The availability of reliable, clean energy poses one of the biggest challenges to our national and economic security, and a look at America's future energy needs reveals that total energy consumption is going to increase significantly over the next 20 years.

Over the past 30 years, the amount of oil our country imports has risen from about 30 percent of all the oil we consume to approximately 70 percent. About 20 percent of those imports come from the Middle East, which also contains over half of the world's total proven oil reserves. Unless we make changes, we will be even more dependent on this volatile region. This dependence is also resulting in a massive transference of wealth and accumulation of trade deficits for our country. In July alone, the US spent a record $51 billion on foreign oil.

In August, I visited the Republic of Georgia after a series of attacks from Russian forces and observed firsthand how energy demand is playing out geopolitically. In this case, it was demonstrated by the muted response from many European countries to Russia's military incursion into Georgia, because many nations rely on Russia for oil and gas. This further highlights the need for our country to get serious about finding more and using less of our own energy.

Energy fuels our economy. If we don't have an adequate supply of energy, our economic growth will suffer. However, it (Strategy, continued on page 16)
A contingent of 34 students from Korean and US universities spent a day this past summer with Tennessee scientists on Knoxville’s Third Creek, a tributary of the Tennessee River and an impaired urban stream being restored to health through the efforts of state and local agencies.

The students, 19 from Korean universities and 15 from US schools, were participants in the inaugural Korea-America Student Conference (KASC), which seeks to build bilateral relationships among future leaders from the two nations. The KASC students visited the University of Tennessee (UT) July 19-23 as part of a month-long seminar that included sessions at George Washington University, Brown University, and the University of California, Berkeley. UT’s Howard Baker Jr. Center for Public Policy hosted the students during their visit.

UT’s Water Resources Research Center (WRRC) and the Knox-area Water Quality Forum sponsored the activities on Third Creek and demonstrated various methods for evaluating overall stream health. WRRC is a division of UT’s Institute for a Secure and Sustainable Environment (ISSE).

“The assessment methods can be applied to urban watersheds around the world,” said event organizer Ruth Anne Hanahan, an ISSE senior research associate. But Hanahan insists that the activities on the creek sought to impart a broader lesson.

“Regardless of nationality, everybody lives in a watershed,” said WRRC Director Tim Gangaware. “The plants and aquatic species may differ, but the principles of water-quality assessment and habitat protection and restoration are fairly universal. We hope these students will take home what they’ve learned here about biodiversity and stream health and apply it to their own watersheds.”

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“The message I hope the students received is that we all have contributed, in most cases unknowingly, to the current state of our waterways and the larger environment,” she said. “In the end, it is really up to us—citizens, business owners, elected officials—to collaborate in improving watershed health. Service learning projects, like the activities on Third Creek, engage students directly in their communities and help raise awareness of important issues that are all too often neglected or overlooked.”

Gavin Luter, Baker Center coordinator, voiced a similar sentiment.
“Student participants and conference organizers expressed interest in participating in a service activity while at UT,” said Luter. “Overall, water issues are a major public policy issue and one that affects citizens around the globe. The activities on Third Creek allowed students to make the connection between Knoxville’s water-quality issues and similar issues facing much of the rest of the world.”

Greg Babbit, project manager for the Tennessee Stream Mitigation Program, spoke to the students about efforts to restore a segment of Third Creek by stabilizing banks, re-establishing the creek’s natural meander, and removing invasive plant species and replacing them with natives.

Under the guidance of Jonathan Burr, a biologist with the Tennessee Department of Environment and Conservation (TDEC), students waded into the creek and captured fish species in nets to assess the stream’s aquatic diversity and ecological health. Among the dozens of netted fish were two small but mature smallmouth bass and a warmouth. Their presence, Burr said, indicates the stream’s improving water quality. The fish were released unharmed following the assessment.

Burr’s TDEC colleague, Larry Everett, assisted the students in collecting and assessing macro invertebrates, organisms that live on the creek bottom and have no backbones. Diversity in these species, which include crayfish, snails, stoneflies, mayflies, and caddisflies, is also reflective of improving water quality.

