2009 ANNUAL REPORT

INITIATIVE FOR RENEWABLE ENERGY & THE ENVIRONMENT

INSTITUTE ON THE ENVIRONMENT

UNIVERSITY OF MINNESOTA
Driven to Discover℠

INSPIRATION TO APPLICATION

TRANSFORMING THE CHALLENGES OF TODAY INTO THE PROMISES OF TOMORROW

The University of Minnesota's Institute on the Environment is discovering solutions to Earth's biggest problems through cutting-edge research, partnerships and leadership development. Our signature program, the **Initiative for Renewable Energy and the Environment** (IREE), is a central part of this mission.

When it comes to energy and the environment, there is no shortage of new ideas. More challenging is to find connections among them. Too often visionaries, investors and implementers work in parallel, their paths never completing the circuit that transforms inspiration into application.

Catalyzing such connections is what IREE is all about. Established in 2003 to disburse revenues from the Xcel Energy Renewable Development Fund, IREE promotes statewide economic development; sustainable, healthy and diverse ecosystems; and national energy security.

We meet this goal by supporting the best ideas around. To date, some 425 faculty, staff, students and visiting scholars have been involved in IREE projects. In fiscal 2009, IREE invested almost $6.3 million in 28 research projects. Close to $900,000 in additional matching funds are earmarked for projects that could bring another $13.6 million to the U of M and its partners.

Our vision: a better Minnesota and a better world. Our passion: to advance the development of economically and environmentally beneficial renewable energy systems, transforming the challenges of today into the promises of tomorrow.

PARTNERSHIPS & OUTREACH

IREE IS A TEAM BUILDER, LINKING INNOVATION WITH THE PRIVATE- AND PUBLIC-SECTOR RESOURCES NEEDED TO MOVE TOWARD APPLICATION.

GREENER CITIES

IREE and the Twin Cities Metropolitan Council are assessing sewage as a substrate for fuel-producing algae; creating algal systems to clean up wastewater; exploring the development of a better city bus; and providing students with summer internships.

NONSTOP ENERGY

IREE partnered with Xcel Energy on a research project to evaluate and demonstrate wind energy storage technologies.

PREMIUM BLEND

An IREE-sponsored collaboration between Rochester Public Utilities and the U of M, Rochester combined fuel cells and geothermal energy in a hybrid energy system.

MANUFACTURING MAKEOVERS

IREE research connections with 3M are opening doors to reducing power-plant emissions, growing algae to sequester carbon dioxide, and improving the economics of ethanol production.

SINCE 2003, FUNDING FROM IREE HAS HELPED LEVERAGE MORE THAN $47.8 MILLION IN FEDERAL AND OTHER GRANTS.

WIND POWER PLAYERS

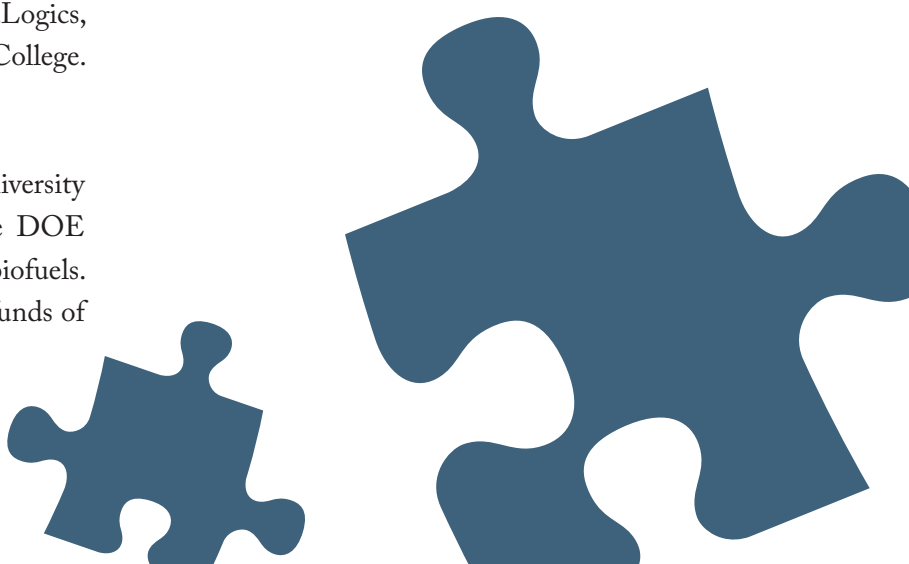
The U.S. Department of Energy awarded up to $8 million to an IREE-led consortium to advance wind energy technologies. The consortium includes the U of M, Barr Engineering, Eaton Corporation, Honeywell, Lockheed Martin, Luna Innovations, Siemens Energy, 3M, WindLogics, Syracuse University and Dakota County Technical College.

SINGLE-CELLED SUCCESS

A team of U of M researchers and BioCee, a university start-up company, received $2.2 million from the DOE for a research proposal using bacteria to produce biofuels. IREE provided early-stage support and matching funds of $300,000 for this project.

BIOMASS EFFECT

Based on results obtained through IREE investments, the National Science Foundation awarded $1.9 million to develop a "one-pot" method for converting biomass to more functional fuels.



