

# CCCEE

## Civil, Construction and Environmental Engineering

*Annual Update 2008 - 2009*



IOWA STATE UNIVERSITY  
College of Engineering





<b>PERSPECTIVE</b> James Alleman	<b>page 3</b>
<b>STRUCTURES</b> Paul Giroux Terry Wipf Sri Sritharan	<b>page 4</b> <b>page 5</b> <b>page 6</b>
<b>GEOTECHNICAL</b> David White	<b>page 7</b>
<b>MATERIALS</b> Chris Williams	<b>page 8</b>
<b>TRANSPORTATION</b> Nadia Gkritza	<b>page 9</b>
<b>ENVIRONMENTAL</b> Shauna Hallmark Say-Kee Ong Hans van Leeuwen	<b>page 10</b> <b>page 10</b> <b>page 11</b>
<b>POLICY AND LEADERSHIP</b> Ed Jaselskis	<b>page 12-13</b>
<b>CONSTRUCTION</b> Brad Perkins	<b>page 13</b>
<b>2008-2009 METRICS</b>	<b>page 14-15</b>

## • a common goal •

### letter from the chair

In the modern parlance of academic outcomes, impact is our department's heart and soul goal. Forged by insight, innovation, and inspiration on a daily basis within our Cyclone classrooms and labs, Iowa State's engineering legacy truly lays a catalytic foundation for our future success. Our latest 2009 annual report accordingly highlights an exciting cross-section of student, staff, and faculty activities now underway within our ISU Civil, Construction, and Environmental department, all of which share a common focus on next-generation concerns and solutions for critical infrastructure and environmental grand challenges, including:

- Paul Giroux is promoting national awareness and efforts tied to sustainable bridge systems, as a critical factor in the future success of our entire transportation network,
- Terry Wipf and Sri Sritharan are exploring cutting-edge applications for next-generation advanced structural designs and materials,
- David White is developing the first US Earthworks Engineering Research Center for advanced studies in the realm of geo-construction,
- Nadia Gkritza is a critical partner in ISU's newly-funded NSF project on



21st Century National Energy and Transportation Infrastructure Balancing Sustainability, Costs, and Resiliency (NETSCORE-21),

- Chris Williams is redefining the notion of green highways using biorenewable-based asphalt binders,
- Say-Kee Ong is investigating the fate and impact of chemical, antibiotic, and pharmaceutical compounds within our aqueous environments,
- Shauna Hallmark is studying hybrid school bus operations intent on reducing both fuel consumption and exhaust emission,
- Hans van Leeuwen is hard at work developing beneficial options for converting biofuel wastes into valuable co-product residuals,
- Ed Jaselskis directs our college's Engineering Policy and Leadership Institute, through which ISU is aggressively introducing our engineering graduates to the issues and challenges of playing vital roles as next-generation leaders in the arena of public policy, and
- Brad Perkins is teaching our students about (LEED)<sup>®</sup> parameters to construct high-performance green buildings nationally and on campus for future generations.

Taken together, these efforts collectively convey and reflect a positive, uplifting sense of perseverance and pride already underway within our CCEE team ... and we welcome like-minded partners who share our passion for generating world-class impacts!

James E. Alleman  
Department Chair, Professor



# • the challenge •



Nearly one-quarter of the nation's 600,000 bridges are currently structurally or functionally obsolete. As federal, state, and local governments struggle to find ways to stretch their transportation infrastructure dollars, more and more emphasis is being placed on sustainable bridge design.

ISU graduate R. Paul Giroux (ConE, 1979) was a keynote speaker at the 2009 Construction Research Congress held in Seattle, Washington, on April 5-7, 2009. Giroux has been with Kiewit Corporation for thirty years and has worked on numerous heavy civil construction projects throughout the United States. At the Congress, Giroux spoke on improving the sustainability of our nation's bridges.

"Sustainability is a concept we hear a lot about these days," Giroux says, "In the bridge market, sustainable development is the challenge we face to be good stewards of society's limited financial and natural resources, not only for today's bridge needs, but also for the bridge needs of the future."

Giroux noted several historic bridge designers as visionary examples for promoting sustainable bridges, including renowned Iowa State graduate and Oregon bridge designer Conde McCullough. McCullough's said the economics of bridge construction are "unquestionably the highest, most difficult and most important feature of bridge engineering." Giroux says, "McCullough was ever mindful of not wasting the taxpayer's money. He paid great attention to site conditions, stream behavior, durability, navigation requirements, traffic considerations, architectural features, and available funding."

Giroux also cited Kiewit's \$1.28 billion, I-25 Transportation Expansion built in Denver, Colorado as an excellent example of sustainable infrastructure development. (Pictured above). Referred to as the "T-Rex" project, T-Rex was a unique collaboration

between the Colorado Department of Transportation (CDOT) and the Regional Transportation District (RTD) and was the nation's first multi-modal project in the nation to use the design-build delivery method. Built from 2001 to 2006, the Kiewit-led joint venture project included the reconstruction of 17 miles of I-25 and I-225, 19 miles of new double track light rail transit lines, 13 light rail stations, three parking structures, eight interchanges, and more than 75 bridges and tunnels. "With an eye to the future, the T-Rex project enhanced our nation's interstate highway system, improved Denver's regional and local traffic capacity, and added light rail transit as a viable alternative for local commuters," Giroux says. "Construction was performed in a way that minimized disruption to the public and the environment."

