2012 with support from Hank and Rebecca Conn, center benefactors and loving parents grieving the loss of their daughter, Leigh Ann.

The inaugural prize was won in 2013 by Dr. Michael Graetzel, developer of the dye-sensitized solar cell. The 2015 prize was awarded to Dr. Dan Nocera for the development of the Artificial Leaf and large-scale flow battery. In 2017, Dr. Jay Whitacre was recognized for ultra-low cost sodium-ion batteries. In 2019, Dr. Shuji Nakamura was awarded for his innovations in solid state LED lighting and electronics that enable education, healthcare, and worldwide energy savings in the billions.

As Program Officer, Andrew Marsh has worked to raise the caliber and integrity of the prize competition, its worldwide impact, and its prestige as a premier university event and outreach tool. Each round of competition has seen increased numbers and quality of applicants, more difficult and competitive international reviews, and higher levels of excellence celebrated in its laureates. Marsh orchestrates the entire process, including prompting the assessment and growth trajectories for further defining the prize identity, scope, and impact with the center staff and associated faculty, Speed School and A&S deans, UofL presidents, and the prize benefactors Hank and Rebecca Conn. The on-site portion of the program with the prize laureates has evolved into a series of highly successful events consistently reflecting a positive image for the University of Louisville. As testament to their belief in its overwhelming impact and need for enduring legacy, the Conns have endowed the LAC Prize in perpetuity with the intent to raise its dispersal from $50K to $100K.

ASSOCIATED FACULTY

ENABLING RESEARCH SUCCESS

Involving and recruiting faculty and enabling their success is a key to the center's vision. Since its inception, Conn Center has provided start-up support to facilitate strategic hiring for junior faculty across engineering and science disciplines. In addition to providing lab support, the center also provided research directions, mentored junior faculty, and enabled small group research proposals. As of 2021, over 80% of all associated faculty have received federal or state grants on energy research relevant to Conn Center's thematic areas, highlighted below.

- Several junior faculty – Moises Carreon (ChemE), Jinjun Liu (Chem), Farshid Ramezanipour (Chem), and Hui Wang (MechE) – each won prestigious CAREER awards from NSF and several major grants for energy research.

- Professors Mark McGinley (Civil & EnvE) with Michael McIntyre and Aly Farag (Elec & CompE) are working on improving energy efficiency of cement manufacturing, which has the potential to reduce global energy consumption and equivalent greenhouse gas emissions.

- Professors Hui Wang and Badri Narayanan (MechE) are funded on several projects to develop solid electrolytes and interfaces toward safer and high energy density lithium-ion and lithium-sulfur batteries.

- Professors Gautam Gupta (ChemE), Farshid Ramezanipour, Craig Grapperhaus, and Robert Buchanan (Chem) are working on electro- and molecular catalysts for hydrogen and oxygen evolution reactions important for the solar fuels theme.

- Professors Michael Nantz and Chris Burns (Chem) with Kunal Kate (MechE) played a role in purification of xylose from biomass-derived hydrolyzates and natural fiber-based composites as part of the center's biomass/biofuels theme.

- Professors Delaina Amos (ChemE), Craig Grapperhaus and Frank Zamborini (Chem) with Bruce Alphenaar (Elec & CompE) have worked on advancing dye sensitized and perovskite solar cell technology as part of the solar manufacturing R&D theme.

- Professors Gamini Sumanasekera, Ming Yu, and Jayanthi Chakram (Physics) with Badri Narayanan (MechE) continue to play significant roles in advancing Conn Center's advanced energy materials research through experimental and computational studies.

Bioinformatics
Somnath Datta, PhD
Susmita Datta, PhD

Biology
Margaret Carriero, PhD
Sarah Emery, PhD
Paul Himes, PhD
Mark Running, PhD
David Schultz, PhD

Chemical Engineering
Delaina Amos, PhD
R. Eric Berson, PhD
Moises Carreon, PhD
Xiao-An Fu, PhD
Gautam Gupta, PhD
Noppadon Sathisuksanoah, PhD
Thomas Starr, PhD
Gerold Willing, PhD

Chemistry
Richard Baldwin, PhD
Robert Buchanan, PhD
Chris Burns, PhD
Craig Grapperhaus, PhD
Gerald Hammond, PhD
Sachin Handa, PhD
Jinjun Liu, PhD
Michael Nantz, PhD
Farshid Ramezanipour, PhD
Heather Rypkema, PhD
Frank Zamborini, PhD

Civil & Environmental Engineering
Mark French, PhD
Omid Ghasemi-Fare, PhD,
W. Mark McGinley, PhD, PE
Thomas Rockaway, PhD
Zhihui Sun, PhD

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Computer Science & Engineering
Adel Elmaghraby, PhD
Aly Farag, PhD
Olfa Nasraoui, PhD