SUPPORTING STUDENTS

PROCEEDS FROM IREE'S ANNUAL E3 CONFERENCE SUPPORT OUTSTANDING STUDENT PROJECTS. THIS YEAR'S RECIPIENTS INCLUDE:

◄ NO PLACE LIKE HOME

A solar-powered house, designed and built by students with IREE support, competed with 18 others from around the country in a federally-sponsored Solar Decathlon. Two years in the making, Minnesota's entry came in first in lighting design and engineering, and fifth overall.

WASTE, WATER, WIKI

Transforming human waste to methane, improving sanitation and sharing solutions worldwide are three Engineers Without Borders projects benefiting from IREE funding. The waste-to-gas project will provide renewable fuel in Haiti. The sanitation initiative is helping a community in Mulobere, Uganda. And, through a "Geo-Wiki," the U of M student group will share successes for others to emulate.

RACE WAY

IREE provided an early investment in the U of M's 2008-09 solar vehicle project, leveraging resources to sponsor this student-led endeavor. The vehicle beat 10 other competitors, taking first place in the Formula Sun Grand Prix in Texas.

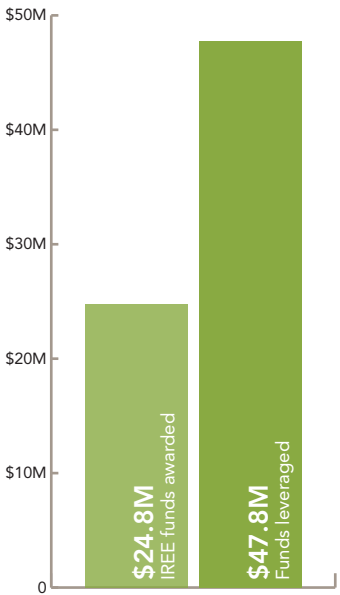
FROM AGRONOMY TO ZnO

Fourteen undergrads are pursuing renewable energy research this year with up to $1,700 each in IREE support. Goals include boosting corn yield, improving small-scale digesters for turning waste to fuel, converting biomass to industrial chemicals, and enhancing solar power.

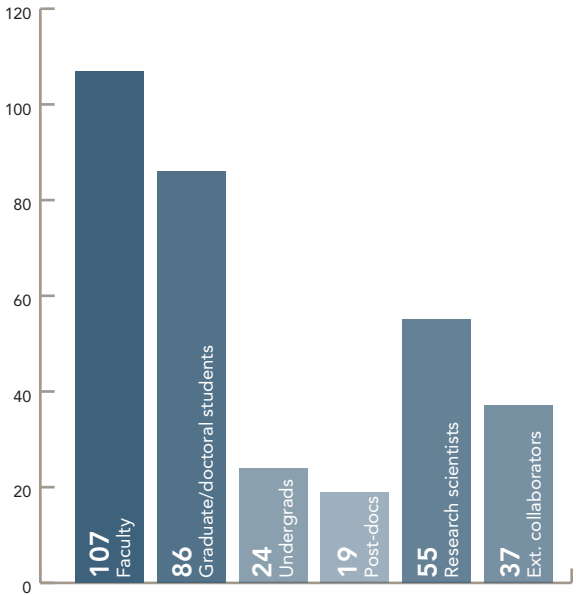
FACTS & FIGURES

IREE-FUNDED RESEARCH HAS LED TO EXTENSIVE PUBLICATION IN SCIENTIFIC JOURNALS, TECHNOLOGY PATENTS AND DISCLOSURES, AND EXTERNAL PARTNERSHIPS, ALONG WITH THE EDUCATION OF UP-AND-COMING ENERGY LEADERS.

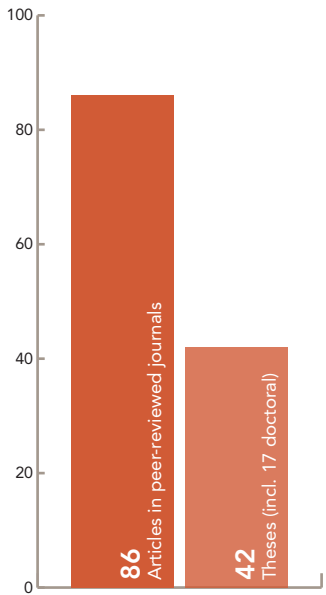
FINANCES



PERSONNEL



PUBLICATIONS



RESEARCH

SINCE 2003, IREE HAS AWARDED SOME $24.8 MILLION TO 170 RESEARCH EFFORTS, ADVANCING INNOVATION AND APPLICATION IN SIX KEY AREAS:

- BIOENERGY & BIOPRODUCTS
- CONSERVATION & ENERGY EFFICIENCY
- SOLAR
- WIND, HYDRO & GEOTHERMAL
- POLICY, ECONOMICS & ECOSYSTEMS
- HYDROGEN PRODUCTION, STORAGE & USE

2009 has been a particularly rewarding year. The foundation laid in previous years helped bring new federal renewable energy funding to Minnesota. IREE researchers' track records and matching funds allowed a rapid response to economic recovery-related grant opportunities. Through our large, seed and matching grant programs, we were able to invest in nearly 30 groundbreaking projects. The following pages showcase just a few.


Chuan

BUILDING BETTER BIOFUELS

BIOMASS IS ALL AROUND—BUT NOT ALWAYS IN THE FORM NEEDED. TREE LIMBS CAN'T MAKE A TRACTOR GO, AND CORN WON'T RUN YOUR GAS STOVE.

Improving conversion of biomass to fuels that fit the conventional liquid and gas framework is the task of two groups receiving IREE grants this year.