Giroux continues, "Increasingly, sustainable bridge solutions will come from teamwork between bridge owners, regulators, the public, academia, designers, and the builders all working towards the same goal. It will take finding the correct balance between social, economical, and ecological benefits in our bridge designs."

Giroux is a frequent Iowa State University campus lecturer and says, "My education from Iowa State still today influences my practicable approach to problem-solving and overcoming challenges."



## Buchanan County, Iowa was the site of the first bridge in the U.S. built with Pi-shaped girders made of ultra high performance concrete. (UHPC)



"The benefits ultimately should be a reduction in long-term costs associated with bridge maintenance. It is very likely that further advances with UHPC will yield bridge designs in which the deck and superstructure last for the same duration, thus eliminating the need for intermittent and costly deck replacement," says Terry Wipf, director of the Bridge Engineering Center at the Institute for Transportation (InTrans) and CCEE professor and structures division leader.

Initiated in 2006, this bridge project in Buchanan County uses a modification of the optimized Pi shape originally proposed, but the general cross section shape was retained.

Wipf says, "It is anticipated, with a successful application of UHPC, further advances in developing cost-effective uses will begin. These new advances will focus on reducing costs by taking advantage of a higher strength material with almost zero permeability, which should minimize deterioration. The optimization, validation, and acceptance of the proposed girder cross section represents a significant step in more widespread adoption."

# • close to home •

Usage of UHPC has already begun! Sri Sritharan, CCEE associate professor and associate chair for graduate programs and research, is currently investigating the use of UHPC for bridge substructure piling.

The researchers also hope to benefit Iowans during the research process. "We'd like to strengthen our bridges, as well as strengthen Iowa. The fabrication of the Pi girder was done out of state due to specialty formwork issues, but our research team completed the entire design using only Iowa-based engineers," says Wipf.

Other members of the research team consist of:

- Fouad Fanous, CCEE professor
- Matt Rouse, CCEE assistant professor
- Brent Phares, CCEE adjunct assistant professor and associate director of the Bridge Engineering Center
- Dean Bierwagen, methods engineer, Iowa Department of Transportation
- Brian Keierleber, Buchanan County engineer
- Curtis Monk division bridge engineer, Iowa Federal Highway Administration (FHWA).





## • a new direction •

With the world's energy consumption projected to grow by 50% over the next 20 years, the U.S. Department of Energy has challenged the nation to produce 20% of its total power from wind by 2030. The state of Iowa is one of the leading wind energy-producing states in the nation and already obtains close to 5% of its electricity from wind energy. Iowa State is working to play a central role in the research and development of wind technologies to help the United States realize not only its 2030 goals, but the broader goals of the College of Engineering's 2050 Challenge as well.

Currently, tubular steel towers are the industry standard in wind turbine construction. However, these large-scale pre-fabricated steel towers present some problems in terms of their manufacturing costs, design constraints and long-distance transporting.

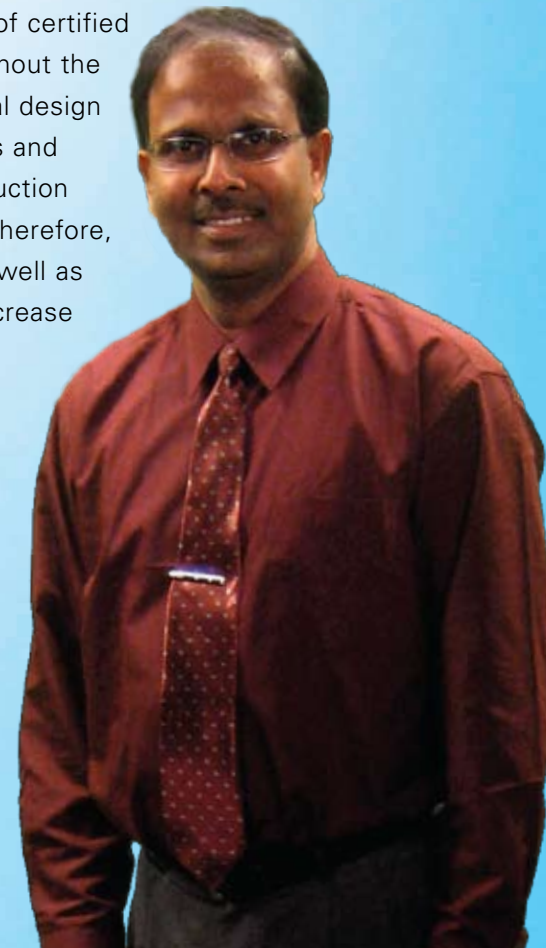
Wind turbines are typically located in remote areas and transported by truck. Because of this, the diameter of the steel tower sections is limited by transporting capabilities and the overall height of the tower can only be so high. The power of the wind turbine is thus lessened because the taller the tower turbine, the more energy it can produce. CCEE Associate Professor Sri Sritharan, along



with other Iowa State researchers are working to overcome these challenges.

