NEBRASKA CENTER FOR ENERGY SCIENCES RESEARCH

JUNE 2022 | ISSUE 1

Nebraska Public Power District
Always there when you need us

ENERGY CENTER CHRONICLES

PROGRESS THROUGH NCESR AND NPPD COLLABORATION

The Collaboration

The Nebraska Center for Energy Sciences Research (NCESR), chartered in 2006, is a collaboration between the Nebraska Public Power District (NPPD) and the University of Nebraska-Lincoln (UNL). NPPD provides funding for the NCESR.

UNL Office of Research and Economic Development covers most of the Facilities and Administrative costs (F&A) for the NCESR. F&A includes some infrastructure and operational expenses, though UNL incurs a variety of other charges to support research.

The NCESR funds enable UNL faculty to conduct innovative research to develop or enhance clean energy technologies.

The NCESR mission is to conduct energy research that produces new technologies, processes and systems that provide new or significantly enhanced renewable energy sources and improves the quality of life and economic opportunity for all Nebraskans.

The overall goal of the NCESR is to develop research and education programs in energy sciences by fostering interdisciplinary collaboration among UNL faculty and with other research institutions, public-sector agencies, and private sector companies with similar interests. The Center supports both basic and applied research and has a broad mandate to explore a range of renewable energy opportunities (including biofuels, wind and solar energy), as well as opportunities for energy conservation.

As of January 1, 2022, NCESR has funded 122 competitive research projects for Cycle 1 – Cycle 16. Since the inception of the NCESR, there have been more than 25 projects that have received over one million dollars in external funding. The overall return on investment for each $1 invested is $8.16.

What's inside:

The Perks of Project Energy Nebraska

UNL Environmental Studies Project Makes a Difference in Communities

NCESR provides funding to help support the UNL Environmental Studies Program's collaboration with International Council for Local Environmental Initiatives (ICLEI) and the Conservation Nebraska (AmeriCorps Program) for Project Energy Nebraska.

ICLEI USA is a global and national non-profit with a network of 2,500 local and regional governments dedicated to making communities more economically, socially and environmentally sustainable. The Denver-based office of the non-governmental organization continues to support local governments within Nebraska.

Please contact David Gosselin at dgosselin2@unl.edu if you have questions.

Project Energy Nebraska is a student-led project designed to assist local Nebraska communities in attaining information on their emission output and reducing said emissions. Students work with clients to calculate their greenhouse gas (GHG) inventories, then work with collaborators to develop solutions.

Students compile data that enables them to determine which aspects of clientele energy output contribute the most to emissions. Then they use the data to bring awareness of climate change and high emissions to community residents and assist local government in addressing such challenges.

The final products will seek to lower greenhouse gas emissions in these cities, improving the health and daily life of residents while reducing environmental degradation.

The UNL Project Energy Nebraska class started in the spring semester of 2021. Now, more than 22 students during the past three semesters have developed their capacity to work with Nebraska Communities to develop GHG inventories, provide recommendations for reducing environmental impacts, and communicate with stakeholders in Norfolk, Grand Island, and Lincoln. The goal for the spring 2022 semester is to develop products for Norfolk and Lincoln that can be used as a model and foundation for engaging communities. Norfolk is specifically in the NPPD service areas, which will assist NPPD to create GHG inventories and develop plans for reducing energy use.

Key concepts the future student leaders learn are Emissions Accounting Principles; Client Directed Work Structure; Policy Research; Emissions Modelling and Forecasting; Applied practical knowledge; Project management; Audience-oriented, multi-media communication; and Collaborative Teamwork.

The outcomes from this project will provide a framework to build capacity among students for GHG accounting. This will help students when they graduate from UNL to contribute to solutions for current and future local, regional, and global environmental challenges; possess the necessary knowledge and skills to be successful in the job market, pursue graduate degrees, and work across disciplines.

The project is also working with Conservation Nebraska to establish two summer internships for students to work with a new set of communities. This is a great student program. It fits well with NPPD's community interaction efforts and UNL's engagement thrust.

Power Your Mind with an Energy Sciences Minor

The energy science minor is designed to offer an educational component to University of Nebraska students that will prepare them for positions with companies that are producing or developing renewable energy sources or conventional fossil fuels sources or with organizations that manage energy use or the environmental impacts of energy use.

