Public Abstract

Recycling Midwest's Energy: Improving Energy Efficiency and Reliability to Enhance Economic Development

Objective: The objective of this program is to significantly improve the economics of Distributed Energy and demonstrate to key Midwestern industries that recycling energy will help foster industrial revitalization by reducing energy costs, improving energy reliability, increasing productivity, reducing emissions, mitigating volatile gas prices and lowering electric prices. This proposal addresses two program areas identified in the State Technologies Advancement Collaborative solicitation, Industrial Technologies and Distributed Energy, with Industrial Technologies serving as the primary program area.

Benefits: Recycling energy is a process by which otherwise wasted energy is captured and used productively thereby significantly improving the economics of advanced distributed energy (DE) technologies and/or combined heat and power (CHP) systems. It is anticipated that up to 0.25 Quads of energy could be recovered by recycling energy, or capturing what is often referred to as "free fuel," within the four Midwest industries showcased in this program. Up to 1.5 Quads of energy could be recovered by recycling energy in these same industries throughout the country. Specific program deliverables include:

1. Helping the selected industries design and develop recycling energy projects using advanced DE/CHP technologies within the participating states.

- 2. Showcase the benefits of recycling energy in actual industrial-scale installations.
- 3. Foster revitalization of four select Midwest industries that can be replicated in other industries and states.

Budget and Time Frame: The estimated cost of this 18-month project is $4,132,143, with $3,636,000 in cofunding. The funding requested from NASEO is $496,143 - only 12% of the total project costs.

Methodology:

1. Identify and quantify recycling energy opportunities within four industries and five corresponding Midwest states. (i.e. ***Ethanol*** – WI/IL, ***Food Products*** – MN/OH, ***Natural Gas Gate Stations*** – IL/IN, and ***Municipal Wastewater*** – IL/IN).
2. Create toolkits for state agencies to use in developing recycling energy opportunities.
3. Document case studies that demonstrate the benefits of recycling energy in select industries.
4. Help state agencies conduct conferences or other recycling energy outreach activities.
5. Implement a recycling energy demonstration project within a minimum of two of the four showcase industries, while providing substantial separate funding for additional demonstrations.

Sponsoring Organizations: The University of Illinois at Chicago, Energy Resource Center (UIC/ERC) is leading this team.

Contact:
John Cuttica
University of Illinois, Chicago, Energy Resource Center
cuttica@uic.edu

Public Abstract

Novel Circulating Fluidized Bed Membrane Reformer for the Efficient Production of Pure Hydrogen for Fuel Cells from Renewable Bio-oils and Black Liquors

The primary objective of the proposed research is to develop novel catalytic steam reforming membrane technology for the production of pure hydrogen for fuel cells. The fuel for the reformer will be from such renewable sources as pretreated bio-oils and black liquors. The heart of the process is an efficient **C**irculating **F**luidized **B**ed **(CFB)** Reformer, which overcomes most bottlenecks of earlier technologies, including the **B**ubbling **F**luidized **B**ed **M**embrane **R**eformer **(BFBMR)** developed earlier by the P.I. Our objective will be achieved through many research routes. First, new catalysts will be developed and tested to meet the increased carbon formation encountered with bio-oils and black liquors. The catalyst will be designed to promote water-gasshift and reforming reactions for maximization of hydrogen and minimization of CO production (e.g.: Nickel based and Oxide catalysts such as Cr2O3). Second, a pilot plant will be designed, constructed, and operated to test the catalysts and develop rigorous design and control equations for replication and scale-up. Extensive mathematical models will be developed to describe fluid mechanics in the reformer, reaction kinetics, and a coupling of these models to predict the behavior of the process. The reformer configuration allows the utilization of heavy pre-treated renewable feedstocks, and incorporates hydrogen and oxygen selective membranes to recover pure hydrogen and selectively feed oxygen to greatly enhance reformer efficiency. Low temperature hydrogen selective membranes will be developed for enhanced hydrogen recovery and gas conditioning prior to dry reforming that further increases hydrogen recovery and reformer efficiency. The process will be optimized to maximize hydrogen production, minimize energy consumption, and reduce the cost/kg H2 production from $5-6 to the target cost of $1.5. The work will be completed over three years through the cooperation of Auburn University and the University of Alabama (this proposal), and through a linked proposal from the University of Virginia. The budget for the proposed research is $1,004,666 (including requisite cost-share), with an additional $201,565 associated with the linked proposal from the University of Virginia. The research not only addresses biomass issues in both of these states for efficient energy and hydrogen production, but utilizes expertise from each university to benefit Alabama, Virginia, and the nation. This research will result in lower energy use for production of pure hydrogen. It will use feedstocks from the forest industry to enable development of the hydrogen economy, as well as produce syngas that can be used for the production of chemicals. The combination of reforming to make hydrogen and dry reforming to reduce carbon dioxide and make syngas will reduce emissions. This work is directly related to DOE mission of energy efficiency and the development of renewable and alternative fuel sources. The technology is highly integrated, combining **CFBs**, membranes, and adsorbents into a single reformer with continuous catalyst regeneration and circulation. Publishing of results will be extensive in high-quality journals and conferences, and a book will be published by the investigators. A multidisciplinary approach will be adopted to maximize the exploitation of a number of fields in science and technology to advance and enable the novel reformer technology for deployment.