Sritharan says, "We are interested in the use of concrete as the construction material for wind turbines. While the use of conventional concrete would represent a large increase in section size and weight, using high strength or ultra-high strength concrete could potentially resolve this problem.

A concrete tower composed of this material could be highly prestressed, making the entire concrete cross-section effective." Sritharan continues, "The construction of such towers design could also be modularized, meaning multiple smaller segments would be combined to create a section of the tower. This would eliminate transportation difficulties associated with larger, heavier sections, and allow a smaller crane to be used during the tower construction. These modular pieces could be cast on-site, or prefabricated – there are number of certified pre-casters throughout the country. An optimal design of concrete towers and an efficient construction technique would, therefore, decrease cost, as well as allow towers to increase in height – both would contribute to reducing the energy cost and meeting the 2030 goals."



## • from the ground up •

The Earthworks Engineering Research Center (EERC) is a research center dedicated to accomplishing rapid advancements in quality, economy, construction, and performance of the geotechnical aspects of infrastructure. Its focus is to improve the fundamental understanding of earth mechanics, while providing enabling technologies and supportive public policies.

CCEE Associate Professor David White is the director of EERC, which is housed at Iowa State University's Institute for Transportation (InTrans). He says, "The EERC will integrate geotechnology and construction engineering in research and academic programs. This a unique combination of skills — most engineers have expertise in only one area."

White says, "The EERC is working towards smarter, more cost-effective infrastructure development and rehabilitation. This starts at the bottom — a solid

foundation supports and significantly determines the performance of every structure."

He continues, "Safe, dependable, and sustainable physical infrastructure systems are vital to maintaining America's economic vitality. Yet many of our systems — roads, bridges, dams, tunnels, sewer systems, public buildings, and others — are old and in bad shape. Investing in soil engineering and technology improvements that result in faster, cheaper, and longer-lasting foundations could potentially save taxpayers billions of dollars in the future."





## • an innovative road •

Like much of western society, the U.S. paved highway and road system is heavily dependent on oil. The asphalt industry, in particular, relies on the oil industry to supply the compounds needed for asphalt road construction. As oil refiners overhaul equipment to achieve maximum output of highly profitable fossil-based fuels, the asphalt industry is experiencing drastic shortages. Where 40% of a barrel of oil was formerly designated for asphalt material production, the newer systems allocate only 10%. Because asphalt is used for more than 90 percent of U.S. highway surfaces, this shortage has forced federal, state, county, and municipal governments to delay transportation infrastructure repairs and construction.

Chris Williams, CCEE associate professor, along with other Iowa State University scientists and engineers are working on new technologies to produce bio-oil that can substitute for petroleum-based ingredients in asphalt. The process used to produce the bio-oil is called fast pyrolysis.

Bio-oil is produced by quickly heating fibrous non-food biomass, such as switchgrass, hybrid poplar, or cornstover to 400-500 °C, followed by rapid quenching of the vapors to



produce bio-oil and biochar. The bio-oil is separately into different fractions — some of which appears to be ideal materials for asphalt. (Pictured above).

Preliminary tests using bio-oil fractions in asphalt applications indicate that bio-oil asphalt is more durable in cold and hot temperatures. Other benefits include lower energy requirements for mixing the asphalt and lower greenhouse gas emissions.

Asphalt industry leaders are closely monitoring the opportunities provided by bio-oil. "Finding additional sources of asphalt binder that are alternatives to crude oil, that are bio-based, and renewable, could further develop Iowa into a leader for the nation and the world in the development of bio-based technologies," said Bill Rosener of the Asphalt Paving Association of Iowa. "It is great to think of Iowa-grown crops being used to construct Iowa roads."

"Sustainability is the coupling and balancing of environmental stewardship and economic opportunity."

- Chris Williams



## • finding a balance •

In the United States, much of our energy is consumed by electricity production and vehicle transportation — two interdependent, critical national infrastructures. As hybrid electric transportation systems, such as plug-in hybrid electric vehicles and hybrid electric trains, become more widely used, these interdependencies will increase rapidly.

