



Kentucky Renewable Energy Consortium

A KREC Compendium – 2005 to 2011



CONTENTS

KREC Advisory Board Members	Inside Front Cover
Charting Kentucky's Renewable	2
Energy Future	
KREC Goals and Objectives	2
KREC Partners with 25x25	3
Outreach Activities	4
KREC Awards and Recognition	6
Competitive Grants Program I	7
Competitive Grants Program II	8
Organizational Chart.....	Back Cover

Kentucky Rural Energy Consortium (KREC) Original Advisory Board

University of Louisville, J.B. Speed School of Engineering:

Tom Starr, Associate Dean for Research, J.B. Speed School of Engineering

Cam Metcalf, Executive Director, Kentucky Pollution Prevention Center

Charlie Staff, Executive Director, Distillers Grain Technology Council, Director, Food Processing

University of Kentucky, College of Agriculture:

Nancy Cox, Associate Dean for Research and Director, Agricultural Experiment Station

Rich Gates, Professor, Biosystems and Agricultural Engineering

Sue Nokes, Professor, and Department Chair, Biosystems and Agricultural Engineering

Mike Montross, Associate Professor, Biosystems and Agricultural Engineering

Don Colliver, Professor, Biosystems and Agricultural Engineering

Kentucky Department for Energy Development and Independence:

John Davies, Deputy Commissioner, Department for Energy Development and Independence

Greg Guess, Director, Division of Efficiency and Conservation

James Bush, Renewable Energy Program, Division of Renewable Energy and Energy Efficiency

Government, Industry:

Melissa Howell, Executive Director, Kentucky Clean Fuels Coalition

Anna Kindrick, Former Director of Agricultural Marketing and Agribusiness Recruitment, Kentucky Department of Agriculture

Laura Knoth, Director, Public Affairs Division, Kentucky Farm Bureau

Hank List, Vice President, Government Relations, Kentucky Association of Manufacturers

Harvey Mitchell, Former Director of Agricultural Outreach, The Center for Rural Development

Tony Moreno, Consultant, RE Strategies, LLC

Keith Rogers, Executive Director, Kentucky 4-H Foundation

John Wright, Vice President of Strategic Planning, Owensboro Grain

KREC is administered by



KPPC

J.B. Speed School of Engineering
University of Louisville

(502) 852-0965

Fax: (502) 852-0964

Toll Free: (800) 334-8635, ext. 8520965
Louisville, Kentucky 40292

www.kppc.org

KPPC is Kentucky's primary resource to help businesses, industries and other organizations develop environmentally sustainable, cost-saving solutions for improved efficiency. Based at the University of Louisville J.B. Speed School of Engineering, KPPC provides technical information and assistance that is free, confidential and nonregulatory.



Printed on Recycled Paper

KREC – Charting Kentucky's Renewable Energy Future

The Kentucky Rural Energy Supply Program was established in 2005 by a federal direct appropriation to benefit the citizens of the Commonwealth by creating a unified statewide consortium to promote renewable energy and energy efficiency in Kentucky. The U.S. Department of Energy (DOE) initially funded the consortium with a \$2 million operational grant. In 2008, DOE again provided \$1.96 million in funding for KREC. From the beginning, KREC understood the value of providing a statewide forum for the discussion of Kentucky's long term energy needs and economic development potential.



KREC I

2005 – 2007

The Kentucky Rural Energy Consortium (KREC) was formed at the outset of the program to advance energy efficiency and comprehensive research on biomass and bioenergy of importance to Kentucky agriculture, rural communities, and related industries.

KREC was created as a partnership of the University of Louisville's KPPC – Kentucky Pollution Prevention Center and J.B. Speed School of Engineering; University of Kentucky's College of Agriculture, College of Engineering, and Center for Applied Energy Research; other Kentucky Universities; the Governor's Office of Energy Policy and other key state agencies; and agricultural commodities groups and industry partners.

KREC II

2008 – 2011

In recognition of the successful efforts of the first KREC program, KREC received an additional \$1.96 million federal appropriation for a renewal of a DOE grant. The new funding allowed KREC to continue to serve as a clearinghouse and support new research and development and outreach programs for energy efficiency and renewable energy. In 2009, KREC changed its name to more accurately reflect its expanded activities. The Kentucky Rural Energy Consortium became the Kentucky Renewable Energy Consortium and a new logo was designed for the consortium. Continued funding from the DOE allowed KREC to offer a second competitive grants program to researchers in Kentucky's public universities.

Building Partnerships

The Consortium was strongly supported by leaders in agribusiness, government and universities and continues to be a supporting partner of the National 25x25 Initiative. KREC has over 60 community partners and 600 members who have pledged their support for the goals and mission of the organization. KREC members include Kentucky land grant colleges and state university researchers focused on developing innovative renewable energy technologies.

Throughout its six-year history, the consortium encouraged researchers, industry leaders, agriculture representatives and policymakers to collaborate on renewable and sustainable energy solutions.

