

IBHE PROGRAM REPORT
Center for Clean Energy Research and Education (CENCERE)

- 1. Reporting Institution:** Eastern Illinois University
- 2. Reporting Program:** Center for Clean Energy Research and Education (CENCERE)
- 3. Date:** January 15, 2019
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5. Introduction:

Committed to reducing dependency on coal and develop a sustainable energy source, Eastern Illinois University received the approval from the state legislature to construct a Renewable Energy Center (REC), replacing the 90 year-old coal-burning physical plant. The REC broke ground for its construction on November 9, 2009 and was opened for operation on October 7, 2011. It is considered to be a "living laboratory" for our students to learn the realistic operation of a renewable energy application.

In order to integrate student learning with opportunities brought by the Renewable Energy Center, the campus community decided to establish an interdisciplinary Center for Clean Energy Research and Education (CENCERE). The Center involves students, faculty and staff from the Renewable Energy Center. Various academic units that are part of the CENCERE include: Biological Sciences, Business, Chemistry, Communication Studies, Economics, English, Geology and Geography, Physics, Political Science and Technology. The Center was approved by the EIU Board of Trustees on January 7, 2011 and by the Illinois Board of Higher Education on April 12, 2011.

The mission of CENCERE is articulated as follows:

- To contribute to the operation of the Renewable Energy Center as it supplies energy to the campus.
- To facilitate collaborative research in renewable energy by faculty across the entire university.
- To enable students to study clean energy in order to be informed in environmental protection, natural resource preservation, and social responsibilities and solutions.
- To become a national leader in clean energy research and education.

6. Objective Alignment:

The evidence of faculty collaborative research and student engagement can be demonstrated by our impressive list of funded projects. Various departments and outside agencies worked collaboratively to secure grant opportunities that involved our students in a majority of the funded projects.

Student learning objectives for CENCERE are those identified for each of the undergraduate and graduate academic programs. CENCERE'S unit objectives from the original proposal are identified under section "8" Assessment of Unit Outcomes" on page 5. The unit's outcomes, under each identified objective, are discussed on page 6.

a. CENCERE Building:

On March 1, 2013, the Board of Trustees, President Perry, and the Charleston Area Charitable Foundation broke ground for the building of the Center for Clean Energy Research and Education, north of the Renewable Energy Center. The building includes an analytic lab, a biomass storage and processing lab, a biomass gasification lab, and a space designated as an Idea Incubator. The building is in operation since Spring 2015.



b. Funded Projects:

The following lists some of the funded projects related to CENCERE's mission:

1. Illinois Sustainable Technology Center (ISTC), "Exploratory Study on Gasification of Pelletized Grassy Biomass," May 15 –Nov. 16, 2013 (PI: Peter Ping Liu, Project Manager: Jerry Cloward) (\$16,938);
2. Illinois Sustainable Technology Center (ISTC), "Evaluate Feasibility of Sustainable and Economical Utilization of Biomass Gasification Byproducts," Jan. 15-Dec. 15, 2013 (Collaborating PIs: Vinodkumar A. Patel (ISTC), Dr. Brajendra Kumar Sharma (ISTC), Peter Ping Liu), (\$29,682);
3. Charleston Area Charitable Foundation, "Construction of Center for Clean Energy Research and Education (CENCERE) Building," March , 2013 - June 30, 2014 (\$300,000);
4. Presidential Research Fund (PRF), "Densification of Corn Stover for Gasification Technology," Eastern Illinois University, July 2, 2011 –June 30, 2013 (PI: Thomas Canam, Co-PI: Peter Ping Liu) (\$19,609);
5. President's Research Fund, EIU, 2013, "Assessing the Feasibility and Environmental Impact of Native Warm Season Grasses As Biomass for Bioenergy in the Midwest," 2013, (Thomas Canam) (\$20,000);
6. Council for Faculty Research, EIU, 2013 "The Effect of Treated Wastewater and Background Environmental Sources on Bacterial Community Structure of Local Streams," 2013, (Thomas Canam) (~\$5000);
7. National Science Foundation, "Enhancing Undergraduate Education Through Student-Led Research in Biomass Renewable Energy," Transforming Undergraduate Education in Science, Technology, Engineering and Mathematics (TUES), Jan. 2012 – Jan. 2015 (PI: Peter Ping Liu) (\$198,694);
8. Council on Faculty Research, Eastern Illinois University Investigation of Long-term Stability of Porphyrin-sensitized Solar Cells, (PI: H. He), Grant Period: 11/13-07/14, (\$4,616);