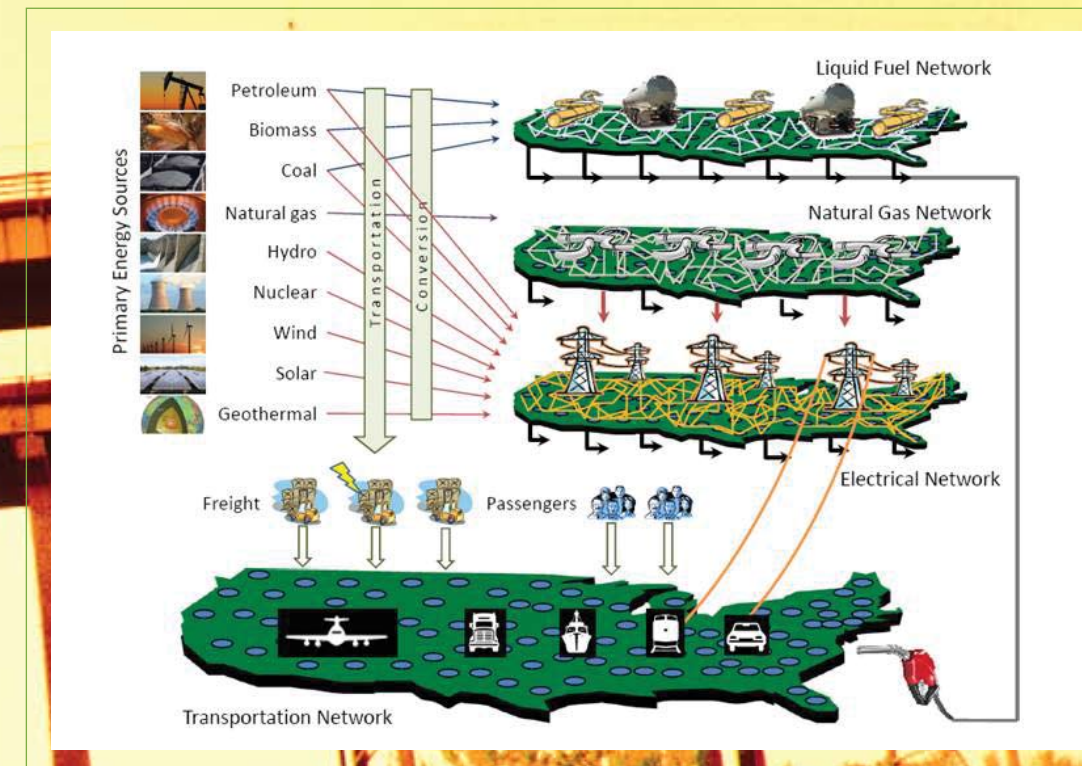
Konstantina "Nadia" Gkritza, CCEE assistant professor and co-principal investigator, provides expertise in transportation engineering and infrastructure investment planning for the 21st Century National Energy and Transportation Infrastructures Balancing Sustainability, Costs, and Resiliency (NETSCORE-21).

Gkritza says, "A sustainable transportation system is affordable and equitable, operates safely and

efficiently, reduces environmental stresses, and enhances economic development and global competitiveness."

The mission of NETSCORE-21 is to design a national system that integrates energy and transportation infrastructures and develops new energy supply technologies.

NETSCORE-21 is addressing the challenge of finding the nation's energy resource portfolio for the next 40 years with optimal sustainability, cost, and resiliency. Successful achievement of this goal has a potential long-term impact whose scale is at the trillion dollar level.





## • an important lesson •

Iowa State University's Institute for Transportation (InTrans, formerly the Center for Transportation Research and Education) helped Iowa's Nevada and Sigourney school districts put two of the country's first hybrid school buses on the road. The buses use an electric motor at street speeds and their V-8 diesel engines kick in at higher speeds. CCEE Associate Professor Shauna Hallmark, along with other researchers, will study and evaluate the performance of these two buses to determine if they could provide an economically viable alternative for more schools.



School buses represent a major segment of our country's transportation sector in trips delivered, fuel consumed, and pollutants emitted. There are 450,000 school buses in the U.S. that transport 25 million children on approximately 10 billion student trips each year. These buses consume 1.1 billion gallons of diesel fuel and emit thousands of tons of pollutants per year.

Options for reducing bus emissions include using different fuels, such as biodiesel or natural gas, and using add-on emission control devices, such as particulate filters and oxidative catalysts. Usage of hybrid electric technology offers another option. Hybrids are available in the passenger vehicle market, as well as the transit bus market, however, there are no commercially available hybrid school buses. Hybrid electric school buses have the potential to reduce emissions and overall life-cycle cost when compared to conventional diesel buses.

## • emerging concerns •

What environmental effects do our prescription drugs and personal care products have on our drinking water, surface water and groundwater? This is the question CCEE Professor Say Kee Ong is attempting to answer. This class of chemical compounds is referred to as "contaminants of emerging concerns" and consists of such products as pharmaceuticals (e.g. ibuprofen, pain killers), estrogenic compounds, antibiotics and antimicrobial compounds (e.g. triclosan in anti-microbial soaps).

Ong's research focuses on the fate and effects of these contaminants and potentially hazardous compounds in engineered systems (wastewater treatment systems) and natural systems (groundwater and soils).