KREC Goals and Objectives

- Facilitate and sponsor research to develop renewable energy and energy efficiency technologies of importance to Kentucky.
- Serve as a model for state efforts to decrease dependence on imported fuels, to increase energy efficiency and to increase reliance on energy production from solar, wind, hydro and biomass resources.
- Seek out opportunities to fund and support research activities for energy efficiency, biomass and bioproducts.
- Serve as a clearinghouse and networking group to exchange knowledge, programs and ongoing activities of the Consortium and related state and federal programs.
- Build partnerships throughout the Commonwealth that advance KREC, state and federal renewable energy and energy efficiency initiatives.
- Provide a forum for discussing the 25x25 National Initiative in Kentucky and develop and distribute the *25x25 Roadmap for Kentucky* report.



KREC complements Kentucky's *7-Point Strategy for Energy Independence* by leveraging state and federal funds to promote energy efficiency and renewable energy research and development by Kentucky's colleges and universities that will benefit Kentucky's citizens, communities and industries.



Some of KREC's early founding members (left to right): Charlie Staff, Executive Director, Distillers Grain Technology Council; John Davies, Deputy Commissioner, Department for Energy Development and Independence; Cam Metcalf, Executive Director, Kentucky Pollution Prevention Center and KREC's Project Director; Harvey Mitchell, Director of Agricultural Outreach, The Center for Rural Development; Tom Starr, Associate Dean of Research, J.B. Speed School of Engineering.

KREC Partners with 25x'25

In early 2007, KREC's Advisory Board convened a diverse group of stakeholders and launched a state-wide renewable energy and energy efficiency initiative. The vision of the Consortium was to promote and recommend an ambitious goal for Kentucky—

"By the year 2025, Kentucky will use renewable energy and energy efficiency as means to get at least 25 percent of its total energy from improved technologies and renewable resources such as solar, wind, biomass and biofuels."

While developing the Kentucky initiative, KREC found common ground with the National 25x'25 Action Plan. The national plan is a grassroots renewable energy initiative backed by businesses, organizations and individuals united by a common interest in making America's energy future more secure, affordable and environmentally sustainable.



Why partner with 25x'25?

Kentucky's, and the nation's, prosperity depends on having a reliable supply of clean, sustainable energy now and far into the future. Yet world events, climate change, uncertain supplies, and an ever-growing global demand for fossil fuels have converged to place our collective energy future in jeopardy. KREC believes that **responding effectively to the world's new energy realities will be one of the most urgent and important challenges of our time.** To meet this challenge, we must identify and pursue aggressive, yet achievable, solutions to meet our energy needs. Now, more than ever, there are abundant new business opportunities in safe, clean energy alternatives. New innovative ideas are emerging every day, while both private and public investments in alternative energy research and development and energy efficiency technologies are growing at a rapid pace.

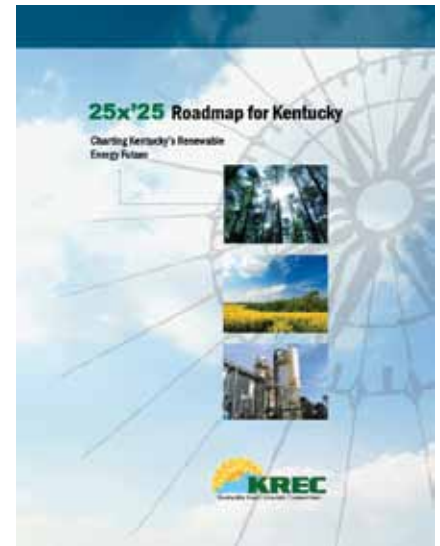
The Roadmap for Kentucky

The purpose of the 25x'25 Roadmap was to set out an important part of KREC's strategic vision for the energy future of Kentucky. It sought to significantly accelerate the growth in renewable energy, and proposed that the Commonwealth achieve a contribution of 25% of its energy mix from renewable energy sources and energy efficiency efforts by 2025. KREC requested that the State Legislature, the Governor, utility companies, the PSC, the Attorney General, environmental groups and other consumer, commercial, and public sector stakeholders endorse this target goal.

In order to have statewide representation and public input into the development of the 25x'25 Roadmap, KREC held three "town hall" public meetings across the state in August, September and October of 2007 to enable an active exchange of information and allow stakeholders to voice their concerns, ideas and perspectives on energy development and environmental stewardship. The town hall meetings were held in Frankfort, Somerset and Princeton Kentucky and were attended by a

diverse group of people representing farming, forestry, consumer and environmental protection, the Sierra Club energy committee, energy researchers and representatives from Kentuckians for the Commonwealth, as well as cattle producers, business people and alternative energy producers.

In 2008, KREC published a "Legislative Prospectus" that was distributed to Kentucky legislators. The prospectus outlined the key recommendations and findings of the 25x'25 Roadmap and encouraged legislative policy that would advance renewable energy and energy efficiency within the state.