9. College of Sciences, Early Research Support Grant, Eastern Illinois University, Acquisition of an Ultrasonic Cleaner for Photovoltaic Research, 2014, (PI: H. He) (\$600);
10. Interdisciplinary Research in the Sciences (IRIS) Grant, Efficient Solar Traps, College of Sciences, Eastern Illinois University, AY 2012-13 (Peter Andrew, Patrick Coulton, Steve Daniels, Peter Ping Liu, Mark McGuire) (\$1,000);
11. Charleston Area Charitable Foundation, Equipment for Center for Clean Energy Research and Education, Nov. 2, 2010-April 15, 2012 (\$56,500);
12. Lumpkin College of Business and Applied Sciences, Eastern Illinois University, Integrated Learning of Biomass Renewable Energy, FY 2010-11 (Peter Liu) (\$1,000);
13. US Environmental Protection Agency, Fungi for Bioenergy: Development of a Sustainable Biomass Pretreatment System, Aug. 15, 2014-Aug. 14, 2015 (Thomas Canam) (\$14,892);
14. President's Research and Creative Activity Funds, Eastern Illinois University, Molecular Engineering of Broadband Light Absorbers for Dye-sensitized Solar Cells, (PI: H. He), Grant Period: 06/2014-07/2015 (\$20,000);
15. Council for Faculty Research, EIU, Fall 2015, "The Transcriptome Response of White-Rot Fungi to Energy Grasses" AY2015-16, (Thomas Canam) (~\$5000);
16. College of Science Early Research Support Award. Eastern Illinois University, Purchasing GaussView 5 Software for Computational Studies of Photoactive Materials Research, 2015-2016, (PI: H. He), (\$1,105);
17. College of Science Seed Grant. Eastern Illinois University, Organic Dyes for Dye-sensitized Solar Cells, 2015-2016, (PI: H. He) (\$500);
18. Council on Faculty Research Summer Research, Eastern Illinois University, A Near-infrared Dye for Dye-sensitized Solar Cell, Grant Period: 06/2015-07/2016, (PI: H. He), (\$1,000);
19. Illinois Science and Energy Innovation Foundation in collaboration with HelpAnswers.org, "Smart Energy Consumer Independence Initiative: Smart Energy Solutions Improving the Lives of Elderly Citizens and Consumers with Disabilities," Jan.1- Dec. 30, 2017. (Collaborators: Mark Johnson, Doug Newman, Linda Simpson, Catherine O'Rourke, Rendong Bai and Wuthigrai Boonsuk) (\$47,881);
20. Council for Faculty Research, Summer 2017, "Development of a Software Platform for Transcriptome Analysis" AY2017-18, (Thomas Canam) (\$4500);
21. Lumpkin College of Business and Applied Sciences, Faculty Award for Interdisciplinary Research (FAIR), Campus Composting, AY 2017-18 (Nichole Hugo and Peter Ping Liu) (\$2,500)
22. American Chemical Society Petroleum Research Fund, BODIPY-Pd Complexes for Photocatalytic C-C Coupling Reactions, Grant Period: 09/2014-08/2018 (PI: H. He) (\$70,000);
23. Extreme Science and Engineering Discovery Environment (EXSEDE), Computational Studies of Photoactive Macromolecules for Catalysis and Metal Sensitization, Grant period: 01/2016 – 12/31/18, (PI: H. He) (\$50,000);
24. Illinois Science and Energy Innovation Foundation, "From Smart Grid to Smart Homes: Helping Utility

Customers Fully Utilize the Benefits Offered by Smart Grid,” July 1, 2018-July 30, 2019 (Research Team: P. P. Liu, R. Bai, W. Boosuk, J. Cloward, N. Hugo, T. Israr) (\$99,539);