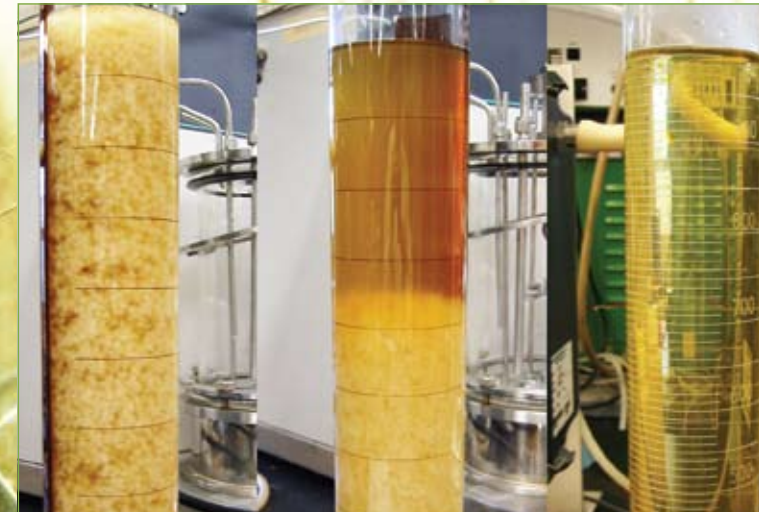
Ong has completed two US EPA projects using Biological Aerated Filters for the treatment of wastewater and removal of nutrient, estrogenic compounds and antibiotics, as well a Siemens project using pilot-scale Denitrification Filters for removal of nitrogen in

wastewaters. Ong recently co-authored a book titled "Contaminants of Emerging Environmental Concern" published by the American Society of Civil Engineers (ASCE).

Ong's interest in sustainable water systems has taken him to Uganda and India where rainwater harvesting projects are being implemented for developing communities. Ong was also recently awarded the 2008 Water Environment Federation (WEF) McKee Groundwater Protection, Restoration or Sustainable Use medal for his work on quantifying the degradation of polycyclic aromatic compounds in groundwater.



## • a winning idea •



CCEE Professor Hans van Leeuwen received national recognition for his leading role in growing microscopic fungus in leftovers from ethanol production for the improvement of the corn-to-ethanol conversion process.

The project was named a winner of a 2008 R&D 100 Award presented by R&D Magazine. The Chicago Tribune has called the awards, presented annually since 1963, the "Oscars of Invention." This is the 30th R&D 100 Award presented to a project affiliated with Iowa State. An award letter said editors and a judging panel consider the project "one of the top 100 most technologically significant products introduced into the marketplace over the past year."

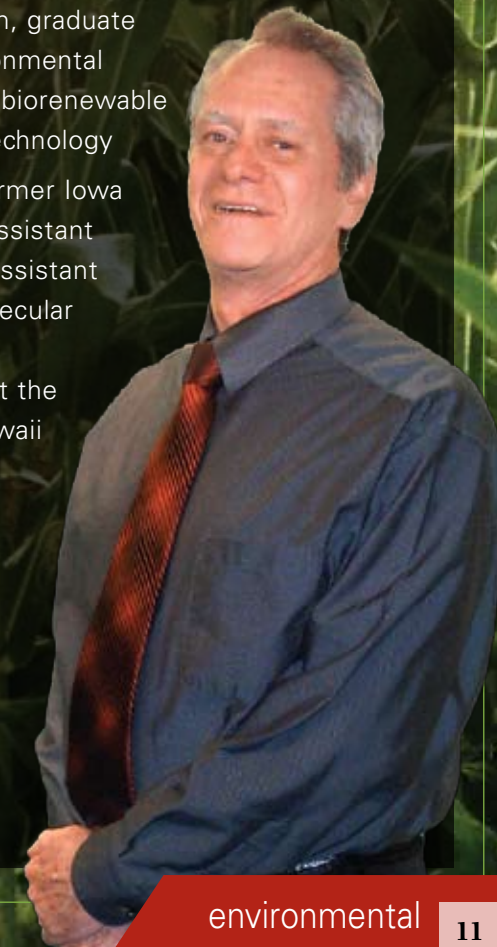
The award winners were featured in the September 2008 issue of R&D Magazine and they were honored at a banquet at Chicago's Navy Pier. Van Leeuwen says, "The corn-to-ethanol industry is, and will be, for the foreseeable future, the mainstay for biofuels production. Recent bankruptcies and moth-balling of ethanol plants has demonstrated this sector is extremely sensitive to fluctuations in energy and raw materials cost. The main problem is the high energy consumption and incompletely developed co-product utilization. Our research is aimed at improving the process

energy efficiency developing additional higher value co-products."

Van Leeuwen continues, "In other words, the current approach to ethanol production is not sustainable because of the very little net energy gain in the production process. The fungal cultivation and water reclamation principle reduces energy inputs by up to one-third. This, in addition to better utilization of all parts of the corn seed, makes for higher sustainability." He also adds, "The fungal process is an easy retrofit to existing ethanol plants, and even easier to integrate with new designs. The savings and additional income could spur a billion dollar per year industrial development."