Key Recommendations and Outcomes of the Roadmap

- 1. Support the Center for Renewable Energy Research and Environmental Stewardship**
In 2009, UofL, in collaboration with the state, established the Conn Center for Renewable Energy Research at the J.B. Speed School of Engineering. The Conn Center provides leadership, research, support and policy development in renewable energy; advances the goal of renewable energy; and promotes technologies, practices, and programs that increase efficiency for energy utilization in homes, businesses and public buildings.
- 2. Increase the Level of Highly Qualified Renewable Energy and Energy Efficiency Expertise**
To this end, KREC funded two competitive research grant programs totaling 14 projects and \$2.3 million in funding.
- 3. Establish Renewable Energy and Energy Efficiency Outreach Programs**
In 2008, KEEPS – Kentucky Energy Efficiency Program for Schools was established to help school districts reduce energy and cut costs.
- 4. Encourage Energy Efficient Homes and Buildings**
KPPC's KEEPS program has helped Kentucky schools achieve significant energy savings and has helped 65 percent of Kentucky's schools become Energy Star Partners – the highest percentage in the nation. KPPC's Environmental Sustainability (ES) program has helped businesses and industries become more energy efficient and reduce costs.
- 5. Support Expanded Use of Biofuels**
While KREC believes that much more work must be done to expand the state's renewable energy resources, in the past six years, Kentucky has seen its biofuels industry grow and its production capacity expand.

KREC – Outreach Activities

A key to achieving KREC's mission and goals is to provide forums for active participation of its partners, members, Kentucky policymakers and the public. In all:

- More than 1,300 people attended KREC meetings, forums, webinars, town hall meetings and events throughout the state
- KREC's Project Director and KPPC Executive Director Cam Metcalf presented at 35 events in the United States and Canada

KREC Quarterly Meetings

During its six year history, KREC held 26 quarterly meetings throughout Kentucky including Frankfort, Louisville, Erlanger, Lexington and Berea. These meetings were an integral part of KREC's



KREC's June 29, 2011 research wrap-up meeting in Louisville

mission to act as a clearinghouse and resource for advancing renewable energy and energy efficiency for the Commonwealth. Each quarterly meeting featured a variety of speakers from government, industry, research, environmental groups, state agencies and national organizations. Quarterly meetings were always an "open forum" for anyone who wanted to speak about policy, environmental issues, renewable energy and energy efficiency initiatives or the lack of progress in developing renewable energy industries and policies within the state.

Representatives from Kentucky's farming and forestry communities, renewable energy industries and state government agencies were frequent speakers and guests at KREC's quarterly meetings. Some of the guest speakers at the meetings included: John Davies, Deputy Commissioner, Kentucky Department for Energy Development and Independence; Len Peters, Kentucky Cabinet Secretary for Energy and Environment; Kentucky State Representative Rocky Adkins; Kentucky State Senator Robert Stivers; Brent Bailey, State Facilitator for the National 25x'25 organization; former Senator Jim Bunning; Tim Hughes, Director,

Kentucky Division of Biofuels and Frank Moore, former director, Kentucky Division of Biofuels. The meetings were open to everyone with an interest in renewable energy issues and initiatives and always encouraged questions and open discussions.

KREC's research wrap-up quarterly meeting was held on June 29, 2011 at Papa John's Cardinal Stadium on the University of Louisville's Belknap Campus. The meeting was attended by more than 50 people who heard from six KREC-funded researchers who presented final summaries of their projects as well as research posters detailing their findings.

Carbon Forum

On September 10, 2009, KREC and Energizing Kentucky held the Kentucky Forum on Carbon Sequestration Through Agriculture and Forestry Management at the Frazier International History Museum in Louisville, Kentucky. The forum was organized by KREC with financial support from Energizing Kentucky.

The forum presented an informative and comprehensive look at carbon policy, biofuels and potential energy crops for the state. A total of 108 speakers and attendees came from six states to share information and offer their expertise on agriculture, forestry, energy, research, government, business and environmental issues.

U of L President James Ramsey opened the forum and spoke about the University of Louisville's commitment to environmental sustainability and renewable energy research. President Ramsey introduced Kentucky Energy & Environment Cabinet Secretary Len Peters, who presented Governor Beshear's strategic energy plan, Intelligent Energy Choices for Kentucky's Future.

Tom FitzGerald of the Kentucky Resources Council spoke on climate change and its potential impact on rural Kentucky. Other speakers at the forum included Frank Moore, former director of the Division of Biofuels in Kentucky's Energy and Environment Cabinet, Roger Thomas, Executive Director of the Governor's Office of Agricultural Policy, Ernie Shea, from the National 25x'25 Initiative, Betty Williamson of the Kentucky Woodland Owners Association, Ruth Logsdon of Cox Interior and Bill Jacob of UPS Airlines.

Wind Energy Webinar

On July 23, 2010, KREC and the Kentucky Department for Energy Development and Independence held a Wind Energy in Kentucky webinar to hear wind energy experts discuss a crucial question: does Kentucky have what it takes to harvest wind energy?

Cam Metcalf, Executive Director of KPPC and Kate Shanks, Assistant Director for the Kentucky Division of Renewable Energy, moderated the hour-long webinar. Sixty-three attendees, representing commercial renewable energy installers and producers, government, consulting, higher education and the public, participated in the webinar and heard Peggy Beltrone from Cascade County Montana, Jeff Reinkemeyer from Iberdrola, Katie Stokes from the Tennessee Valley & Eastern Kentucky Wind Working Group and Dr. Stuart Foster from the Kentucky Climate Center, Western Kentucky University, shared their insights on Kentucky's wind energy potential.