25. National Science Foundation, RUI: Near-infrared Emitting Lanthanide Complexes and Their Metallopolymers, Grant Period: 09/2015-09/2019, (PI: H. He) (\$267, 943).

c. Student-Centered Research:

In addition to the above projects, many students are also engaged in research activities directly or indirectly related to those funded projects. The following lists sample titles of student-led research projects and student names:

1. Biomass Ash Application in Concrete (Sailesh Adhikari);
2. Biomass Gasification Research (Chengdong Hu, Seyedramin Khalilinejad);
3. Biomass Pelletization (George Buzard, Arif A Jalbani, Dave Conwell);
4. Emission Research (Ramadevi Sagi);
5. Go-Kart Project (Matthew Maher);
6. Indeck Solar Array (Arif A Jalbani);
7. Life Cycle Analysis and Green Supply Chain (Sailesh Adhikari);
8. PHP-Oracle Development Project (Fatemeh Khastkhodaardekani),
9. Project Management Tool using PHP-Oracle (Shyam Gurrani);
10. Arduino Project (Rajasri Pingili);
11. Fungi Treatment of Miscanthus, Corn Stovers and Switchgrass (Nalini Uppri, Daniel Flores);
12. Solar Powered Electric Go Kart (Manjil Puri);
13. Amazon Alexa Skill Development (Ajay Akula);
14. Electric Vehicles by Center for American Rural Energy (Grace Wilken);
15. Electric Smart Grid (Tajdar Ahmed);
16. Smart Home Technology Laboratory (Rohan Mehta);
17. Case Study in Beneficial Electrification, Center for American Rural Energy (Tajdar Ahmed, Tanmay Pant and Ayaz Khamisani);
18. Composting at EIU (Grace Wilken);
19. Wind Turbine at EIU (Carl Ray Starwalt);
20. Heat Value of Osage Apple (Carl Ray Starwalt);
21. Energy Potential of Algae Cake (Elizabeth Nixon);
22. Design Methodology for Off-Grid Solar Powered Bus Stop (Ayaz Khamisani);

d. Education:

In an effort to engage our students and help them become leaders and advocates of renewable energies and environmental protection, we have developed undergraduate and graduate degree programs.

Undergraduate Environmental Sustainability Interdisciplinary Minor: The Council on Academic Affairs (CAA) approved the new Environmental Sustainability Interdisciplinary Minor on February 9, 2012. This minor provides students with the skillset needed to be competitive in a job market focused on the applications of environmental sustainability. Students will take courses in alternative energies and sustainability as well as biogeochemical aspects of environmental sustainability. The minor also provides examples of the applications of environmental sustainability to various social systems. Discussions were initiated in Fall 2018 to update the minor.

Master of Science in Sustainable Energy:

An initial discussion was started in April 2011 with the former dean of the Graduate School, to create a new master degree program in Sustainable Energy. As a result of collaborative efforts coordinated by CENCERE, an interdisciplinary Master of Science in Sustainable Energy was developed with participation by 10 schools/departments across the campus. On June 18, 2012, the Board of Trustees (BOT) approved the Master of Science in Sustainable Energy program, presented by former Provost Blair Lord. On December 4, 2012, Illinois Board of Higher Education (IBHE) officially approved the new Master of Science in Sustainable Energy program to be delivered by Eastern Illinois University. During the Fall 2013 Commencement, first two (2) students received the new degree in Sustainable Energy.

Dual Graduate Degree Offerings:

Thanks to the innovative collaboration across the campus, we have developed a total of four (4) sets of dual degree programs. Those dual-degree programs provide students with opportunities to pursue two masters degrees at EIU, which significantly enhance the students' marketability. The following lists the current dual degree programs at EIU:

- MS in Sustainable Energy and MS in Technology

- MS in Sustainable Energy and Master's in Business Administration (MBA)

- MS in Sustainable Energy and Professional Science Master's in Geographic Information Sciences (GIS)

- MS in Sustainable Energy and MS in Biological Sciences

Since its inception, the MS in Sustainable Energy program was able to attract high caliber students. For example, Elizabeth Nixon was a graduate of University of North Carolina and came to our dual degree program of Sustainable Energy and Biological Science. She successfully completed two (2) masters degrees at EIU within two years, and now is a Ph D candidate at the Ohio State University.