Contact:

P.I. - S.S.E.H. Elnashaie, Professor
Chemical Engineering Department, Auburn University
nashaie@eng.auburn.edu

Public Abstract
Biorefining of Food Residuals & Applications of Anaerobic Digestion

Over 663,900 tons per year of food processing residuals are created in Wisconsin alone, and the majority is landfilled. In addition, food processing is a major industry. Wisconsin and other states are working to revitalize food processing and its supply chain, in part, by expanded use of anaerobic digestion. In light of this, the Wisconsin Department of Administration (WDOA), the University of Tennessee, and Marquette University will join forces with STAC to demonstrate a novel biorefining process that generates products in addition to renewable energy from food processing residual digestion. Results of this project will be disseminated and linked to ongoing work in farm manure digestion.

The objectives are to (1) produce renewable energy, (2) gain residual-derived products (3) reduce greenhouse emissions, (4) reduce landfilled volume, and (5) decrease lifecycle cost of residuals management. Additional objectives are to address common Federal and State needs, disseminate results, and transfer technology for broad application.

In biorefining, organic feedstock is converted into energy, chemicals, and other products with minimum waste production. The following novel configuration will be used in a pilot-scale demonstration with valuable byproducts noted:

(1) Food residuals collection
(2) Physical pretreatment
(3) Thermophilic biohydrolysis & fermentation (volatile fatty acids)
(4) Mesophilic biomethanization of volatile fatty acids (methane for energy)
(5) Ultrafiltration (aqueous ammonia and phosphate fertilizer)
(6) Filtrate processing and nutrient reclamation (struvite (NH_4PO_3Mg) fertilizer)
(7) Stabilized biosolids processing (soil conditioner, dairy cow bedding material, etc.)

Collection and pretreatment will use a novel wet waste recovery system (WWRS) that includes vacuum conveyance and mechanical maceration developed by the project team member, Ecology LLC. Thermophilic biohydrolysis & fermentation as well as mesophilic biomethanization will be accomplished using a thermophilic anaerobic digestion elutriated phased treatment (TADEPT) system with an ultrafilter developed by the proposal team members at Marquette University, Drs. Daniel Zitomer and Michael Switzenbaum, with Mr. Thomas Bachman (Triad Engineering, Inc.). Filtrate processing and production of fertilizer, struvite (NH_4PO_3Mg), will be performed by Dr. Robert Burns of the University of Tennessee under a linked proposal.

Long range benefits of biorefining include enhanced national security (reduced dependence on foreign oil), rural economic growth, and US leadership in global bio-based technology. The total cost of the proposed 2-year project is $282,238. The total cost share is $155,955 (55% of the total). The total grant request is $126,283.

Contact:
Barbara Smith
Wisconsin Department of Administration
Barbara.Smith@doa.state.wi.us

Public Abstract
Realizing Energy Efficient Low Income Housing Utilizing Proper HVAC Design, Selection, and Sizing for Panelized Construction

The proposed 18-month demonstration project will address, with the guidance of Mississippi Department of Energy, major industry shortcomings for panelized construction manufactures – energy efficient HVAC design and selection in highly insulated building envelops. Working with existing businesses and University partnerships, this research will break market barriers by providing public resources that help contractors maximize energy utilization in panelized construction detailing HVAC design, selection, and construction techniques.