Other leading participants of this project are:

- Anthony L. Pometto III, professor of food science and human nutrition
- Mary Rasmussen, graduate student in environmental engineering and biorenewable resources and technology
- Samir Khanal, former Iowa State research assistant professor, now assistant professor of molecular biosciences and bioengineering at the University of Hawaii at Manoa.





## • the big picture •

How do we provide clean water,  
universal access to information, and  
health care for over 9 billion people?

How do we develop nonpolluting,  
renewable energy sources while  
building stable worldwide economies?

The College of Engineering at Iowa State University has made a commitment to addressing fundamental, long-term changes that must be made today to ensure, we still have prosperous nations and a high quality of life worldwide, known as the: **2050 Challenge**.

Towards this effort, the College of Engineering has created the Engineering Policy and Leadership Institute (EPLI). EPLI's mission is to increase engagement of engineers in the development of national policies involving the use of technology, and to increase the pipeline of engineers who serve in elected and appointed roles at all levels of government.

CCEE Professor Edward Jaselskis was appointed director. "I'm excited about the institute's mission, especially as our society starts coming to grips with many challenging issues — global warming, water shortages, depletion of fossil fuel energy, and a decaying infrastructure — that will affect us today and for generations in the future," says Jaselskis. "We will need more engineers in leadership positions in companies and government who can understand the technical issues, and who can pass laws that use the best technologies to help our nation prosper." He continues, "We are working towards a smooth transition into future energy resources, while doing it intelligently. We also hope to promote awareness to the general public, helping people make better decisions on an individual level."

"Sustainability is about living responsibly in the present — to provide for a safe, healthy, and secure life for future generations."

- Ed Jaselskis



## • the thematic year •

One major component of EPLI is the "Thematic Year," which is a series of presentations and roundtable discussions dedicated to thoroughly studying an urgent global issue that has significant impact in meeting the 2050 Challenge.

The first Engineering Thematic Year on Energy Security and Sustainability runs from September 23, 2008 through April 23, 2009. The objective is to provide lawmakers and other key constituencies with thoughtful, well-articulated information that can help them in policy-making decisions. National experts have presented their views on energy as

it relates to national security, politics, supply and demand, efficiencies, renewable and non-renewable alternatives, economics and food production.

Findings from all events will be analyzed and then synthesized into a final report, which will be provided to Iowa State University constituencies. As a culmination of each thematic year, these findings will be formally presented and discussed at the Thematic Year Capstone Summit in Fall 2009.

## • in our classrooms & campus •

Sustainability is a core theme within our Iowa State University classrooms. CCEE Lecturer Brad Perkins teaches graduate course CE 594L: LEED® for New Construction (LEED® 2009). He says, "To me, sustainability is designing and constructing a building that balances initial costs against energy and maintenance costs for the complete life cycle. So, overall, we use as little energy and resources as possible. It's all about managing resources today *and* in the future."

Perkins continues, "The class not only prepares students for the LEED® exam, it will prepare them for a growing area of building design and construction. We cover multiple areas of design and construction: architectural, electrical, plumbing, mechanical, site work, etc. This gives them a cross-discipline perspective that they might not get elsewhere."

The Leadership in Energy and Environmental Design (LEED)® initiative is a certification program that serves as the nationally accepted benchmark for the design, construction and operation of high performance

green buildings. This provides measurable criteria using a clearly defined point system for a building's performance. LEED® recognizes performance in five key areas: sustainable site development, water savings, energy efficiency, materials selection and indoor environmental quality.

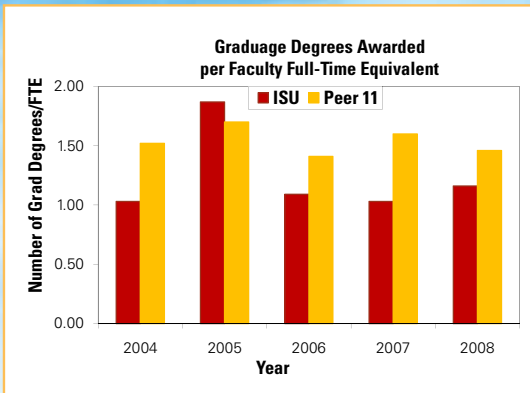
ISU's Morrill Hall, renovated and restored in 2007, is certified LEED® silver and was the first LEED® building at an Iowa Regents institution. The extension to the College of Design building (*pictured below*) is also being constructed to meet LEED® standards.