The minor is for students who desire a broad understanding of energy-related issues and an in-depth knowledge of energy in one or more of four elective thematic areas, as well as for those seeking employment in agriculture, business/industry, communication, transportation, and government. The Energy Sciences minor can be declared by students in any undergraduate major.

Overall, the courses provide an opportunity for students to learn about the capture, production, storage and utilization of energy, as well as the associated energy that societies must make related to economics and the environment. A minor in energy science (ENSC) will include a minimum of 18 credit hours of energy-related courses including four core courses.

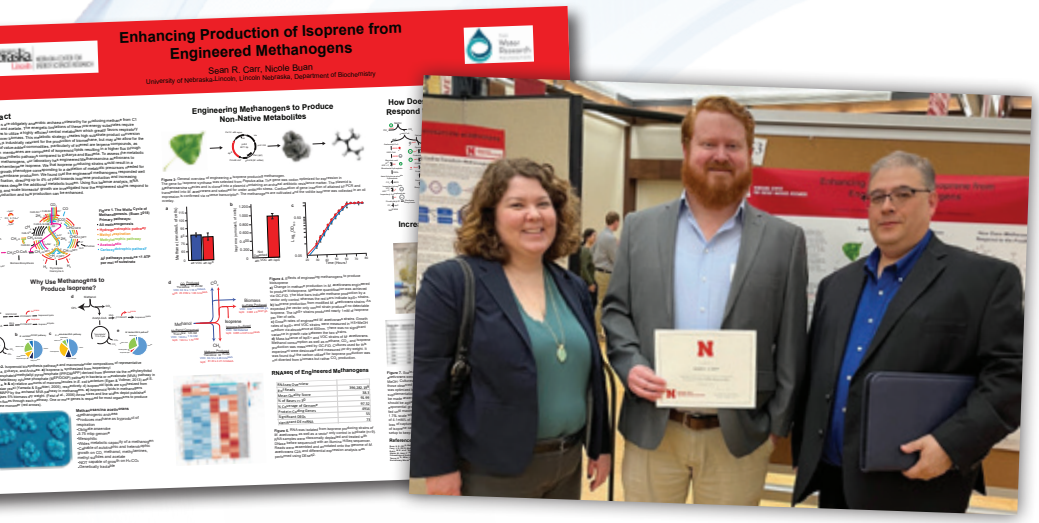
UNIVERSITY of NEBRASKA LINCOLN

More information can be found at energysciences.unl.edu

NEBRASKA CENTER FOR ENERGY SCIENCES RESEARCH

Nebraska Public Power District

Awards Applaud Talent at Student Research Days



Dr. Nicole Buan (UNL Faculty), Sean Carr (UNL Graduate Student), and Roman Estrada (NPPD and NCESR Liaison) recognize a job well done.

The UNL offices of Undergraduate Research, Graduate Studies, and Research and Economic Development hosted a poster session and creative exhibition April 11-12, at the Student Research Days.

The poster session gives students the opportunity to showcase their research or creative work; to communicate their results; and to learn about other areas of research and creative activities. 101 graduate and 190 undergraduate students participated in the event. Four undergraduate and 12 graduate students presented 14 posters associated with Energy Center projects. The competition involved more than 40 faculty and postdoc reviewers who rated student presentations on the basis of their research scholarship and presentation skills.

Anne Stratman, a graduate student working with Dr. Wei Qiao in Electrical and Computer Engineering, presented a poster, titled, "Bidding Wind and Solar as Reserve Products in U.S. Electricity Markets". Anne received a $500 honorable mention award from the College of Engineering.

Sean Carr, a graduate student working with Dr. Nicole Buan in Biochemistry, presented a poster, titled, "Optimizing Scale Production of Isoprene from Engineered Methanogens". Sean received a $400 award/travel grant to present his research at a regional or national conference or to support other research costs.

Maggie Ramsay, an undergraduate student working with Dr. Alexander Sinitskii in the Chemistry Department, presented a poster, titled, "Morphology Control of SnS Nanoplatelets Towards Application as a Two-Dimensional Chemoresponsive Gas Sensor". She received the award for "Most Significant Potential for Real-World Impact" from the Honors Program and a $250 award from the College of Arts and Sciences.

Qiuchen Wu, a graduate student and Alyssa Simpson, an undergraduate student working with Dr. Xia Hong in the Physics and Astronomy Department had the same title for their posters, but their work involves different research. The two posters presented were titled, "Ferroelectric Domain Studies of Free-Standing PbZr0.2Ti0.8O3 (PZT) Membranes". Qiuchen received a $400 travel grant to present his research at a regional or national conference or to support other research costs. Alyssa received a $250 award from the College of Arts and Sciences.