The graduate program has been recognized around the globe. It has attracted two (2) Fulbright scholars, who were referred by Fulbright management agencies at Harvard University and John's Hopkins University, respectively.

e. Environmentally Responsible

Eastern Illinois University is identified as one of the most environmentally responsible colleges in the United States and Canada, according to The Princeton Review. The well-known education services company selected EIU for inclusion in the release of its free downloadable book, "The Princeton Review's Guide to 322 Green Colleges: 2013 Edition." EIU continues to be listed as one of green colleges by the Princeton Review ever since.

Eastern Illinois University was awarded again with the designation of Tree Campus USA by Arbor Day Foundation, after a few years of absence. Grace Wilken, a graduate student in Sustainable Energy and a graduate assistant at CENCERE took a strong lead and help coordinate the Arbor Day tree planting at EIU and City of Charleston (at Lake Charleston) in Spring 2018.

7. Participation:

a. Research Mentorship Program:

A Research Mentorship Program was developed and implemented at CENCERE in the fall of 2013. The major goal of the program is to stimulate new ideas and innovative thinking among faculty and students. Participants include undergraduate and graduate students. The mentorship program proves to be very effective in helping students identify research ideas.

The research mentorship opportunity was extended to Charleston High School (CHS) students. During Fall 2013, Spring 2014 and Fall 2015, there were a total of six (6) students and two (2) science teachers participated in the research mentorship at EIU. Plans are ongoing to enable CHS students to participate in the research mentorship starting in Fall 2019.

b. Integrative Learning:

Dr. Richard G. Jones, Jr. coordinated a public presentation of "Integrative Learning and Renewable Energy, at Eastern Illinois University, on November 7, 2011. Presenter's from the School of Technology included Wei (Wilson) Wang and Christopher Frederick, both graduate students. Presenters from Introduction to Speech Communication Honors included Kyle Burton (The War against Carbon), Fiona Finnegan (The Basics of Biogas), Moriah Ord (Corn as Biomass), Zac Call (Green Architecture) and Katie VanHootegem (Green Schools).

Undergraduate students in four (4) courses for the Applied Engineering and Technology (AET) major were involved in varying stages of research on biomass renewable energy. Students in AET 4943 Manufacturing Management were involved in project planning, implementation, management and evaluation. Students in AET 4002 Materials Testing used the moisture balance analyzer to monitor the moisture content of incoming biomass. Two groups of students from AET 3253 Energy Technology and AET 4873 Current Trends in Energy Technology have been working on a biomass gasification study which involves the use of wood chips and switch grass pellets.

Undergraduate students across different departments were inspired to be engaged in research on biomass renewable energy. For example, Michael Bilek, an undergraduate in Biological Science, has been researching biomass pre-treatment to study its effect on pelletization or densification. Ross Olson, an undergraduate student in Economics department (directed by Ali Moshtaf), completed an undergraduate thesis in the fall of 2013 on "The Market for Corn Stover: A Brief Economic Analysis." His thesis provided an in-depth look at the feasibility of using corn stover as a potential renewable energy source. Those student-led research projects provided students with opportunities to design and implement their own ideas driven by their intrinsic desire and passion.

Graduate students in the Sustainable Energy program have been actively engaged in research, as a part of their program of study. At least eight (8) students presented their research work at the Lumpkin College of Business and Applied Sciences Research and Creativity Symposium in spring 2015. Four (4) students have presented their research at the national conference of the Association of Technology, Management and Applied Engineering, Kansas City, MO on November 5-7, 2019.

The Renewable Energy Center at EIU has served as the practicum site for graduate students in the M.S. in Sustainable Energy program as a part of the degree requirement of CERE 5983 Sustainable Energy Practicum. Three (3) graduate student cohorts conducted their practicum during Spring 2013, Spring 2014 and spring 2015. Since Fall 2016, the practicum has been taking place in Fall semester.

c. Outreach:

Teachers Institute to Educate STEM Teachers on Biomass Renewable Energy:

To effectively prepare a future innovative workforce, it is important that we have knowledgeable and passionate teachers in the area of biomass renewable energy. To this end, we organized a Teachers Institute on Biomass Renewable Energy during summer 2014. Teachers from the surrounding region as well as the Chicago area participated in the Institute. The participating teachers were from subject areas of sciences and career education.