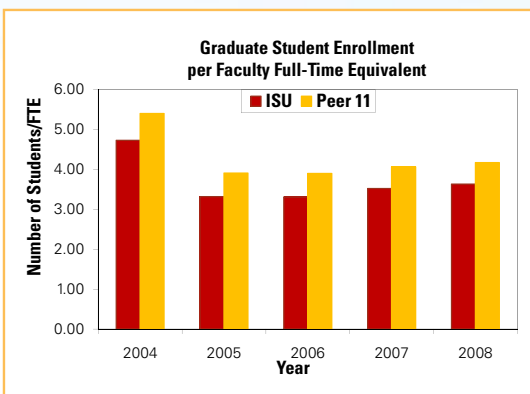


## PEER INSTITUTION COMPARISON

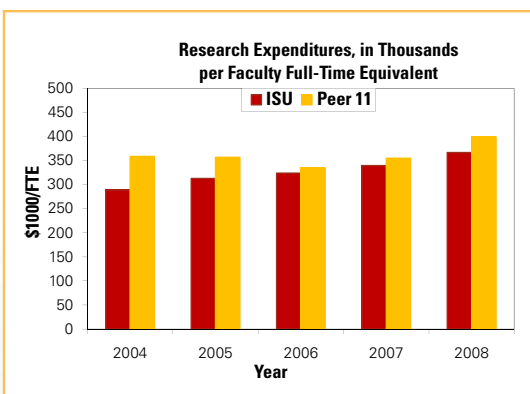
When compared to peer institutions, the CCEE department is in good, solid standing. The charts below show comparisons to similar departments of the Peer 11 land grant universities.



Our graduate degree productivity is less than those of our peers, but are on the rise and the gap is closing.

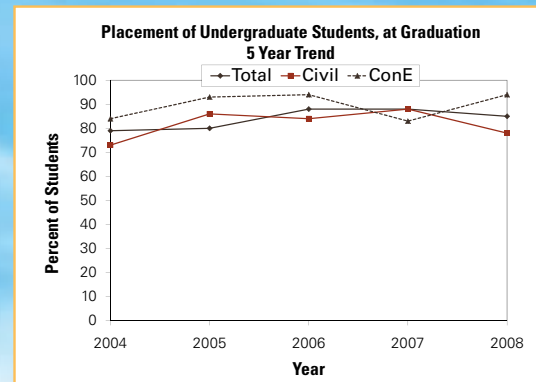


Our graduate enrollment/FTE is increasing, as it is for our peers.

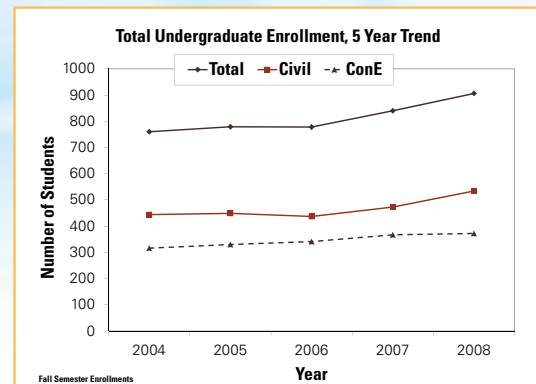


Our research expenditures per faculty FTE are on the rise, though under our peer institution numbers.

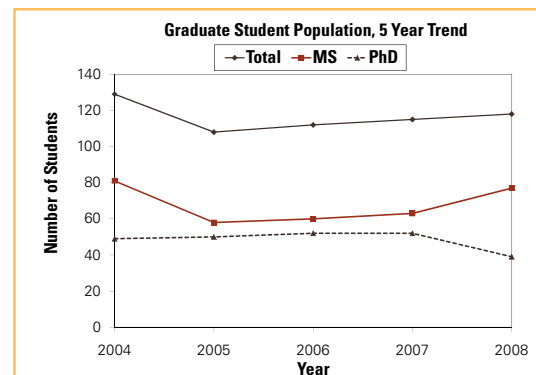
## ENROLLMENT TRENDS



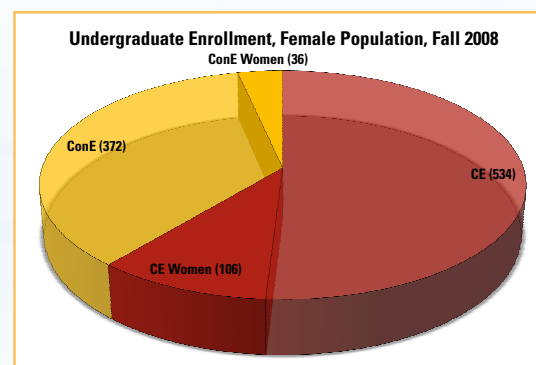
Placement at graduation remains high — 94 percent for construction engineering and 78 percent for civil.



Civil engineering enrollment rose 13 percent and construction engineering enrollment increased slightly.

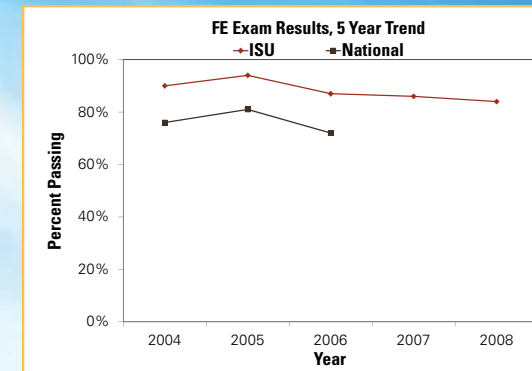


Our total graduate student enrollment increased 3 percent.