Scientist Roger Ruan and his colleagues are advancing the conversion of biomass to bio-oils that can be used to make renewable fuels. Current technologies produce oils that burn poorly, produce sparse heat and have a short shelf life. Ruan's team is developing a portable, thermochemical conversion system. The goal: a pilot commercial facility for producing high-quality, biomass-derived liquid fuels.

Extending sights further, chemical engineers Michael Tsapatsis (pictured) and Aditya Bhan envision a suite of technologies that will allow consumers to transform biomass into more versatile fuels—literally in their own backyard. For starters, they're developing a small-scale device to turn biomass into synthesis gas, methanol and bio-oils, which can eventually be used to make an LPG substitute or high-density liquid fuels.

"We think we'll get a blend" of hydrocarbons, says Bhan. In anticipation of that outcome, the team is also working to improve engines that burn fuels of varying composition. *Biofuels for the Farm: New Technologies for the Production of Biofuels in Small-Scale Systems, $600,000*

SOLAR @ NIGHT

SOLAR ENERGY HAS A LOT GOING FOR IT: IT'S AVAILABLE WORLDWIDE, COMES IN QUANTITIES FAR GREATER THAN GLOBAL ENERGY CONSUMPTION, AND PRODUCES NO CIVILIZATION-THREATENING GREENHOUSE GASES OR OTHER POLLUTANTS.

But it doesn't really fit into your gas tank and it's a challenge to store after dark.

Mechanical engineer Jane Davidson and collaborators from several educational institutions and industry are hoping to get around that obstacle with the help of some strategic salts and other substances.

In one line of investigation, the researchers are using concentrated solar energy, along with a molten carbonate salt catalyst/heat transfer medium, to turn biomass into synthesis gas, which can be used to generate electricity, charge fuel cells or make liquid fuels. Thanks to the solar input, this approach—which the researchers are gearing up to field-test in the California desert—is expected to yield functional fuels with an energy content higher than that of the biomass used to make them.

Another series of studies focuses on splitting water to produce hydrogen gas using solar energy and a two-step conversion process, which involves a metal oxide substrate. Three different approaches are currently being tested. In this case, as with the solar reactor, the output could readily be turned into user-friendly fuels.

These studies show tremendous promise for harnessing energy from the sun. "The sunlight-to-fuel efficiency for everything else is very, very low," says Davidson. "We're talking about giant leaps in going from sunlight to fuel." *Thermochemical Fuels: Solar at Night, $900,086*

TEAM ALGAE

ONE PERSON'S TRASH IS ANOTHER'S TREASURE, AND THE STUFF THAT FLOWS INTO WASTEWATER TREATMENT PLANTS IS LIKE BLACK GOLD FOR SCIENTIST ROGER RUAN.

With big help from some small accomplices, Ruan and colleagues are turning nutrients from sewage into economically viable and environmentally valuable renewable fuels.

Partners in the project include a dozen or so species of algae Ruan found in the wild, which have high oil content and grow well under harsh conditions. These microscopic plants literally eat nitrogen and phosphorus for breakfast—and every other meal. Nourished by the potential pollutants, along with energy from the sun and CO_2, the algae produce biomass that can be transformed into oils and biodiesel.

In collaboration with Metropolitan Council Environmental Services, Xcel Energy and others, Ruan has screened a variety of algae to identify those best suited for the job. He's designed and developed a closed photobioreactor system in which they can do their work. And he's improved the natural light-utilizing system to maximize their productivity.

Ruan is now refining the process for commercial application. One goal is to scale up the continuous growth and harvest system for pilot production of algae as an energy crop and for wastewater treatment. A second is to continue to improve efficiency and effectiveness in algal growth, harvesting and utilization.

"A large, pilot-scale wastewater algae production technology and system should be ready in about two years," says Ruan. *Converting Solid Biomass to Hydrocarbon Liquid Fuels, $250,000*

THIS IS A TEST

BUT DOES IT WORK? THAT'S THE MILLION-DOLLAR QUESTION WHEN IT COMES TO RESIDENTIAL-SCALE NEW ENERGY TECHNOLOGIES.

Led by Michael Reese, the U of M's West Central Research and Outreach Center is installing a facility to come up with answers.

As renewable energy director of WCROC, Reese is building a performance test center to assess and compare small-scale renewable energy systems. Initial test systems will include solar thermal domestic hot water and solar thermal space conditioning. Parameters to be evaluated for manufacturers include energy production, durability, operation ranges and economics. The test center will feature data acquisition and transmittal systems that are intended to allow homeowners, students and others to see test results in real time.

Reese is setting up the infrastructure and installing solar panels and other technologies that will be used to demonstrate and calibrate the testing devices. He's also writing a guide to renewable energy systems for homes and businesses. Next steps will be to develop test protocols and begin using them to test devices under development in the fast-growing field of consumer-scale, renewable energy technology. In addition to solar, the facility will have the capacity to move into testing fuel cells and other technologies as the need arises. *Evaluation, Validation and Demonstration of Small-Scale Renewable Energy Systems for Homes and Businesses, $304,790*

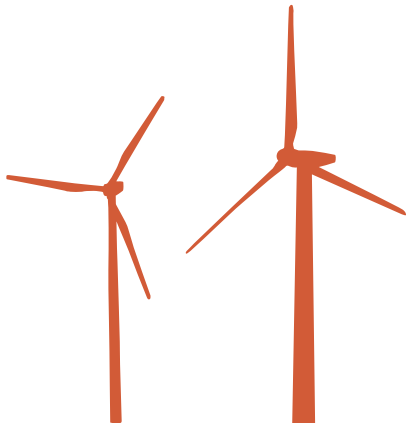
WIND STORM

IMPROVED WIND TURBINE PERFORMANCE IS THE SUBJECT OF STUDY FOR A LARGE IREE-LED CONSORTIUM FUNDED BY THE U.S. DEPARTMENT OF ENERGY.