Specifically, this project will partner with the University of Memphis to research HVAC design and sizing for panelized construction in structural insulated panels with an expanded polystyrene foam core. This project will also research and demonstrated next generation of panelized construction utilizing recycle waste glass. Five energy efficient demonstration houses will be built utilizing existing panelized construction products (structural insulated panels) and one demonstration house will be constructed utilizing the next generation of materials (environmentally sustainable, inert, recycled glass products).

Mississippi State University has been working with various Mississippi small manufacturing businesses to build high quality, energy efficient, panelized housing for low income families. These projects utilize existing Structural Insulated Panels. The previous houses are energy efficient, but are not maximizing their energy use because contractors and mechanical engineers are unfamiliar with Structural Insulated Panels. Working closely with the University of Memphis, five energy efficient homes will be designed by the College of Architecture using manufactured housing techniques and constructed in a controlled environment using a trained labor force provided by United Way of Meridian, MS. The University of Memphis will research and study energy efficient HVAC design for panelized construction and use the five built houses as learning laboratories. The houses will be installed in infill neighborhoods throughout Meridian, MS on city donate land and finished on-site so the character of the house will be integrated into the existing neighborhood. Mississippi Department of Energy will conduct routine energy audits on these houses and publish a manual for proper HVAC selection and design for panelized construction.

Proposal provides 56% ($491,000) cost share and requests 44% ($284,665) in funding.

Contact:
Dr. Judith Phillips
Mississippi State University
phillips@sig.msstate.edu

Public Abstract
A Supply Chain Approach to Promoting Energy Efficiency in the Delaware and New Jersey Food Industry

The Center for Advanced Energy Systems (CAES) at Rutgers University proposes to demonstrate the opportunities to promote energy efficiency within a supply chain in the Delaware and New Jersey regional food industry. The Center for Advanced Energy Systems will coordinate the development and implementation of the project with the assistance of cosponsoring organizations, the Food Policy Institute at Rutgers and the Center for Energy and Environmental Policy at the University of Delaware. CAES has significant state and national experience in developing and implementing industrial energy and productivity improvement programs. The Food Policy Institute has been petitioned by its constituents in various food industry trade organizations to assist with their response to volatile energy costs. The Center for Energy and Environmental Policy is the recognized resource for energy and environmental assistance in Delaware and manages their state's Industries of the Future program for the U.S. Department of Energy.

The project team proposes a two-year, $422,883 project to promote energy efficient practices and technologies through the existing relationships of peers participating in a distinct supply chain. The project will identify strong supply chains operating in the regional food industry and recruit the supply chain leader that most clearly appreciates the potential benefits from a widespread energy conservation program. We will rely upon the strength of pre-existing relationships within the supply chain to disseminate the results of our technical assistance. Our model for technical assistance delivery is the Industrial Assessment Center (IAC) program which has helped over 10,000 small and medium-sized manufacturers become more energy efficient and productive since 1976. CAES currently serves as field manager for the USDOE IAC program assisting twenty-six university-centered industrial assessment teams supply their regional manufacturing bases with technical assistance services.

Ten to fifteen assessments, based on the IAC model, will be performed for diverse participants within one food industry supply chain. These assessments, the subsequent reports and follow-up assistance will form the basis of our demonstration of the processes, practices, technologies, financing sources, and public subsidies available to become more energy efficient. Technical assistance demonstrating the engineering and economics behind energy efficiency is expected to be more easily disseminated and more likely embraced when delivered from peer to peer. The benefits from the technical assistance offered to participants is expected to extend beyond the facility walls and be replicated by affiliates in the supply chain as a model for a revitalized food industry.

Contact:
Scott Hunter, Energy Analyst
Center for Advanced Energy Systems at Rutgers University
hunter@caes.rutgers.edu

Public Abstract

Advanced High Flux, High Selectivity Hydrogen and Oxygen Permselective Membranes for Circulating Fluidized Bed Membrane Reformers for the Production of Pure Hydrogen

The primary objective of the proposed research is the development and selection of hydrogen and oxygen permselective membranes suitable as components of a novel catalytic steam reforming membrane technology for the production of pure hydrogen for fuel cells. The fuel for the reformer will be from such renewable sources as bio-oils and black liquors that can be produced from the abundant biomass supplies in the United States.