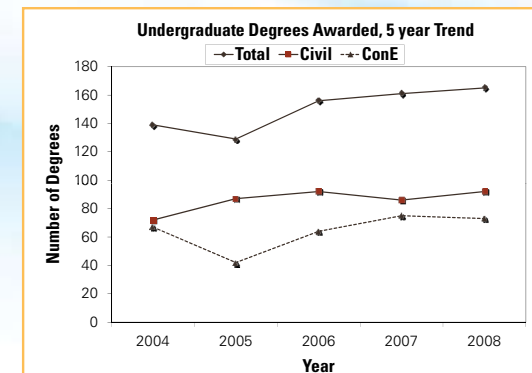


The number of women is increasing at nearly 20% in civil and almost 10% in construction engineering.

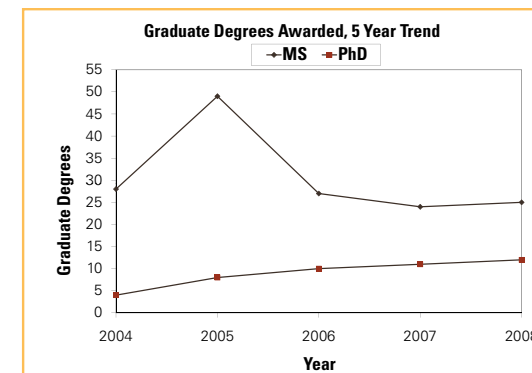
## DEGREES AWARDED



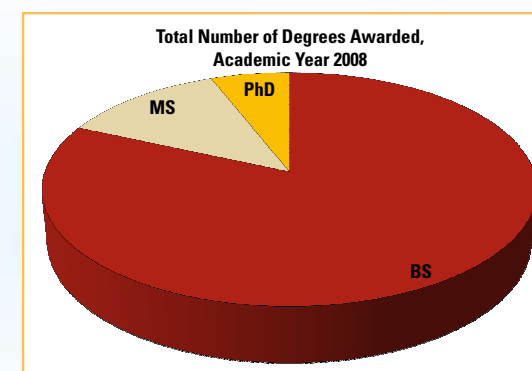
Our students consistently achieve a higher passing rate on the Fundamentals of Engineering exam than the national average.



The number of undergraduate degrees awarded continues to rise.

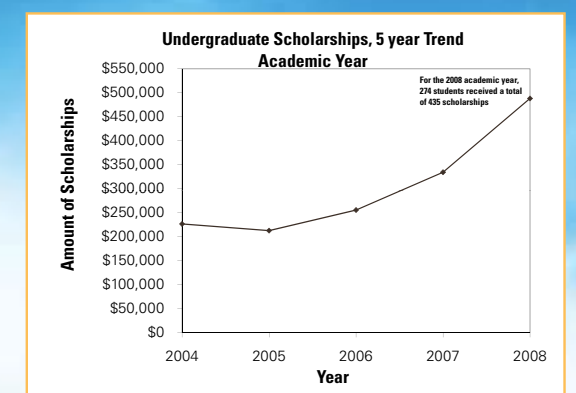


The number of PhD degrees awarded continued an upward trend.

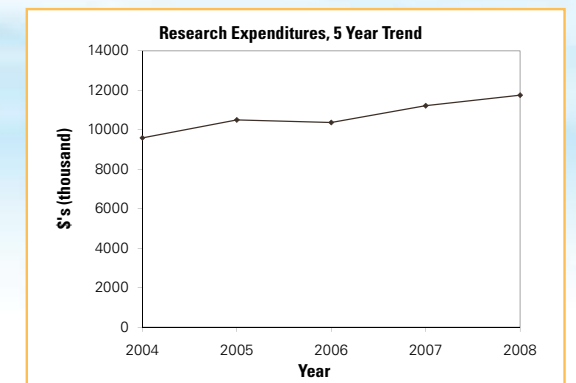


The CCEE department awarded 165 BS degrees, 25 MS degrees, and 12 PhD degrees last year.

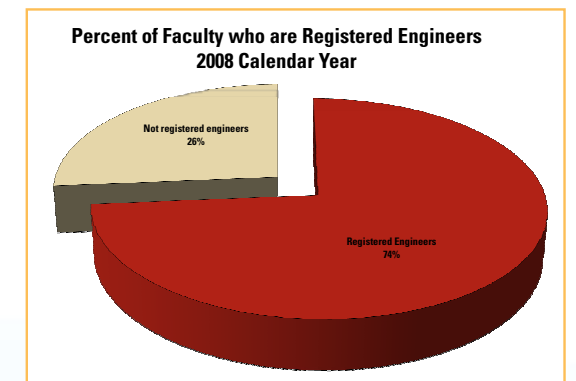
## SUCCESS TRENDS



The number of scholarships has increased and amount per scholarship awarded has reached an all-time high.



Research expenditures increase by almost 5 percent in the past year.



Nearly 74 percent of our faculty are registered engineers.



# IOWA STATE UNIVERSITY

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