KREC – Outreach Activities

Economic Development Forum

In November 2010, KREC held its Economic Development Forum on Renewable Energy in Kentucky on the campus of Berea College. A total of 68 speakers and attendees from a variety of backgrounds brought their perspectives on the opportunities and challenges of building a renewable energy economy in Kentucky. The forum was co-sponsored by the Tennessee Valley & Eastern Kentucky Wind Working Group, the Southern Alliance for Clean Energy, the Kentucky Department for Energy Development and Independence and Energizing Kentucky.

Berea College President Dr. Larry Shinn welcomed attendees to the forum and spoke about the importance of developing a clean energy economy and Berea's efforts to promote sustainability and environmental stewardship. Cam Metcalf, Executive Director of KPPC, then introduced Dr. Len Peters, Kentucky Cabinet Secretary for Energy and Environment, who spoke about Governor Beshear's strategic energy plan and the opportunities for developing biomass industries in the Commonwealth.

A total of 15 forum speakers covered a variety of topics. Dr. Kimberly Jensen and Dr. Chad Hellwinkle from the University of Tennessee and the national 25x25 Alliance presented an overview of energy policy and climate change scenarios that might impact the agricultural sectors and economies of the U.S. They also presented key findings from a recently published study titled Implications of Energy and Carbon Policies for Agriculture and Forestry Sectors, including results for Kentucky.

Since the consortium's beginning, KREC has maintained a close working relationship with state government legislators and policymakers. KREC has worked with the Governor's Office of Energy Policy, later called the Department for Energy Development and Independence, and with members of Kentucky's House and Senate.

In March 2010, Cam Metcalf, Project Director for KREC and Executive Director of KPPC, made a presentation to the Kentucky Senate Natural Resources and Energy Committee on KREC's activities, research funding and successes to date. KREC's testimonial appearance was sponsored by Kentucky Senator Brandon Smith. After the presentation, Metcalf took questions from committee members on topics including coordination and communication among the many renewable energy groups in Kentucky.

REnews

To advance its goal of education and outreach in 2009, KREC created *REnews*, a monthly e-newsletter that keeps KREC members informed of renewable energy initiatives and KREC activities and events. The newsletter is sent to more than 600 KREC members each month.

KREC's Website and Social Media Initiatives

In 2008, KREC designed and implemented a new website with expanded information and resources, including a "renewable energy technology at work" feature. The KREC site is a key component of outreach and communications efforts and provides up to date information on consortium activities.



Dr. Len Peters, Kentucky Cabinet Secretary for Energy and Environment at KREC's Economic Development Forum

The website also provides links to online tools and resources to help visitors find valuable information about renewable energy and energy efficiency activities in Kentucky.

Facebook – KREC began using social media to communicate and expand its reach to members and to the public. The KREC Facebook page allows visitors to see the latest news about renewable energy and KREC activities, and more importantly, provides a forum for discussions and information exchange. The Facebook page has 211 "likes" as of November 2011 and its own web address <http://www.facebook.com/KyKREC>.

YouTube – YouTube has become an active tool that offers videos that provide comprehensive coverage of events such as workshops, webinars, training and information about KPPC activities. By providing video and audio of these events, KPPC offers a new way to access valuable information and training opportunities to a much wider audience.

Flickr – Flickr, an online photo management and sharing application, provides a platform for KPPC to post photos of training, workshops and other events that can be easily accessed and viewed by visitors world-wide. KPPC's photo galleries can be viewed at www.flickr.com/photos/kppc/.

KREC in the News

KREC activities and initiatives have been featured in news articles in various news outlets throughout the state. KREC-funded researchers have also been interviewed about their work in renewable energy.

Distributed press releases/news articles covered in:

Courier Journal, Web News	Courier Journal, Print
Lexington Herald Leader	Business First, Web
Business First, Print	Associated Content, Web
Great Lakes Regional P2	25x25 e-newsletter
Roundtable (GLRPPR)	Democrat & Leader
County Extension Office e-news	Fulton Kentucky News
National Sustainable Agriculture News	Farmer's Pride News
State-Journal Frankfort	KY Ag Policy e-news
The Times Leader Newspaper e-news	

Radio Interviews/Reports:

- Farm Bureau Radio – Cam Metcalf interviewed by Mike Feldhaus coverage of the 25x'25 Town Hall Meetings
- KY Public Radio – Cam Metcalf interviewed by Dan Modlin coverage of the 25x'25 Town Hall Meetings
- KY Public Radio – Tony McVeigh coverage of the Frankfort quarterly meeting
- Farm Bureau Radio – Cam Metcalf interviewed by Mike Feldhaus
- WKYR "Talk Around Town" – Cam Metcalf interviewed by Patty Neal coverage of the KREC Economic Forum

KREC – Awards and Recognition

KREC has been recognized by several national organizations for its work in renewable energy.

The USDA's Grand Challenge Award

In 2008, KREC was selected as one of thirteen winners in a national



USDA competition called the "Grand Challenge." The USDA and the national 25x'25 Alliance co-sponsored the competition to support academic institutions as they assume leadership in achieving solutions to the energy supply and consumption challenges facing the nation.