Electrical & Computer Engineering
Bruce Alphenaar, PhD
Robert Cohn, PhD
James Graham, PhD
Cindy Harnett, PhD
Michael McIntyre, PhD
Shamus McNamara, PhD
John Naber, PhD
Kevin Walsh, PhD

Industrial Engineering
Suraj Alexander, PhD
Lihui Bai, PhD
Yang Li, PhD
Brent Stucker, PhD

Mechanical Engineering
Sundar Atre, PhD
Thomas Berfield, PhD
Bikram Bhatia, PhD
Keng Hsu, PhD
Kunal Kate, PhD
Yongsheng Lian, PhD
Badri Narayanan, PhD
Sam Park, PhD
Glen Prater, PhD
M. Keith Sharp, PhD
Hui Wang, PhD

Medicine
Michael Tseng, PhD

Physics & Astronomy
Chakram Jayanthi, PhD
Sergio Mendes, PhD
Humberto Rodriguez Gutierrez, PhD
Ming Yu, PhD

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TECHNICAL ADVISORY BOARD

GUIDANCE, PERSPECTIVE, AND EXPERIENCE

A top-notch technical advisory board guides the center, comprised of top executives from GE Appliances, Brown Forman, Clariant, and Louisville Gas & Electric, Commonwealth Cabinet Secretaries for Energy and Economic Development, academic deans of engineering and sciences, and Mr. Hank Conn. Offering their collective wealth of knowledge, the technical advisory board reviews center objectives and progress with center leadership to maintain responsiveness and alignment of research and translational efforts that are consistent with federal funding priorities and regional industry interests. The board embraces the vision to create a nationally recognized center of excellence on renewable energy research with scientific relevance, societal impact, and economic growth.

Hank Conn
Benefactor (2009 - Present)

Phillip Conn
Officer, Conn Family Trust (2021 – Present)

Emmanuel Collins, PhD
Dean, JB Speed School of Engineering, University of Louisville (2018 - Present)

Rebecca Goodman
Cabinet Secretary for Energy & Environment, Commonwealth of Kentucky (2020 - Present)

Larry Hayes
Cabinet Secretary for Economic Development, Commonwealth of Kentucky (2020 - Present)

David Huff
Director of Advanced Meter Initiatives, Louisville Gas & Electric/Kentucky Utilities (2012 - Present)

Victor Johnston, PhD
Head of R&D Center Louisville, Business Unit Catalysts, Clariant Corporation (2020 - Present)

Todd Mooradian, PhD
Dean, College of Business, University of Louisville (2019 - Present)

Kevin Nolan
President & CEO, GE Appliances (2011 - Present)

Chris Teeley
Vice President, Global Director Research & Development, Quality Assurance and Packaging, Brown-Forman (2015 - Present)

Mickey Wilhelm, PhD, PE
Dean Emeritus & Professor Emeritus, Industrial Engineering, J.B Speed School of Engineering, University of Louisville (2009 - Present)

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Past Members

John Angus, PhD
Professor Emeritus of Engineering, Case Western Reserve University (2009 – 2011)

Burtron Davis, PhD
Associate Director, Center for Applied Energy Research, University of Kentucky (2010 – 2014)

Gail DePuy, PhD
Interim Dean, J. B. Speed School of Engineering, University of Louisville (2017 – 2018)

Terry Gill
Cabinet Secretary for Economic Development, Commonwealth of Kentucky (2017 – 2019)

Tony Hancock, PhD
President, MEC Ltd. (2014 – 2017)

Kimberly Kempf-Leonard, PhD
Dean, College of Arts & Sciences, University of Louisville (2015 – 2019)

Kris Kimel
President & Founder, Kentucky Science and Technology Corporation (2010 – 2011)

Len Peters, PhD
Cabinet Secretary for Energy & Environment, Commonwealth of Kentucky (2010 – 2016)

Neville Pinto, PhD
Dean, J.B. Speed School of Engineering, University of Louisville (2013 – 2015)

Chandra Ratnasamy, PhD
Head of R&D Center Louisville, Clariant Corporation (2015 – 2019)

Charles Snavely
Cabinet Secretary for Energy & Environment, Commonwealth of Kentucky (2016 – 2019)

Helge Toufar, PhD
Head of R&D Center Louisville, Clariant Corporation (2010 – 2015)

John Usher, PhD
Acting Dean, J. B. Speed School of Engineering, University of Louisville (2015 – 2017)

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Local Innovation, Global Impact

Conn Center for Renewable Energy Research
University of Louisville
The Phoenix House
216 Eastern Parkway | Louisville, KY 40292
conn.center@louisville.edu | 502-852-8597

UofL CONN CENTER FOR RENEWABLE ENERGY RESEARCH

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