Convened and supported by matching funds from IREE, the consortium will receive up to $8 million to support research, development and education. Partners include Barr Engineering, Eaton Corporation, Honeywell, Lockheed Martin, Luna Innovations, Siemens Energy, 3M, WindLogics, Syracuse University and Dakota County Technical College.

Other wind energy research efforts contribute to the flurry of activity advancing wind power generation. St. Anthony Falls Laboratory civil engineers Roger Arndt and Fotis Sotiropoulos are collaborating with 3M to apply flow control technology to design more efficient rotors for wind turbines. Improving on the mechanical gearbox concept is the focus of an IREE seed grant, led by mechanical engineer Kim Stelson. Aerospace engineer Gary Balas is looking to improve energy production by large wind turbines.

On the output end, electrical engineers Ned Mohan and Bill Smyrl have made progress toward better batteries for storing wind-generated electricity in collaboration with Xcel Energy. And innovative installations at the U of M, Morris aim to use wind to generate electricity for campus facilities, as well as hydrogen fuel for transportation and fertilizer production.



PIONEERING POLYMERS

ODDS ARE GOOD THAT, RIGHT NOW, YOU ARE TOUCHING A SYNTHETIC POLYMER. SUBSTANCES BELONGING TO THIS MASSIVE CLASS OF COMPOUNDS, WHICH BOASTS A $450 BILLION MARKET WORLDWIDE, ARE USED TO MAKE EVERYTHING FROM SELF-ADHESIVE MAILING LABELS TO HIGH-DEFINITION TVs.

Most are derived from fossil fuels. Could they be made in a more sustainable manner as well? Environmentally friendly polymers are the focus of the IREE-funded Center for Sustainable Polymers, led by chemistry professor Marc Hillmyer.

Hillmyer and his colleagues are focusing their initial attention on three types of advanced polymeric materials: pressure-sensitive adhesives, toughened plastics such as those used for electronic housings, and polyurethanes, which are found in coatings, foam insulation and other common materials.

One goal is to develop ways to convert organic compounds from sources such as sugar beets, soybeans and pine trees to a palette of new monomers, the building blocks of polymers. Another is to advance catalytic processes for stringing these monomers together. Third, the group plans to optimize properties, such as strength, elasticity and heat resistance, of the polymers produced. Other research will advance the environmental friendliness of polymers by evaluating aspects of the production-to-degradation, life-cycle analysis.

The center's main aim is to reduce the demand for fossil fuels used in the manufacture of nearly all existing synthetic polymers. In addition, the researchers hope to explore what Hillmyer calls "new vistas" offered by biopolymers to produce novel substances with unique properties.

"There's plenty of opportunity there to tap unrealized potential," he says. *Sustainable Polymers: Tomorrow's Advanced Materials, $800,000*

CARBON DOWN, POWER UP

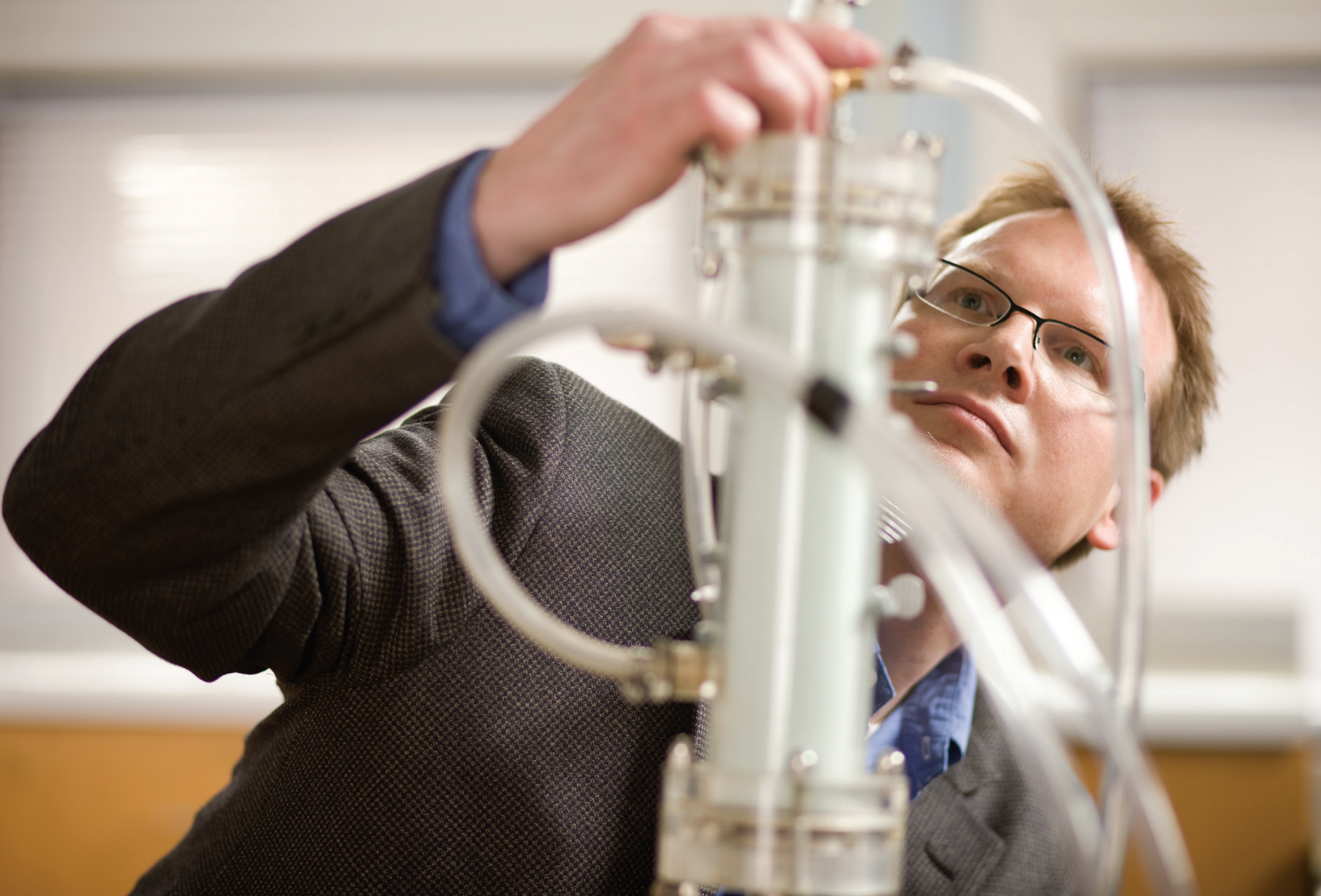
PRODUCE RENEWABLE ENERGY? SEQUESTER ATMOSPHERIC CO_2? HYDROGEOLOGIST MARTIN SAAR AIMS TO DO BOTH—AND AT THE SAME TIME.