The joint entry by KREC, the University of Kentucky, the University of Louisville, Kentucky State University and the Governor's Office of Energy Policy, was chosen by the USDA for the consortium's efforts in promoting energy efficiency and renewable energy in Kentucky and for financially supporting research in solar, hydrogen, ethanol, biomass, and other possible energy alternatives.

"KREC is establishing itself as a leader in the field of renewable energy and rural development research," said University of Louisville President James Ramsey. "Kentucky is uniquely positioned to play a lead role in development of alternative fuels. The University of Louisville, the University of Kentucky and the Governor's Office of Energy Policy are joining forces to ensure a bright future for energy policy and production in Kentucky."

Cam Metcalf received the award on behalf of KREC at the Bio Energy Awareness Days (BEAD II) in Washington, D.C. June 20, 2008 and participated in the BEAD event exhibits.

Innovator Award

In 2009, the Southern Growth Policies Board selected the Kentucky Rural Energy Consortium (KREC) as a winner of its Innovator Award. The award recognizes initiatives that improve economic opportunities and quality of life in the region.



This award recognized KREC for its efforts to encourage economic opportunities relating to bio-products, alternative energy and energy efficiency. As one of 13 Innovators in the Southern region, KREC was publicly honored on June 8, in Biloxi, Mississippi. Governor Haley Barbour presented the award to KPPC's former Assistant Director Don Douglass. Southern Growth Policies Board is a non-partisan public policy think tank based in Research Triangle Park, North Carolina.

National Pollution Prevention Roundtable

MVP2 Award

In 2010, KREC's *Carbon Sequestration Through Agriculture and Forestry Management* publication won the National Pollution Prevention Roundtable's Most Valuable Pollution Prevention (MVP2) Publication Award.

The Carbon Forum publication was developed as an educational guide for the general public to provide details of the forum's purpose and goals and to serve as a living document to share the expertise of forum speakers. It also provides a summary of the environmental and economic advantages of reducing Kentucky's net emission of carbon dioxide. The publication clearly explains the mechanics of CO₂ sequestration and offers options for developing new technologies to responsibly lower emission levels.

As a unique educational guide, the Carbon Forum summary publication addressed the concerns of business, government, agriculture and the public in how best to reduce a major pollutant, while still meeting the state's growing energy needs.

Cam Metcalf received the award on behalf of KREC at the NPPR ceremony in Washington, D.C. and met with Senator Mitch McConnell in his office to share news of the award.



Senator Mitch McConnell and KPPC Executive Director Cam Metcalf in Washington D.C.

KREC's Competitive Grants Program

Through its Competitive Grants Programs, KREC advances and funds innovative research on renewable energy and energy efficiency that focuses on developing resource-responsible technologies and practices for the energy sector. Through this program, KREC awarded more than \$2 million in grants to 14 recipients.

Through its first grant program, KREC funding supported the research efforts of 22 researchers and 22 graduate students at the University of Kentucky and the University of Louisville.

The first competitive grant program funded seven projects for a total of \$1.15M. The state of Kentucky provided \$295,000 for cost share for the first program. Specific areas of research included harvesting and storage of lignocellulosic feedstocks, biocatalysts and bioconversion of lignocellulosic feedstocks into liquid transportation fuels and bioproducts, thermal conversion of biomass into energy and co-products, conversion of solar energy through new technology applications and development of industrially important biochemicals for production in biorefineries.

Research project descriptions are listed below. Final reports for all the KREC-funded research projects are available on KPPC's website – www.kppc.org/KREC.

Competitive Grants Program I 2005 – 2007 Research Projects Awarded Funding

Development of an Ethanol Pilot Scale Facility to Evaluate the Effect of Collection, Storage and Pretreatment of Corn Stover

\$173,627, **Michael Montross** PI, University of Kentucky/University of Louisville

The overall goal of this research is to reduce the cost of corn stover as a feedstock to a biorefinery by reducing collection, handling and storage costs and by increasing the efficiency of pretreatment, enzymatic hydrolysis and fermentation into value-added chemicals. The specific objectives that will be investigated to accomplish this goal will utilize a grain harvesting combine to collect mechanically fractionate high value corn stover components (i.e. cobs, leaves, and husks) that require less severe pretreatment. The assessment of existing ensiling practices for storage and pretreatment of corn stover prior to enzymatic hydrolysis will be studied, as well as the feasibility of performing the operations on-farm. The collection and storage strategies will be compared by fermenting the sugars into ethanol using *Saccharomyces cerevisiae*. The economics of the system will be compared using a partial budget and life cycle economic analysis to existing multi-pass, whole stover, dry baled collection operations that involve transporting material to a central biorefinery. The project will allow for the evaluation of corn stover, a residue available on Kentucky farms, to be converted to a higher value product in rural communities.

Development of an Integrated Solar Heat Pipe System for Improving Building Energy Efficiency

\$162,531, **M. Keith Sharp** PI, University of Louisville

The objectives of this project are to: 1) develop an improved computer model of the system by incorporating climate data for Kentucky; 2) perform a parametric study of system performance options to determine the most cost-effective and energy efficient combination of components; 3) develop integrated design concepts considering appearance, manufacturability, shipping, installation and service; and 4) construct an experiment and test the effectiveness of finned surfaces, fluid fill factor and insulation on the heat pipe in improving system efficiency. Compared to traditional passive solar heating systems, the solar heat pipe system provides a greater improvement in efficiency in Kentucky's cloudy climate than it does in sunny climates.