See posters at ncesr.unl.edu.

First Slam Event names Wini Waters a finalist.

"Slammer" Finalist focuses on Energy

Winifred (Wini) Waters, a Chemistry graduate student and researcher on an NCESR project participated in the April 13, inaugural Student Research Days Slam (sponsored by the Office of Research and Economic Development and Graduate Studies).

The five finalists gave presentations about "What skill or ability have you developed through your research experience or creative activity that you think would make the world better if everyone had it?" Congratulations, Wini, for receiving $100 as a finalist!

Wini presented how her research on assembling nanostructures from two-dimensional materials under the supervision of Dr. Alexander Sinitskii allowed her to increase her frustration tolerance and resiliency, which is the ability to weather frustrating setbacks without setting yourself back.

Two-dimensional materials are extremely fragile, even a speck of dust could break or contaminate her materials resulting in a setback. Her increased frustration tolerance also makes her a better teaching assistant by allowing students to become comfortable with their experiments not initially working and pushing past any frustration.

Dr. Alexei Gruverman is the principal investigator (PI) and Dr. Sinitskii is the Co-PI on the NCESR project "Strain-engineering enhancement of energy efficiency of solar cells based on organic halide perovskites." Dr. Sinitskii serves on the NCESR Executive Council and has led several NCESR research projects.

Congrats to the Undergraduate Summer Interns

Darrell J. Nelson Program Engages in Ninth Year of Energy Science Research

For the ninth year, the NCESR offered a summer internship opportunity in Energy sciences research to undergraduate students in the amount of $5,000 per recipient for the summer of 2022.

Darrell J. Nelson

The summer internship is named after Mr. Darrell J. Nelson, who served 41 years on the Custer County Public Power District and NPPD Boards from 1970-2011, and was an advocate of lifelong learning.

In 2005, Mr. Nelson proposed a partnership between NPPD and UNL for the purpose of engaging in energy sciences research. The following year, NCESR was created with NPPD's support.

To be eligible to apply, the undergraduate student must pursue any major at the UNL; be in academic good standing; be between the sophomore/junior year or the junior/senior year, which is determined by the total semester hours successfully completed; and have a cumulative Grade Point Average (GPA) of 3.0 or above. As part of the application process, the undergraduate student is required to contact and secure a firm commitment from a UNL faculty member to sponsor the application and supervise the energy sciences research work the student proposed to conduct if selected.

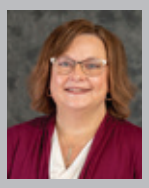
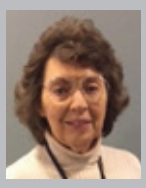
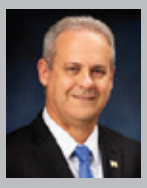
The 2022 summer interns met with staff from NPPD and staff from NCESR in a Meet and Greet session on May 23, 2022.

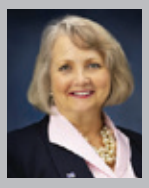
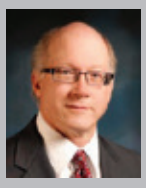
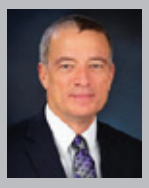
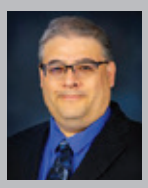
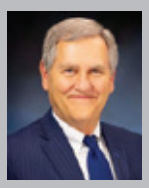
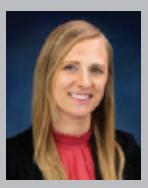
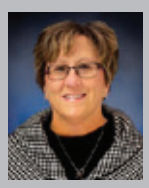
The recipients of the 2022 summer undergraduate internships are:

- Matthew Dohmen, *majoring in Mechanical Engineering*
- Bryce Herrington, *majoring in Physics and Mathematics*
- Laura Kirshenbaum, *majoring in Biochemistry*
- Aidan Larsen, *majoring in Chemical Engineering*
- Camden Olds, *majoring in Physics*
- Jackson Taylor, *majoring in Mechanical Engineering*
- Samantha White, *majoring in Mechanical Engineering*
- Ruthi Zielinski, *majoring in Physics and Mathematics*