Like other renewable energy researchers, he hopes to reduce fossil fuels' contribution of greenhouse gases to the atmosphere by advancing new technology. But he's also hoping to deal a unique one-two punch to climate change by combining that with an opportunity to store CO_2 beneath the surface of the earth.

Working with geologists, engineers, policy experts and economists from California, North Dakota and Minnesota, Saar is developing a closed-loop system that would send CO_2 into geologic formations a mile or two underground and let it gather heat. The system would then return some of the heated CO_2 to turn an electricity-generating turbine at the surface, while most of the injected CO_2 is permanently stored underground.

"It's a high-risk but potentially high-reward kind of research," says Saar. The approach goes beyond others seeking to tap geothermal energy because it uses CO_2 instead of water; it goes beyond other proposals to sequester CO_2 because it generates electricity at the same time.

Results to date are promising. "It looks like CO_2 is roughly twice as efficient at extracting subsurface heat as water is," says Saar. "This potentially could lead to regions using geothermal heat for electricity production that, up until now, were not able to. With CO_2 being roughly twice as efficient, we should be able to extend the geographic regions where geothermal electricity production is possible. Our hope is to eventually stretch it to Minnesota." *Combining Geothermal Energy Extraction and CO_2 Sequestration to Produce Clean, Renewable, Carbon-Negative Electricity, $600,000*



WHAT, WHERE, WHEN?

THOUGHTFUL DECISIONS ABOUT WHICH ENERGY SOURCES TO DEVELOP, AND WHICH TO USE IN VARIOUS CIRCUMSTANCES, INCLUDE CONSIDERATIONS OF PROS AND CONS OF EACH OPTION THROUGHOUT ITS LIFE CYCLE.

For conventional fuels and biofuels alike, that includes impacts of air-polluting emissions such as greenhouse gases, fine particulates and ozone.

To provide policy makers a more comprehensive tool for weighing the costs and benefits of production, distribution and use of a "near-dizzying array" of conventional and renewable energy sources, environmental engineer Julian Marshall (pictured) and ecologist Jason Hill are creating a new kind of life-cycle analysis—one that includes information on the "where" and "when," as well as the "what" of pollution.

Focusing on transportation and electricity generation, the researchers plan to produce a full-cost accounting of the types and amounts of air pollutants generated in growing, extracting, harvesting, processing, distributing and burning various fuels. In addition to assessing fossil fuels and first-generation biofuels, they will also look at cellulosic ethanol and biodiesel from algae.

The study will assess relative impacts of using biofuels to make liquid fuels and electricity. In addition, it will look at when and where impacts occur, and which people—rich, poor, urban, rural—are most likely to pay the costs and reap the benefits. The issue gets complex, says Marshall, because particulate and ozone impacts tend to occur where fuels are extracted, processed and burned, while greenhouse gases impact everywhere.

"We're looking for fuels that do well for both attributes: climate change and air pollution," says Marshall. "We're looking for the win-win." *Air Pollution Impacts of Conventional and Alternative Fuels, $599,786*

IREE PROJECTS

This listing includes projects that were active and awarded in FY 2009. Search our database at **environment.umn.edu/forms/project_search_form.php** for more details on all IREE projects, both active and closed.