Nicholas E. Chmielewski, a graduate of the J.B. Speed School of Engineering built and helped install a full scale prototype of the solar heat pipe system on UofL's ShelbyHurst Campus.

Differentiating Microbial Pathway and Membrane Adaptations for Enhanced Performance in Extreme Environments

\$160,763, **Sue Nokes** PI, University of Kentucky

Few bacteria can convert biomass to ethanol directly, but *C. thermocellum* has this ability. However, to be commercially viable, this microorganism must tolerate more ethanol in the fermentation broth. This project will explore natural adaptations this organism has made to ethanol in order to use this information to further improve the organism. The overall goal of this project is to mathematically model the biochemistry and membrane structural characteristics of wild-type and ethanol-adapted thermophilic, anaerobic bacteria, *C. thermocellum*, in response to environmental stress, such as high concentrations of ethanol in the fermentation broth. The overall goal will be

achieved by measuring carbon flow through the biochemical pathways of the cell and quantifying changes in the cell membrane between the two cell types of *C. thermocellum* as the external environment is changed; and correlate the biochemical and cell membrane changes with environmental treatments to gain a mechanistic understanding of cellular adaptations in an ethanol-tolerant organism.

Dr. Sue Nokes, keynote speaker at the June 29, 2011 KREC quarterly meeting, discussed her initial 2005

KREC-funded grant and how it helped in securing a \$6.9 million DOE grant for the University of Kentucky Biosystems and Agricultural Engineering Department. The new grant, which begins in July, 2011, will support research for a new biofuels project at UK.



Novel Catalytic Approaches for Bio-Oil Upgrading

\$101,083, Czarena Crofcheck PI, University of Kentucky

Crude bio-oil, which can be obtained from the thermal processing of biomass, is a potential renewable replacement for crude petroleum oil. However, it is not stable for long periods of time, which makes it difficult to store and transport. Our objective is to examine two concepts aimed at catalytic deoxygenation of bio-oil, mild cracking over base catalysts and metal oxide-catalyzed deoxygenation. The efficacy of the catalytic treatments will be assessed, as applied to a model bio-oil and a crude bio-oil produced via fast pyrolysis from softwood biomass. This assessment will be based both on characterization of the resulting bio-oils, as well as standard methods for quantifying bio-oil viscosity and color. Development of these processes will facilitate bio-oil stabilization to a product suitable for shipment to a centralized biorefinery, where subsequent product separation and upgrading can take place. The overall objective of this project is to examine two novel processes to increase the stability of bio-oil so that it can be shipped to refineries for conversion to fuels and chemicals.

Photocatalysts for Solar Energy and Hydrogen Production

\$314,280, Gerold Willing PI, University of Louisville

This project, which provides seed funding for a new research initiative in the Commonwealth of Kentucky, looks at a new, low cost solar cell with dramatically improved efficiency. The solar cell technology that is proposed here, if successful, could be used for generating electricity or for producing hydrogen from water. This new solar cell would be scaleable for household use and could quickly be propelled into commercial application. The most important characteristic of solar technology is that it does not cause pollution while generating energy.

Production of Biomass Briquettes as an Alternative Fuel Source

\$125,759, Michael Montross PI, University of Kentucky

The overall goal of this research is to produce a premium, durable briquetted biomass fuel from agricultural and wood wastes that is an attractive alternative energy source for coal-fired boilers, for industrial process heat and steam generation, and could potentially be utilized in residential applications. The feedstocks investigated are corn stover, fescue, and wood waste as a fuel source for the briquettes. Assess the performance of inexpensive binders available from farms and agricultural processing facilities (e.g., poultry litter, gum residue from soybean oil extraction plants, and distillers grain from ethanol production facilities) to lower the production cost of the briquettes. After manufacturing, the energy content, chemical composition, and strength and attrition characteristics of the briquettes produced will be measured.

Weather Responsive Ventilation for Residential Energy Efficiency and Indoor Air Quality

\$109,988, Donald Colliver PI, University of Kentucky

Between one-third and one-half of the cost of heating and cooling a well-insulated house is due to air leaks. Indoor air quality concerns become important when buildings are built tighter to reduce these leaks in order to reduce the heating and cooling bills. This project

will determine the optimal amount of air to bring into the house in order to maintain adequate indoor air quality while minimizing the energy used for ventilation. It will then develop and test a prototype fan control system, which will adjust the amount of ventilation in the house. The control will be based on outside temperature and wind velocity.

Competitive Grants Program II 2008 – 2011 Research Projects Awarded Funding

The 2009 Competitive Grants Program received 43 letters of inquiry for projects covering a wide range of renewable energy and energy efficiency research interests at six Kentucky universities. Twenty-nine of these projects responded to KREC's Request for Proposals (RFP), issued in May, 2008. Projects were reviewed according to the guidelines set forth in the RFP and a total of \$864,000 was awarded to the seven projects listed below.