Summer Camp for High School Students on Biomass Renewable Energy:

To encourage young students to be interested in learning biomass renewable energy, a high school student summer camp on biomass renewable energy was delivered during the summer 2014. High school junior and senior students from the area as well as from the Chicago area participated in the summer camp.

Energy and Technology Research Mentorship Program for High School Students:

To stimulate early interests in science, technology, engineering and mathematics (STEM) by young generations, a Renewable Energy Research Mentorship Program has been established at CENCERE. The program was first formally launched in fall 2013 in collaboration with Community School District #1 leaders and Charleston high school faculty. Throughout the semester, a high school science teacher and three (3) high school students interacted on a weekly basis with faculty, undergraduate and graduate students who were conducting various facets of renewable energy research including solar, wind, and bio-renewable energy.

Three (3) Charleston High School (CHS) students and a science teacher participated in the research mentorship program in Fall 2013 and Spring 2014. Another group of CHS students and a teacher participated in Fall 2015. CHS has stopped sending students due to lack of teacher resources in Spring 2016. An effort was made in Fall 2018 with the school district, and plans are on the way to resume the research mentorship for CHS students in Fall 2019.

Idea-Incubator:

The idea-incubator in the CENCERE building was designed to attract current business owners and entrepreneurs to collaborate with CENCERE's research and development effort. It is hoped the Idea Incubator will facilitate regional business and help grow the local economy. Officials of Coles Together and the Charleston Chamber of Commerce helped to disseminate the availability of space. In April 2016, a local company was hosted in the idea-incubator.

Center for American Rural Energy (CARE):

The idea-incubator space at CENCERE was also used to host the Center for American Rural Energy, which is a consortium effort among EIU CENCERE, UIUC Prairie Research Institute, Coles Moultrie Electric Cooperative, Lake Land College, and Coles Together, with endorsement by the National Rural Electric Cooperatives Association.

Illinois Innovation Network Hub and ISEIF Consumer Engagement and Research Center:

Provost Gatrell is leading an effort to collaborate with Lake Land College and University of Illinois at Urbana-Champaign to solicit funding to establish an EIU Hub as a part of Illinois Innovation Network. If funds are materialized, the physical facility of CENCERE will be expanded. Proposal is also being submitted to Illinois Science and Energy Innovation Foundation (ISEIF) to establish an ISEIF Consumer Engagement and Research Center for down state Illinois (at the existing CENCERE facility).

26. Assessment of Unit Outcomes:

Assessment plans have been developed for each of the graduate degree programs by the unit in which the degree program is housed. The plans are submitted annually to the Center for Academic Support and Assessment (CASA). Feedback from the Director of CASA, Dr. Karla Sanders, serves to inform the program coordinators and the Director of CENCERE about the effectiveness of the programs learning objectives in order to allow for continuous program improvement. A combination of direct and indirect assessment measures serve to provide the necessary data to enhance our academic programs, as well as contribute to the overall quality functioning of CENCERE.

The following, lists the original objectives of CENCERE and the corresponding accomplishments:

1. Build a research-scale biomass gasification reactor:

With the help of university foundation staff, CENCERE secured financial support from Charleston Area Charitable Foundation in the amount of \$56,500. With this support, a research-scale biomass gasification system was established. The system includes materials feeding system, biomass gasification

reactor, syngas filtering mechanisms, an industrial scale internal combustion engine, an electrical generator, an electrical charger, a rechargeable battery bank, and an electrical inverter.

2. Conduct biomass energy demonstration:

Having established a research-scale biomass gasification system, various demonstrations on biomass energy production were conducted for students, as well as for the general public. Demonstrations took place at various events including Earth Day celebration, EIU Homecoming, and class activities. Consequently, a graduate level course (TEC 5533) on biomass gasification was developed. The formal course, a part of the Sustainable Energy graduate program, enables us to educate our students about bio-energy as an integral part of our academic offering.

Several video projects were completed on biomass energy, including biomass planting, pelletization and gasification. Those videos have been used frequently to educate our students and the public regarding the importance of bioenergy for a clean environment.