John Shubzda, a stormwater engineering technician for the city of Knoxville, guided students through a visual study of the creek, which assessed the stability of the bank, width of the riparian corridor, and density of the canopy shading the creek from the sun.

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Before returning to the UT campus, KASC students pulled on work gloves and removed a few re-emerging invasive plants, including Mimosa (Albizia julibrissin) and amur bush honeysuckle (Lonicera maackii), along the stream corridor. Prior to the restoration of Third Creek, these and other invasive plant species dominated much of the land bordering the waterway.

KASC, now in its first year, is based on the successful Japan-America Student Conference, the oldest student-run cultural exchange in the United States, which began in 1934. Both programs are administered by the nonprofit International Student Conferences. Korean universities will host next year’s conference.

FOR INFORMATION ON KASC OR INTERNATIONAL STUDENT CONFERENCES, VISIT: HTTP://WWW.ISCDC.ORG

FOR INFORMATION ON THE WATER QUALITY FORUM OR THIRD CREEK, CONTACT RUTH ANNE HANAHAN: RHANAHAN@UTK.EDU
Scientists and government officials from the United States and China met in Beijing recently to explore research and development issues associated with the sustainable production of biofuels, including ethanol, biodiesel, and biogas.

The conference, “Bioenergy Consequences for Global Environmental Change,” convened October 15-18 in Beijing and emphasized the need for sustainable production of biofuels as an essential part of broader national energy, agricultural, and land-use policies. US participation in the conference was sponsored in part by a grant from the National Science Foundation.

Conference presenters discussed biofuels’ potential role in slowing global climate change by reducing greenhouse gas emissions and increasing carbon sequestration, methods for managing the land-use changes that will result from increased production of biofuel crops, the importance of expanded production of non-crop biofuel feedstocks, and the cultivation of bioenergy crops to restore degraded and deforested lands.

The Beijing conference built on a China-US workshop held at UT in September 2007, which also focused on the environmental impacts of bioenergy production. (Access 2007 conference proceedings here: http://isse.utk.edu/jrceec/workshops/proceedings07.pdf)

Evolving, Expanding Collaboration
The October conference grew from an initiative launched in July of 2006, through which scientists from the University of Tennessee (UT) and Oak Ridge National Laboratory (ORNL) joined Chinese Academy of Sciences (CAS) researchers in establishing the China-US Joint Research Center for Ecosystem and Environmental Change. US participants in the center include UT’s Institute for a Secure and Sustainable Environment (ISSE), the UT/ORNL Joint Institute for Biological Sciences (IIBS), UT’s Center for Environmental Biotechnology, and Purdue University’s Center for the Environment. Chinese participants include three units of CAS: the Institute of Geographical Science and Natural Resources Research (IGSNRR), the Research Center for Eco-Environmental Science, and the University of Science and Technology of China.

“These participating organizations have demonstrated a commitment to addressing environmental challenges to which both the United States and China have contributed significantly,” said ISSE Director Randall Gentry. “In creating the China-US Joint Research Center, we have created a forum for the exchange of ideas as well as a durable framework for future collaborative research.”

The Beijing conference built on a China-US workshop held at UT in September 2007, which also focused on the environmental impacts of bioenergy production. (Access 2007 conference proceedings here: http://isse.utk.edu/jrceec/workshops/proceedings07.pdf)

Jing-Hua Cao, deputy director of the CAS Bureau of International Cooperation, opened this year’s conference by noting that every major step forward in human civilization has been accompanied by improvements and upgrades to existing energy systems and that China and the United States should take the lead in developing a new, sustainable energy regime.

“Both China and the US now lead the world in the consumption of fossil fuels and emissions of greenhouse gases that contribute to global warming,” Cao said. “For those reasons, our two nations are strategically and economically linked to the development of sustainable energy supplies.”

(Biofuels, continued on page 12)
ISSE’s Community Partnership Center (CPC) is building a wireless broadband (Wi-Fi) network in downtown Knoxville to encourage asset-based economic and community development. For the first application, CPC has partnered with several community organizations in Knoxville to create a wireless walking tour to increase visibility and awareness of regional African-American heritage.