BIOENERGY, BIOFUELS & BIOPRODUCTS

Biofuels for the Farm: New Technologies for the Production of Biofuels in Small-Scale Systems (RL-0004-09)
LEAD RESEACHER: Michael Tsapatsis (IT)
TOTAL FUNDING: $600,000
To develop catalytic processes and reactor configurations for the conversion of biomass to fuels, small-scale engine technology that can handle significant variations in feedstock composition, and process modeling and energy integration approaches for small-scale systems.

Biohydrogen-Based Biofuel Cells: Highly Efficient and Clean Electricity Generation Using Mixed Wastewater Feedstocks – A Rural Development Project (RS-0010-09)
LEAD RESEARCHER: Jun Zhu (SWROC)
TOTAL FUNDING: $70,000
To investigate the feasibility of developing a biological fuel cell system, which consists of a bio-hydrogen-producing fermenter connected to an enzyme-based fuel cell that can produce electricity directly from waste biomass.

Converting Solid Biomass to Hydrocarbon Liquid Fuels (RL-0032-09)
LEAD RESEARCHER: Roger Ruan (CFANS)
TOTAL FUNDING: $250,000
To develop catalytic reforming techniques for converting biomass to hydrocarbon liquid fuels using a thermochemical process.

Designer Proteins for Efficient Enzymatic Degradation of Recalcitrant Cellulose (LG-B4S2-2005)
LEAD RESEARCHER: Claudia Schmidt-Dannert (CBS)
TOTAL FUNDING: $122,500
To develop and understand procedures for less costly, more efficient disruption of the crystalline matrix of biomass for biofuels and bioproducts production.

Enhanced Biogas Formation from Animal Waste: Evaluation of a New Technology for Increased Biogas Quality and Quantity (RS-0006-09)
LEAD RESEARCHER: Michael Sadowsky (CFANS/BTI)
TOTAL FUNDING: $67,716
To evaluate the scientific basis for enhanced biogas production, as well as improved gas composition produced by an anaerobic digester using the Hogen process.

Environmental Genomic Libraries for Discovering Novel Enzymes for Bioenergy and Biocatalysis (SG-B1-2006)
LEAD RESEARCHER: Michael Sadowsky (CFANS/BTI)
TOTAL FUNDING: $49,932
To construct a series of metagenomic libraries that can subsequently be used to identify novel biocatalysts for alternative energy and other research and development needs.

Gene Expression in the Cattails *Typha latifolia*, *Typha Angustifolia* and *Typha x glauca* (SO1-2007)
LEAD RESEARCHERS: Bradley Cook (MSU), Nathan Springer (CBS), Daniel Toma (MSU)
TOTAL FUNDING: $28,000
To study the differential gene expression among three cattails, which vary phenotypically in traits critical to understanding biofuels production, invasiveness, nutrient retention, water quality and hybrid vigor.

Hydrothermal Carbonization of Algae and Agricultural Wastes: Synthetic Bio-coal (RS-0037-09)
LEAD RESEARCHER: Kenneth Valentas (BTI)
TOTAL FUNDING: $70,000
To use carbon that has been fixed and sequestered by algae and other plant materials to rapidly and efficiently produce synthetic coal.

An Integrated Approach for Optimization of Microbial Fuel Cells (LG-B8-2005)
LEAD RESEARCHERS: Daniel Bond (BTI), Edward Cussler (IT), Raymond Hozalski (IT), Timothy LaPara (IT)
TOTAL FUNDING: $476,912
To devise new methods for studying microbial power sources and integrate this experimental work with modeling, allowing a more rational understanding of the scientific, technical and commercial feasibility of this process.

Mass Culture of Microalgae for Biofuels (M1-2007)
LEAD RESEARCHER: Roger Ruan (CFANS)
TOTAL FUNDING: $40,000
To develop transferable technologies for the mass culture of microalgae, utilizing nutrients from wastewater and the carbon from flue gas, for biofuel production (this project also involves Professor Nancy Carpenter and students at the UMM).

Maximizing Production of Fermentable Sugars, Fiber and Energy by Matching Biomass Species to Landscape Position (LG-B11-2005)
LEAD RESEARCHERS: Gregg Johnson (CFANS), Hans Jung (USDA-ARS/CFANS), Craig Sheaffer (CFANS), Ulrike Tschirner (CFANS), Don Wyse (CFANS)
TOTAL FUNDING: $497,021
To assess environmental impacts, conduct economic analyses and characterize a diverse set of herbaceous and woody plants for their potential yields of biomass, fiber and fermentable sugars at two locations in Minnesota.

Minnesota Microorganisms for Electrical Biocatalysis: Novel Bacteria from Minnesota Habitats that Use Electrodes to Increase Bioproduct Value and Capture Carbon (RS-0013-09)
LEAD RESEARCHER: Daniel Bond (CBS)
TOTAL FUNDING: $70,000
To identify novel bacteria and obtain new models for the study of organisms able to link electricity to biological carbon capture and biocatalysis.

Rational Development of Industrial Strains (RM-0012-09)
LEAD RESEARCHER: Friedrich Srienc (BTI)
TOTAL FUNDING: $20,485
To develop microorganisms using metabolic engineering tools for the production of biofuels.

Recombinant Lignin Depolymerase with Enhanced Stability and Catalytic Activity (LG-B4-2005)
LEAD RESEARCHERS: Steve Gantt (CBS), Simo Sarkanen (CFANS)
TOTAL FUNDING: $370,000
To isolate, characterize and produce the first true lignin-degrading enzyme for biofuels and bioproducts production.