The Team



NCESR TEAM: *top row*
Dr. Jerry Hudgins, *Interim Director (Chair, Electrical and Computer Engineering)*
Dr. Mark Riley, *Associate Director (Associate Dean, College of Engineering)*
Brenda Coufal, *Program Coordinator*
Lorraine Moon, *Office Associate*

NPPD PARTNERS: *bottom row*
Tom Kent, *President & CEO and NCESR External Advisory Committee Vice Chair*
Jerry Chlopek, *Board of Directors Chair and NCESR External Advisory Committee*
Mary Harding, *Board of Directors and NCESR External Advisory Committee*
John McClure, *Executive Vice President External Affairs & General Counsel*
John Swanson, *Director of Generation Strategies & Research and NCESR Liaison*
Roman Estrada, *Generation Research Sr. Program Manager and NCESR Liaison*
Alan Dostal, *Part-time Director of Research and NCESR Liaison*
Tannon Asche, *Community Engagement & Public Relations Lead*
Jan Modelski, *Assistant Secretary to the Board*

Cycle 15 NCESR Projects

Deep dive into their Importance and Progress

Seven Cycle 15 projects received funding for the 2nd year of the two-year grant cycle, which end December 31, 2022. The Year 1 and Year 2 funding for the Cycle 15 awards total $1,203,696. We are excited to share their progress after one year into the two-year project.

THE PROJECTS

Strategies to Sequester Carbon and Improve Soil Productivity in Nebraska: Biochar and Cover Crops

Relates to NPPD Low-Carbon Initiative

PRINCIPAL INVESTIGATOR (PI)
Dr. Humberto Blanco,
Professor Agronomy and Horticulture, UNL
CO-PI
Dr. Sabrina Ruis

Biochar is thought to be a strategy to improve soil properties and soil carbon in low carbon and degraded soils. Moreover, combining biochar with nitrogen fertilizer could further improve biochar potential.

We established an experiment in 2018 evaluating the impacts of biochar application at 0, 0.52, 1.04, 2.08, and 4.16 ton carbon/acre with and without nitrogen fertilizer (0, 75, and 150 lb/acre) on soils and crops at the High Plains Agricultural Laboratory near Sidney, Nebraska.

The system was no-till proso millet-field pea-winter wheat-sunflower under rainfed conditions. We have collected data annually. Biochar increased soil organic carbon concentration and soil pH but had no or inconsistent effects on compaction, water infiltration, plant available water, soil nitrate concentration, and soil structure. Biochar increased crop yields in some years. Nitrogen fertilization did not enhance biochar ability to improve soil health and crop yields. Results to date suggest biochar can increase soil carbon concentration and have small or no effects on other parameters.

Utilization of Biochar as a Methane Management Strategy in Cattle

Relates to NPPD Low-Carbon Initiative

PI
Dr. Andrea Watson,
Research Assistant Professor, Animal Science, UNL
CO-PI
Dr. Galen Erickson

Biochar has been proposed as a technology to capture carbon in stable, long term storage. Limited research has suggested feeding biochar to ruminant animals can reduce methane emissions, further reducing the carbon footprint of food production (meat and milk).

We are studying impacts of biochar in cattle diets. We measured cattle performance (feed intake, body weight gain, feed efficiency, carcass characteristics) and emissions of carbon dioxide and methane from cattle in four separate experiments.

In each experiment, the biochar had different physical properties and was included at 1% of the diet. Biochar did not positively impact cattle performance or reduce methane emissions in these experiments. Physical characteristics of the biochar and quality of the diet it is fed with are both of interest and likely interact.

Further research is being conducted using UNL's calorimetry chambers to identify feed additives that reduce methane emissions from cattle. This research will better inform models that drive policy decisions and social discussions on the impacts of agriculture and animal food production.

Charge Carrier-lattice Interactions in Halide Perovskite Soft Semiconductor Devices

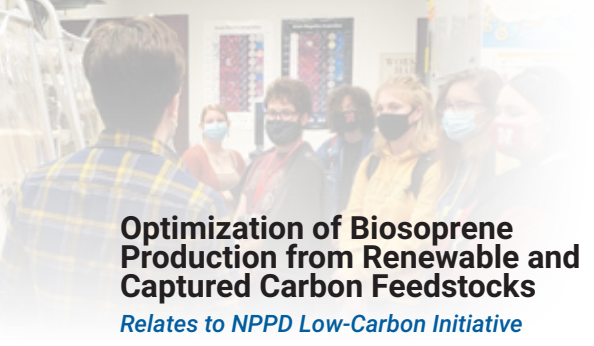
Relates to NPPD Low-Carbon Initiative

PI
Dr. Yinsheng Guo,
Assistant Professor, Chemistry, UNL
CO-PI
Dr. Congrui Grace Jin

We aim at understanding how soft bonding and anharmonic lattice motion impacts the material properties and optoelectronic performances of halide perovskite semiconductors. By studying intrinsic lattice dynamics in bulk crystals and interfacial defects, we are developing an understanding of how fundamental materials behavior defines and limits metal halide perovskite device performance.