The tour features 15 historically and culturally significant sites in and around downtown. While at or near each site, with handheld Wi-Fi devices, users can read a brief narrative text about the site’s importance and see photos of people, buildings, and locations relevant to Knoxville history. Users can also view a short video on the historic and cultural significance of each site.

The Beck Cultural Exchange Center is the lead community organization on the project. The Beck Center, part of the Knox County Library System, researches, collects, and preserves information and artifacts on African-American achievement and culture. Knoxville’s Carpetbag Theatre, a performing arts organization, has created digital stories that provide virtual interpretation of each site on the tour. Also involved is the Literacy Imperative, a community development organization in Knoxville’s Empowerment Zone that promotes various forms of literacy and workforce development.

In addition to the 15 tour sites, the wireless network will be accessible to users at main public gathering areas throughout downtown such as Market Square, the Old City, Volunteer Landing, and downtown parks and green spaces. The network, which will also cover the length of Gay Street, will be available in outlying areas and significant historic sites around downtown. A 2.5 square mile wireless broadband network will be available throughout downtown, allowing people to log on for free with any Wi-Fi-enabled device, such as a laptop, PDA, iPhone, or other handheld device.

“With this cultural heritage tour, we hope to create an immersive experience for people to view historic photos and learn about notable people, past uses of various buildings, or happenings at significant sites while standing at or near the site,” said CPC Program Coordinator Eric Ogle, who manages the project.

The UT Office of Information Technology (OIT) is providing technical support for the project. OIT boasts the largest on-campus wireless network in the nation. The Knoxville-Oak Ridge Regional Network (KORRnet, now DiscoverET.org) is providing server administration, and the community network’s local content is mirrored on the servers for the downtown network.

Original funding for the project comes from the Empowerment Zone program of the US Department of Housing and Urban Development.

“Beyond its initial use, the wireless network could ultimately serve as a mechanism to provide visitors with information on watershed boundaries and conditions, environmental reports, recycling, and important environmental policies affecting the community,” said Ogle.

For more information, contact Eric Ogle at 865-974-4562 or email eogle@utk.edu
Al Gore has dramatized the fact that humans are changing the climate in ways and at such a rate that will soon constitute dangerous interference with the Earth’s climate system. Such interference not only imperils the planet’s ecological and human health, it also violates the UN Framework Convention on Climate Change, to which the United States is a party. (Find information on the framework here: http://untreaty.un.org/cod/avl/ha/ccc/ccc.html)

The current situation as regards human contribution to climate change prompts some difficult questions: How does human society reduce future damage to acceptable levels? And, further, what are acceptable levels?

MESSING WITH MOTHER NATURE

Whether we like it or not, we are messing with Mother Nature, and we need a framework for managing climate change in the interest of human and ecological well-being.

The climate system is enormously complex, and we are still learning about it and all the other systems with which it interacts. Precisely because of this state of ignorance there is a wide range of views about what to do, if anything, about climate change and humans’ role in it. There are contrarians who argue, notwithstanding the findings of the Intergovernmental Panel on Climate Change (IPCC, the UN organization that shared the 2007 Nobel Peace Prize with Al Gore), that global warming is largely a natural phenomenon, and they question the validity of models used for projecting future climate change. Others argue that the large negative impacts are far in the future when people will be richer and better able to afford the damage or avoid it, so why worry now? Still others, who accept anthropogenic global warming as real, argue that its expected consequences warrant only a measured response. It should, they contend, take its place among all the other societal needs and threats.

In this essay I adopt the position of the IPCC, that the risks, even catastrophic risks, from climate change are real and significant and should be avoided if the costs (social, political, and economic) are not prohibitive.

The framework for managing climate change consists of three strategies. The first of these is mitigation, involving actions to reduce greenhouse gas (GHG) emissions or to remove them from the atmosphere. Most of the emphasis so far has been on this strategy.

The second is adaptation, including actions to reduce greenhouse gas (GHG) emissions or to remove them from the atmosphere. This is akin to ordinary emergency preparedness, but it is much more far sighted. It includes such things as developing drought-resistant crops, applying technology to manage water resources more intelligently, and reducing the consequences of sea level rise. This strategy may also include new technologies for reducing the intensity of hurricanes. The third strategy is generally termed geoengineering, which includes a variety of approaches.
A Journey Halfway around the World
Reveals Shared Concerns, Opportunities

ARTICLE BY: RANDALL GENTRY
PHOTOS BY: DAVID BRILL

In October, I was among a group of US scientists who traveled to China to participate in the conference “Bioenergy Consequences for Global Environmental Change,” which was hosted by the Chinese Academy of Sciences in Beijing.