Sustainable Forest Feedstock for Bioenergy Production: Enhancing Physical and Economic Availability (RM-0004-09)
LEAD RESEARCHERS: Dennis Becker (CFANS), Dean Current (CFANS), Anthony D'Amato (CFANS)
TOTAL FUNDING: $44,895
To determine the availability of forest biomass for use in bioenergy and fuel applications in Minnesota.

Sustainable Polymers: Tomorrow's Advanced Materials (RL-0009-09)
LEAD RESEARCHER: Marc Hillmyer (IT)
TOTAL FUNDING: $800,000
To design, prepare and implement advanced polymers from biomass for a wide range of applications, and to establish a Center for Sustainable Polymers at the U of M.

Use of Transcriptomics to Identify Lignin-Degrading Enzymes in Fungi (RS-0028-09)
LEAD RESEARCHER: Steve Gantt (CBS)
TOTAL FUNDING: $75,000
To better understand how lignin is broken down—a process that is vital to converting complex feedstocks to biofuel.

Utilization of Corn Cobs for Biomass Gasification Systems: Comprehensive Evaluation and Demonstration (D1-2009)
LEAD RESEARCHERS: Deborah Allen (CFANS), James Barbour (UMM), Lowell Rasmussen (UMM), Michael Reese (WCROC), Jeff Strock (SWROC), Joel Tallaksen (WCROC/UMM)
TOTAL FUNDING: $74,836
To collaborate with a diverse public/private team in assessing and evaluating the utilization of corn cobs in biomass gasification systems.

ACRONYMS

ARS: Agricultural Research Service
BTI: BioTechnology Institute
CBS: College of Biological Sciences
CFANS: College of Food, Agricultural and Natural Resource Sciences
CINRAM: Center for Integrated Natural Resources and Agricultural Management
ETH: Eidgenössische Technische Hochschule
HHH: Humphrey Institute of Public Affairs
IT: Institute of Technology
MSU: Minnesota State University
NRRI: Natural Resources Research Institute
SAFL: St. Anthony Falls Laboratory
SOC: Southern Research and Outreach Center
SWROC: Southwest Research and Outreach Center
UMM: University of Minnesota, Morris
USDA: United States Department of Agriculture
WCROC: West Central Research and Outreach Center

Projects continue on next page...

POLICY, ECONOMICS & ECOSYSTEMS

Air Pollution Impacts of Conventional and Alternative Fuels (RL-0026-09)
LEAD RESEARCHER: Julian Marshall (IT)
TOTAL FUNDING: $599,786
To perform spatially-and temporally-explicit life cycle assessments for biofuels and the fossil fuels they displace; this research will provide new knowledge on the costs, benefits and tradeoffs of greenhouse gas emissions and air quality related to biofuel production.

Low Carbon Fuel Standards (M1-2008)
LEAD RESEARCHER: Steven Taff (CFANS)
TOTAL FUNDING: $25,000
To investigate the policy and economic implications of implementing a low carbon fuel standard in Minnesota and to select and calibrate an appropriate life cycle assessment model.

State Climate Action Planning: Geography of Regional and National Climate and Renewable Energy Policy (RS-0034-09)
LEAD RESEARCHER: Elizabeth Wilson (HHH)
TOTAL FUNDING: $69,100
To investigate Minnesota's greenhouse gas reduction policy and renewable technology choices by analyzing results from 14 state climate action plans facilitated by the Center for Climate Strategies.

SOLAR, WIND & ENERGY CONSERVATION

Advanced Energy-Efficient Roof System (M4B-2004)
LEAD RESEARCHER: Jane Davidson (IT)
TOTAL FUNDING: $250,000
To create a one-piece modular roof panel that reduces the total energy required for heating and cooling of a new home by no less than 10 percent.

Advancements in Solar Heating and Cooling (M6-2008)
LEAD RESEARCHER: Jane Davidson (IT)
TOTAL FUNDING: $100,000
To develop a system that uses liquid desiccants as part of a strategy to provide annual storage for three dominant thermal end uses in residential buildings—domestic hot water, space heating and space cooling—to achieve net-zero energy homes.

Combining Geothermal Energy Extraction and CO_2 Sequestration to Produce Clean, Renewable, Carbon Negative Electricity (RL-0014-09)
LEAD RESEARCHER: Martin Saar (IT)
TOTAL FUNDING: $600,000
To investigate the feasibility of developing a geothermal power plant that generates electricity in low to intermediate heat flow regions, while sequestering carbon dioxide in the subsurface.

Creation of Energy-Efficient Inorganic-Bonded Structural Insulated Panels (RS-0029-09)
LEAD RESEARCHER: Matthew Aro (NRRI)
TOTAL FUNDING: $52,650
To combine the properties of chemically-bonded inorganic binders with regionally-sourced and underutilized red pine forest thinnings in order to create moisture-, decay-, fire- and mildew-resistant structural insulated panels.

Development of a High-Resolution Virtual Wind Simulator for Optimal Design of Wind Energy Projects (M4-2008)
LEAD RESEARCHERS: Fernando Porte-Agel, Fotis Sotiropoulos (SAFL)
TOTAL FUNDING: $72,000
To advance wind turbine design and optimization through meso-scale modeling, large-eddy simulation of the atmospheric boundary layer at the scale of a wind farm, and high-resolution, three-dimensional modeling at the scale of a wind turbine.