Large Size, Lithium Ion Batteries for HEV Applications

\$199,996, Mahendra Sunkara & Gamini Sumanasekera PI, University of Louisville

New energy technologies based on electric/hybrid electric vehicles (EV/HEV) are crucial to the enrichment of U.S. economic security and reducing dependence on foreign oil. Currently, a major hurdle to achieving this goal is that safe, cost-effective and weather-tolerant large lithium ion batteries for vehicular applications requiring a pack-capacity for 100 miles per charge, are not readily available.



Dr. Mahendra Sunkara, Conn Center, J.B. Speed School of Engineering, University of Louisville.

A Li-ion battery is comprised of a negative electrode (anode) which is typically graphite, a positive electrode and a non-aqueous liquid electrolyte. Although carbon electrodes have been the conventional anode materials, a few challenges persist and limit their use for electric vehicle applications. Some of the disadvantages with carbon anode materials include low storage capacity, low compatibility with other polymer electrolytes and ionic liquids and safety temperature range. Hence, it is necessary to develop new non-carbon based anode materials.

Optimal Energy Usage Control for Residential Solar Photovoltaic Systems

\$50,000, Donald Colliver PI, University of Kentucky

In a house, there are many different ways to utilize the energy production from photovoltaic collectors. For example, the power can immediately be put back on to the electrical grid, used to heat or cool the house, used by many electrical appliances or stored in either electrical or thermal storage devices to be used or put on the grid at a later time. The control of these systems has the

potential to be very complex. Control systems need to be analyzed to determine the potential increases in efficiency and developed to optimize these energy storage and flows.

The objective of this project is to demonstrate and determine the effectiveness and maximum potential savings (energy, dollars or carbon) of an optimized energy management system in a house which has multiple sources of energy.

Nanostructured Device Designs for Enhancing the Performance of Thin Film CdTe/CdS and CIS/CdS Solar Cell Devices

\$181,528, **Vijay Singh** PI, University of Kentucky

The increasing demand for energy (from 14 terawatts in year 2000 to 50 terawatts in year 2050) and its environmental impact require a renewed effort and novel approaches to developing clean and efficient energy sources. Nanoscience and nanotechnology offer exciting approaches to addressing these challenges. At the root of the opportunities provided by nanotechnology is the fact that all the elementary steps of energy conversion (such as charge transfer, molecular rearrangement, chemical reactions etc.) take place at the nanoscale. Thus the development of new materials, device structures as well as methods to characterize, manipulate and assemble them, creates an entirely new paradigm for developing new and revolutionary energy technologies.



Dr. Vijay Singh, University of Kentucky.

The proposed research involves the fabrication, characterization and analysis of Nanoscale heterojunctions inside an insulating Alumina (Al₂O₃) matrix and applying this understanding to increase the short circuit currents and efficiencies of solar cells based on above semiconductors. The potential applications of this research include energy conversion, display devices and sensors. These thin film solar cells are already part of a multi-billion industry, which is growing at a fast pace.

Dr. Singh will continue related research with a five-year, \$1.26 million grant from the National Science Foundation. The NSF grant will fund work on developing techniques for forming new solar cell materials by utilizing electron beam for nanoscale processing in liquid phase.

Investigation of Cooling Season Performance of a Solar Heat Pipe System

\$91,568, **M. Keith Sharp** PI, University of Louisville

This project evaluates options for enhancing the performance during the summer cooling season of a novel passive solar heating system that utilizes the one-way heat transfer of heat pipes to significantly improve heating performance relative to conventional systems. This system has already been shown to be roughly twice as effective as the typical direct gain system during the heating

season and, with this proposed project, is expected to demonstrate similarly significant increases in effectiveness during the cooling season. This project will support the growth of renewable energy research in the Commonwealth and result in the creation of new commercial and industrial opportunities in renewable energy.

The objective of this project will be to quantitatively evaluate various cooling options with computer simulations, and bench-scale and full-scale experiments.

Production of High Value Cellulase Enzymes from Tobacco Biomass

\$100,475, **Eric Berson & Keith Davis** PI, University of Louisville

The objective of this research project is the development of lower cost, plant-based expression systems to produce enhanced cellulose degrading enzymes. Reduction in the cost of mass-producing cellulase enzymes, a key economic bottleneck in the conversion of biomass to ethanol, will boost production of second generation biofuels. Tobacco plants can play a role in producing cellulase enzymes for ethanol production.

The objectives are to optimize plant-based expression systems to produce enhanced, lower-cost cellulose-degrading enzymes, compare plant-produced CBH1 to CBH1 purified from Spezyme CP, and obtain preliminary data for more comprehensive proposals to federal agencies such as the Department of Energy and the Department of Agriculture.

This project incorporates an important Kentucky agricultural resource, tobacco, that has recently become under-utilized due to known health issues associated with smoking. The use of tobacco crops to mass produce enzymes works towards the goal of developing more efficient and economical methods for producing a fermentable sugar stream from biomass, and for the downstream conversion of biomass to fuels and chemicals.