3. Begin preliminary study of various biomass sources as potential energy alternatives:

Students in TEC 5533 Biomass Gasification and Renewable Energy course have conducted preliminary screening on many potential biomass sources available in the region. Examples of tested biomass include wood chips, tree debris, grass clippings, Arundo Donax, yard waste, grass clippings, hedge apple, dog waste, miscanthus, switch grass, corn cobs, corn stover and so on. Higher heat value (HHV) was measured for the biomass, which shows the energy production potential for each biomass. Those tests have been conducted as a regular part of student learning process.

4. Establish analytical/testing capability to support research, development and quality assurance in the Renewable Energy Center operation:

With the support from Charleston Area Charitable Foundation, a gas chromatograph (GC) instrument was acquired. The GC has been used to test the chemical composition of syngas produced as a result of biomass gasification. Another project funded by the National Science Foundation enabled us to acquire several pieces of major analytic instrument, including a moisture analyzer, an oxygen bomb calorimeter, an in-line syngas analyzer (Gasboard 3100P), and an emission analyzer (E8500) for monitoring the emission pollutants.

5. Systematically develop alternative biomass sources for the Renewable Energy Center:

Four acres of land were allocated to experiment with the growth of dedicated energy crops, north of the Renewable Energy Center. Planted crops include miscanthus, switch grass and fast-growing poplar trees. Those crops were meant to demonstrate possible alternative biomass sources to be used for future operations of Renewable Energy Center. Through a donation by the Lumpkin Family Foundation of Mattoon, EIU Sustainable Energy students are now working with nearly 120 acres of farmland to research switch grass and big bluestem tall grass to create biomass renewable energy.

6. Study other clean energy sources:

In addition to biomass energy, students and faculty have engaged in the study of other forms of clean energy alternatives, including wind energy and solar energy. Dr. Isaac Slaven (School of Technology) and his students have been conducting rope safety and durability studies to support operations of wind energy installation and maintenance. Dr. Hongshan He (Department of Chemistry) and his graduate students have been developing organic solar cell materials, which promises flexible solar cell designs in the future. It is worth noting that there is a strong student interest in studying solar energy.

A CENCERE solar project, made possible by a donation from Indeck Energy Services, Inc, allows students and faculty to study the performance of solar arrays manufactured by two different vendors. The solar arrays were established on east side of the CENCERE building, and are connected to the "cloud" for continual data recording. A large number of data is available for students to study, for

example, ambient temperature, daily, monthly, and yearly energy production from each subpanel, north and south arrays and across the system, as a whole.

Based upon the early accomplishment, research scope has been expanded, especially to include energy efficiency, energy management, smart electric grid, smart home and smart building applications. On 2017-18, one project was awarded Illinois Science and Energy Innovation Foundation (ISEIF) through HelpAnswers.org on “Consumer Independence using Smart Grid.” Another project was funded directly by ISEIF in 2018-19, which is entitled “From Smart Grid to Smart Homes: Helping Utility Customers Fully Utilize the Benefits Offered by Smart Grid.”

10. Conclusion:

Since its inception, CENCERE has accomplished its original mission. In fact, CENCERE has far exceeded its original expectations or its founding vision as a research and education center. For example, the idea of creating a new graduate program was conceived as a result of the collaborative research among colleagues. The collaboration facilitated by the formation of CENCERE provided us with experience and confidence to develop a multi-disciplinary graduate program for studying sustainable energy. Thanks to the collaborative spirits and support from all participating departments, the Master of Science in Sustainable Energy program is able to attract interest from students around the world. With the support provided by CENCERE, students are actively engaged in various research activities as an integral part of the educational process. In summary, CENCERE has proven to be an effective mechanism and infrastructure to facilitate interdisciplinary research and education on clean energy and sustainability across the university.

11. Outcome

a. Decisions:

- Program in Good Standing
- Program flagged for Priority Review
- Program Enrollment Suspended

b. Explanation

On behalf of Academic Affairs, I appreciate the commitment of the faculty and program to high quality programming and innovation through CENCERE. In particular, the varied interdisciplinary programming is commendable. The report clearly demonstrates a commitment to academic excellence and student success.