Evaluation, Validation and Demonstration of Small-Scale Renewable Energy Systems for Homes and Businesses (RL-0007-09)
LEAD RESEARCHER: Michael Reese (WCROC)
TOTAL FUNDING: $304,790
To evaluate small-scale renewable energy systems and become an accredited performance test center. The team will work to create a business model and to jumpstart the infrastructure for a self-sustaining, fee-based center.

Hydrostatic Transmission for Wind Power Generation (RS-0008-09)
LEAD RESEARCHER: Kim Stelson (IT)
TOTAL FUNDING: $57,406
To assess the potential economic and technical advantages of using a hydrostatic transmission rather than a mechanical gear box for wind power generators.

Improved Energy Production for Large Wind Turbines (RS-0039-09)
LEAD RESEARCHER: Gary Balas (IT)
TOTAL FUNDING: $50,000
To study the tradeoffs associated with controlling wind turbines, with the potential impact of enabling the construction of larger, more efficient wind turbines.

Laterally Integrated Photovoltaic Devices (RL-0019-09)
LEAD RESEARCHER: Philip Cohen (IT)
TOTAL FUNDING: $800,000
To develop an inexpensive, integrated package using holographic concentrator optics to split the solar spectrum and direct each band toward polycrystalline solar cell components.

Multi-Port DC-DC Converter for Universal Use with Renewable Energy Sources in Residential Homes and Buildings, and in Fuel Cell Vehicles (LG-C9-2005)
LEAD RESEARCHER: Ned Mohan (IT)
TOTAL FUNDING: $111,984
To reduce the size and increase the efficiency of a power processing unit that can be used to switch among alternate forms of renewable energy, fuel cells and plug-in hybrids in residential homes and commercial facilities.

Next Generation Dye-Sensitized Solar Cells (RS-0009-09)
LEAD RESEARCHER: David Blank (IT)
TOTAL FUNDING: $70,000
Photovoltaic devices convert solar energy into electricity. In order to improve their performance, this project aims to reveal the unknown events that occur immediately after light absorption in dye-sensitized solar cells.

Reduction of Carbon Dioxide to Methane Using Nanostructured Heterojunction Photocatalysts (RS-0021-09)
LEAD RESEARCHER: Eray Aydil (IT)
TOTAL FUNDING: $69,178
To examine and establish a new class of nanostructured photocatalysts with the aim of converting carbon dioxide and water to methane using sunlight.

Routes to High-Performance, Multi Junction CIGS-Based Photovoltaics (M7-2008)
LEAD RESEARCHERS: Eray Aydil (IT), Stephen Campbell (IT)
TOTAL FUNDING: $160,000
To build and test a vacuum deposition system for thin-film photovoltaics made from copper-indium-gallium-selenide.

Sodium Sulfur Battery Energy Storage and Its Potential to Enable Further Integration of Wind (M2A-2008)
LEAD RESEARCHER: Ned Mohan (IT)
TOTAL FUNDING: $58,285
To build a wind energy storage system using sodium sulfur battery technology in partnership with Xcel Energy, with the goal of controlling and dispatching power as needed for supply and transmission system stability.

Thermochemical Fuels: Solar at Night (RL-0001-09)
LEAD RESEARCHER: Jane Davidson (IT)
TOTAL FUNDING: $900,086
To harvest and store solar concentrated energy via high-temperature, thermochemical processes. Faculty and students are collaborating with national and international experts to develop processes and reactors that gasify biomass with concentrated solar energy.

Universal Utility Interface for Plug-in Hybrid Electric Vehicles with Vehicle-to-Grid Functionality (RS-0025-09)
LEAD RESEARCHER: Ned Mohan (IT)
TOTAL FUNDING: $70,527
To develop a novel interface between a utility and PHEV battery pack in order to demonstrate a complete system with bidirectional power flow capabilities.

RENEWABLE HYDROGEN

Enhancing Phototrophic Production of Hydrogen by Genetic Engineering of *Chlamydomonas reinhardtii* (LG-H4-2005)
LEAD RESEARCHERS: Paul Lefebvre (CBS), Carolyn Silflow (CBS), Michael Flickinger (North Carolina State University)
TOTAL FUNDING: $404,988
To characterize and improve the production of hydrogen by the unicellular green alga *Chlamydomonas reinhardtii*.

Metabolic and Regulatory Landscape of Photosynthetic Evolution of Hydrogen (LG-H3-2005)
LEAD RESEARCHERS: James Cotner (CBS), Arkady Khodursky (BTI)
TOTAL FUNDING: $270,000
To understand the regulatory, physiological and environmental requirements of hydrogen production by Cyanobacteria.

Renewable Hydrogen Energy for the Farm (LG-MC3-2005)
LEAD RESEARCHERS: E.L. Cussler (IT), Kent Mann (IT), Lanny Schmidt (IT), William Smyrl (IT), Michael Tsapatsis (IT)
TOTAL FUNDING: $620,000
To demonstrate new and more efficient routes for making hydrogen from biomass; to develop robust methods of purifying this hydrogen for fuel cells; and to create fuel cells capable of producing 0.1 to 10 kW of power with this hydrogen.

INSTITUTE ON THE ENVIRONMENT

UNIVERSITY OF MINNESOTA

Driven to Discover℠

1954 Buford Avenue, Suite 325 St. Paul, MN 55108 (612) 624-7266 iree@umn.edu

environment.umn.edu/iree

Photos: Researchers, Josh Kohanek; Solar house, Patrick O'Leary