Membrane reactors achieve higher efficiency by integrating in the same unit the reactor which generates the product with a separator that extracts it. *Hydrogen permeable membranes* in particular have been used in some implementations of steam reformers for hydrogen production, and they are now recognized to be the components that still limit the overall performance of the system, as they determine process efficiency and purity of the hydrogen product. As such, the availability of a novel, convenient membrane with improved lifetime and the possibility to achieve a much higher hydrogen flux would constitute an important step forward towards the practical implementation of the technology, and a determinant step to enable its commercial feasibility. In this approach, novel hydrogen membrane designs will be discovered by adopting a general template and optimizing configuration, materials, and fabrication techniques. *Oxygen permeable membranes* on the other hand are used to supply the oxygen needed for the partial oxidation of hydrocarbons, which would reduce the energy consumption of novel steam reformers. In this instance, commercial membranes are available but their actual performance under operation conditions is unknown. These membranes will be tested and selected to achieve optimal supply for the overall reaction and long-term stability under the reaction conditions.
This project is linked and closely integrated with the research proposed by Auburn University and The University of Alabama (AL) on the design and construction of a novel and efficient circulating fluidized bed reformer, which would incorporate the hydrogen and oxygen selective membranes fabricated and selected in this project. The work will be completed over three years; the budget for the proposed research is $ 198,812 (including requisite cost share) with an additional $ 1,004,666 associated with the linked proposal from Alabama.

This work will meet the overall research goal through several objectives. First, new hydrogen selective membrane designs, materials and fabrication techniques will be developed in order to implement novel, efficient, convenient and reliable membranes, suitable for operation in the proposed steam reformer. Second, optimum oxygen selective membranes will be selected among commercially available designs. Third, permeation equations will be experimentally determined for both types of membranes and passed on to the reactor designers in the linked proposal. Last, hydrogen permeable membranes will be fabricated and tested for long term performance and reliability in the pilot plant that will be constructed in the framework of the linked project.
The process will be optimized for maximum production efficiency and minimum energy consumption, reducing the cost of hydrogen production from $5-6/kg to $1.5/kg. By using renewable feedstock from biomass and reducing harmful emissions, this work responds to the DOE mission of energy efficiency and development of renewable and alternative fuel sources.

Contact:

P.I. – G. Zangari, Associate Professor
Dept. of Materials Science and Engineering, University of Virginia
gz3e@virginia.edu

Public Abstract

Deploying catalytic combustion technology in the production of natural wood charcoal

Sponsoring Organizations:
Virginia Tech
Virginia Department of Mines, Minerals & Energy – Division of Energy
West Virginia University
West Virginia Development Office – Energy Efficiency Program
Virginia Department of Forestry
West Virginia Division of Forestry

Objectives:

• Develop a portable wood charcoal manufacturing process for the Central Appalachian region that uses catalytic combustion to control air pollution.
• Determine the performance, operational characteristics, and costs of the charcoal manufacturing process.
• Evaluate markets for natural wood charcoal, assess profit-potential and develop marketing strategies.
• Deploy the portable kiln technology through public agencies in the states of Virginia and West Virginia.
• Demonstrate the methods for making portable kilns and for producing and marketing natural wood charcoal to forest managers, landowners, organizations, forest-products processors, entrepreneurs and other interested parties.
• Provide low or no-cost technical support to private and public organizations and individuals for producing natural wood charcoal.

Total Project Budget: $408,415

Timeframe: January, 2004 – June 2006.

Benefits:

• Improved utilization and economic gain from small diameter and commercially undesirable tree species and waste from wood products manufacturing.
• Cost-effective and environmentally sound reduction of logging slash and understory fuels that pose risk of wildfire.
• Create economic opportunities in rural forested areas.
• Increase timber value and forest health.

Methods: University research and development; public outreach including demonstrations, short-courses, landowner assistance programs, and print and online publications; deployment by public and private interests across the Central Appalachian region in Virginia and West Virginia; university faculty, graduate and undergraduate student teaching and learning.

Contact:
Philip Radtke
Virginia Tech
pradtke@vt.edu