We developed new tools and methods to probe materials behaviors at the nanoscale and demonstrated direct visualization of ferroelastic twin domain walls across the halide perovskite family. We also developed numerical models to understand the optical effects at these interfaces. To probe nanoscale structural dynamics, we have developed near-field optical measurement of surface-enhanced Raman spectroscopy in the terahertz frequency range.

The project produced two manuscripts and preliminary data for proposals under development. Undergraduate and high school students participated in summer research in our research program.



Optimization of Biosoprene Production from Renewable and Captured Carbon Feedstocks

Relates to NPPD Low-Carbon Initiative

PI
Dr. Nicole Buan,
Associate Professor and ASPIRE iChange Coordinator Biochemistry, UNL
CO-PI
Dr. Karrie Weber and Dr. Mark Wilkins

Technologies are critically needed to convert wind, solar energy, and captured carbon dioxide emissions to drop-in fuels and chemicals. This project will scale up growth of a patented "isoprenogen" organism to synthesize bioisoprene and renewable methane from inexpensive carbon feedstocks including carbon dioxide.

The project will explore ways to increase bioisoprene and renewable methane yields using synthetic biology, microbial consortia, and fermentation engineering strategies. The project will result in innovative research, intellectual property, and bioprocess data which will be used to compete for external federal funding and to pursue industry partnerships. If successful, the project will result in scalable technology to generate fuel from carbon dioxide emissions.

Low Temperature Titanium Extraction from Low-Cost Pigments (TiO2)

PI
Dr. Li Tan,
Associate Professor, Mechanical and Materials Engineering, UNL
CO-PI
Dr. Alexey Krasnoslobodtsev

We compared two different processes to treat TiO2, one via electrochemistry and another by a reactive gas phase. Exceptional efficiency of the latter process, its relevance to additive manufacturing, as well as its easiness in scale up, triggered one patent disclosure by NuTech Ventures, an NSF grant (I-Corps), and the formation of a startup company (Deep Ti, LLC).

Very recently, the team identified two research/commercialization partners, one being the Army Research Laboratory and another being the NEAT Lab (College of Engineering), to develop a prototype platform for Ti6Al4V powder reconditioning.

Strain-Engineering Enhancement of Energy Efficiency of Solar Cells Based on Organic Halide Perovskites

Relates to NPPD Low-Carbon Initiative

PI
Dr. Alexei Gruverman,
Professor, Physics and Astronomy, UNL
CO-PI
Dr. Alexander Sinitskii

We exploit mechanical strain to enhance energy efficiency of the solar cells based on organic halide perovskites (OHP) and other photovoltaic (PV) materials. OHP materials are surging in this quest as a likely replacement for silicon as the solar cell material due to their low-cost fabrication, excellent crystallinity and appealing PV properties. Combining energy inputs from light and mechanical vibrations opens a possibility of developing a photo-electromechanical energy harvester that can still supply energy in the absence of one input.

We investigated enhancement of the PV effect in the well-known bulk OHP crystals and atomically thin semiconductor MoS2. Mechanical strain was developed by bending the crystals and by applying local stress using a sub-micrometer size probe.

This leads to enhancement on the PV effect by 10,000 times. In other words, PV response can be modulated by the combination of light illumination and induced mechanical strain. The results are an exciting example of exploiting a novel mechanical coupling phenomenon for development of advanced electronics devices.

Application of Biochar as Carbon Sequestering and Beneficial Additive in Concrete

Relates to NPPD Low-Carbon Initiative

PI
Dr. Jiong Hu,
Associate Professor, Civil and Environmental Engineering, UNL
CO-PI
Dr. Adam Smith and Dr. Seunghee Kim

We are studying the use of different types, sizes, and amounts of biochar in concrete with encouraging results. Because of its high surface area and unique physical properties, the introduction of biochar can lead to concrete strength improvement or up to 20% of cement reduction of concrete. Biochar could also be used to improve the interface between recycled aggregate and cement paste, which could enhance recycled aggregate concrete properties and greatly encourage the use of recycled aggregate.