Development of a Solid Catalyst-Based Technology for Production of Biodiesel from Waste Vegetable Oils

\$200,000, **Mahendra Sunkara & Paul Ratnasamy** PI, University of Louisville

The 2007 Renewable Fuel Standard (RFS) and Energy and Independence Security Act designates 22 billion gallons of the 36 billion gallons of biofuels production by 2022 to come from non-food-based biomass (such as nonfood crops, waste vegetable oils, algae, switch grass, waste biomass, municipal wastes etc.). This has caused a change in focus during the last few years, from renewable to sustainable (economically and environmentally) raw material for biofuels.

In response to this change, the biofuels industry worldwide is now focusing on the development of next generation feedstocks and technologies. The United States produces in excess of 3 billion gallons of waste vegetable oils annually.

Catalytic technology can convert Waste Vegetable Oils (WVO) into biodiesel. Unlike refined oils, WVOs contain significant amounts of Free Fatty Acids (FFA), water and other impurities. A solid catalyst-based technology for conversion of WVOs is, currently, not available worldwide. We propose to develop such a technology in this project.

The project involves reacting triglycerides and FFAs in Waste Vegetable Oils with methanol over a solid catalyst to yield, quantitatively, the fatty acid methyl esters (FAME known popularly as "biodiesel") and glycerol. This glycerol (> 98% pure) will be suitable for use as a chemical feedstock. Unlike the current alkali – catalyzed processes, there will be no metal contaminants (like Na or K) or soap in the outlet from the reactor containing the solid-catalyst. Biodiesel from WVOs is, still, one of the few economically profitable options available to the biofuels industry provided an appropriate technology is available.

The Conn Center recently announced that AliphaJet, Inc. has successfully licensed and demonstrated a highly cost-effective catalytic method (BoxCar™) for making jet biofuel from renewable products such as plant and animal triglycerides and/or fatty acids.

The catalytic method was developed at the University of Louisville's Conn Center for Renewable Energy Research by Senior Research Scientist, Paul Ratnasamy, PhD, who patented the process in 2010. The licensing of Dr. Ratnasamy's process is a major success for the Conn Center, which conducts and facilitates R&D on potentially commercializable renewable energy and energy efficiency technologies.

Cost Effective Energy Efficient School Design-Applied Research – Energy Efficiency

\$40,614, **W. Mark McGinley** PI, University of Louisville

The goal of this project will be to use Leadership in Energy and Environmental Design (LEED) for Schools-New Construction and Major Renovations, and the Kentucky Green and Healthy Schools Design Guidelines to develop a list of low life-cycle cost systems (both first cost and maintenance costs) that can be used to meet, at least in part, the energy efficiency and sustainability goals of the State of Kentucky. Specially, the study will focus on evaluating building envelope systems, day-lighting and heating and cooling system configurations that have, or could be, incorporated into school designs. The investigation will also include a structural, energy and economic analyses of a prototype middle school building to determine the effects of the systems described above, as well as the effect of:



Dr. Mark McGinley, University of Louisville.

1. Increased design life. The investigation will evaluate how life-cycle costs are changed by increasing the design life of the schools and what is the most cost effective design life for a school.

2. Day-lighting on envelop/building performance and cost. The investigation will look at optimizing the costs of day-lighting systems while maintaining the effectiveness of this lighting source and the building energy performance.

Patents for KREC-funded grants have included the following:

- M.K. Sunkara, J.H. Kim and V. Kumar, "Reactor and Method for Production of Nanowires", US Provisional Patent Application Filed, 60/978,673, October (2007).
- M.K. Sunkara, P. Meduri and G.U. Sumanasekera, "High capacity anode materials for Li Ion batteries", US Provisional Patent Application 61/141,502, December (2008).
- M.K. Sunkara, J.H. Kim and V. Kumar, "Reactor and Method for Production of Nanowires", US Provisional Patent Application Filed, 60/978,673, October (2007).
- Catalytic Isomerisation of fatty acid esters. U.S. 61/ 350238; patent filed on June (2010).
- Process for the production of paraffinic hydrocarbons. U.S.61439112, patent filed on February (2011).
- Process for the production of fatty acid alkyl esters (Being filed by the Office of Technology Transfer at the U.S. Patent office)

Additional Funding Awarded to KREC Researchers

KREC-funded projects have secured an additional **\$11.6 million in grants** to continue their research.

Dr. Sue Nokes' project began with a 2007 seed grant from KREC which helped her secure additional funding -- \$250,000 from Sun Grants and almost \$1 million from the U.S. Department of Energy and the Department of Agriculture in 2009. In 2011, Dr. Nokes helped secure a \$6.9 million DOE grant for the University of Kentucky Biosystems and Agricultural Engineering Department.

Dr. Vijay Singh from the University of Kentucky will continue related research with a five-year \$1.26 million grant from the National Science Foundation.

In 2011, Dr. Don Colliver, a KREC-funded researcher in Round I and II and Larry Holloway, Chair of the Electrical and Computer Engineering Department at the University of Kentucky, secured a \$1.5 million grant from the Department of Energy.

KREC – Organizational Chart

KREC is administered by KPPC – Kentucky Pollution Prevention Center, J.B. Speed School of Engineering University of Louisville. KREC's Advisory Board is made up of members of the University of Louisville, the University of Kentucky and the Kentucky Department for Energy Development and Independence.