We are evaluating the performance of the developed biochar-concrete for different potential applications, including pavement, bridge, building, and railroad ties. We will also evaluate the associated economic, environmental, and social benefits.

The goal of the study is to demonstrate the feasibility and marketability of the novel approach, where biochar is used as a carbon sequestering and beneficial additive in producing concrete. Due to the amount of concrete usage, the success of the project is expected to broaden the application and usage of biochar significantly.

Cycle 16 NCESR Projects

A spotlight on the low-carbon initiative projects

NCESR and NPPD continued to partner for the 16th energy research seed-grant competition that began on April 1, 2021 with the release of the Cycle 16 - Request for Proposals (RFP). Preproposals were sought that addressed science (basic research) or technologies in the focus areas of cybersecurity, energy storage, carbon sequestration, energy management, energy infrastructure resilience, energy literacy, non-carbon combustion fuels and associated turbines and sustainable agriculture.

Twenty faculty teams submitted preproposals and 15 were invited to submit full proposals. The 15 finalists gave their presentations on November 2, 2021 to NCESR's Executive Council (EC). The EC prepared recommendations for funding and Dr. Jerry Hudgins presented these recommendations to NCESR's External Advisory Committee (EAC) on Dec. 10, 2021. The EAC made the final decision to award $679,380 for Year 1 to eight Cycle 16 projects. Each new Cycle 16 project is intended to cover the two-year period of January 1, 2022 through December 31, 2023; however, funding was only provided for the first year. Funding for the second year is provisional and based on project performance.

We applaud all of the Cycle 16 projects for their focus on improving renewable and/or sustainable energy. The Cycle 16 Projects are required to address science or technologies in at least one of the following focus areas: Cybersecurity; Energy Storage; Carbon Sequestration; Energy Management; Energy Infrastructure Resilience; Energy Literacy; Non-Carbon Combustion Fuel and Associated Turbines; and Sustainable Agriculture.

The following two projects are highlighted because of their work toward being a part of the positive change relating to NPPD's focus for the Low-Carbon Resources Initiative (LCRI) to support low- and zero-carbon emission goals in the energy industry. Watch for updates for all Cycle 16 Projects in future issues of the *Energy Center Chronicles*.

THE PROJECTS

Diamond-Coated Metallic Structures for Molten-Salt Thermal-Energy Storage Systems

Relates to NPPD Low-Carbon Initiative

PI
Dr. Bai Cui,
Associate Professor, UNL Mechanical and Materials Engineering
CO-PI
Dr. Yongfeng Lu

The research goal is to develop a low-cost, large-area deposition method for diamond coatings on metallic structures to address critical corrosion issues in molten-salt thermal-energy storage (MSTES) systems for solar thermal and nuclear power stations. Protective diamond coatings can extend the lifetime and reliability of metallic structures of the MSTES systems and thus reduce the maintenance and replacement costs.

This proposal will address the Department of Energy (DOE) Energy Storage Grand Challenge by sustaining the global leadership of the US in thermal energy storage utilization and exports with a secure domestic manufacturing supply chain. This NCESR project will provide the resources needed to develop the key data and process design to extend the landscape of the utility industry and create a research platform for future DOE funding. This could allow for more solar energy (thermal plants instead of photovoltaic, PV) and/or nuclear (0 carbon dioxide production) generating sources.

Flexible Secondary-Life Battery for Grid Energy Storage

Relates to NPPD Low-Carbon Initiative

PI
Dr. Wei Qiao, *Hyde Professor, UNL Electrical and Computer Engineering*
CO-PI
Dr. Liyan Qu

Reusing retired electric vehicle batteries in secondary applications before they are recycled could help reduce the upfront costs of electric vehicle batteries, increase the value of a used electric vehicle, and represent a potential market of low-cost energy storage for the electric grid. However, there are barriers to overcome to make second-life batteries (SLBs) more economically competitive than new batteries. This project explores an innovative concept for a flexible SLBs with hot-swappable, modular SLB packs for grid energy storage.

The outcomes of the proposed research will not only address some of the major techno-economic challenges on energy storage for grid modernization and renewable energy but also help reduce the upfront costs of electric vehicle batteries and increase the values of used electric vehicles. This could allow for more wind and solar energy generating sources.

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