Among our US contingent were researchers from UT, Oak Ridge National Laboratory, Purdue University’s Center for the Environment, and the US Environmental Protection Agency.

Over three days, more than 60 scientists from the two participating nations gathered and shared perspectives rooted in fields ranging from plant genetics to sociology, from ecosystem dynamics to land-use policy.

Through the presentations and the discussions they inspired, the Sino-American research team explored opportunities in the field of sustainable bioenergy production and common concerns regarding climate change and the carbon cycle. (For details on the conference, see “US and Chinese Scientists Meet to Shape Biofuels’ Future” on page 4.)

In the process, we further nurtured a collaborative relationship we at ISSE began with our Chinese colleagues in 2006, through the establishment of the China-US Joint Research Center for Ecosystem and Environmental Change. (For information on the center, visit the ISSE Web site: http://isse.utk.edu/jrceec/)

Although scientific interaction was the

(Journey, continued on page 8)

Randall Gentry directs UT’s Institute for a Secure and Sustainable Environment and serves as associate professor in UT’s Department of Civil and Environmental Engineering. Contact him at 865-974-4251 or email rgentry@utk.edu.
principal purpose of our trip, our visit to China provided an important secondary benefit by greatly enhancing our understanding of the Chinese people, their culture, and their customs. I believe that this understanding will prove essential to future collaboration between two nations situated at opposite points on the globe and marked by very different political, economic, and social systems.

Though vastly different, our two cultures share much in common, including a devotion to family and friends, an abiding concern for the environment, and an eagerness to engage fellow scientists from across the globe in purposeful discussion and research. The remarkable warmth and hospitality demonstrated by our Chinese friends amply bore this out.

It has been my experience that, in the context of these shared values, our differences are dwarfed by our commitment to improving conditions for all citizens of the world, and I fully expect that our recent visit to China will mark the early stages of a research venture that will unite Chinese and US scientists well into the future.

Presented here and on the pages that follow are images captured during our trip, which included visits to the urban centers of Beijing and Shanghai and a journey to the Qianyanzhou Experimental Station in rural, subtropical southeastern China. The images and extended captions tell a very small part of the story of a vast and culturally diverse nation that is closely linked, both economically and environmentally, with our own.

I invite you to contact me to learn more about the China-US Joint Research Center for Ecosystem and Environmental Change, ISSE’s role in the partnership, or emerging opportunities for collaborative research.

THE OLD AND THE NEW IN CHINA’S LARGEST CITY

On the opposite bank, the stalwart structures of the historic Bund, which once contained European and American banks, trading houses, and consulates, date back to the late 1900s. Shanghai, China’s largest city, has an official population of 14 million, though some estimates that include nonregistered residents exceed 21 million.
China’s urban roadways are crowded with vehicles of every description, including innovative gas-powered cars, carts, and motorcycles as well as bicycles bearing enormous loads.
Rice is the staple crop in China’s rural southeast, occupying nearly every hectare of arable land. The mature plant droops under the weight of ripened seed before being harvested—almost entirely by hand—and then run through a hand-cranked thresher to separate seed from straw. The rice straw is formed into mounds that will later provide fodder for livestock (in rural China, most cattle are draft animals, not sources of food and milk) and fuel for cooking and heating. Farmers spread the “paddy” (rice grain still encased in the hull) on roads and other paved surfaces to dry before being bagged and sent to mills that remove the hull and, in the case of white rice, the bran.
In 1982, the Chinese Academy of Sciences established Qainyanzhou Agricultural Experimental Station in rural Taihe County, Jiangxi Province, in southeastern China. Over previous decades, area farmers, seeking firewood for cooking and heating, had stripped timber from all but 1 percent of the once-forested hilly terrain. Researchers and the local government have restored forest cover to 35 percent of the area. Pine represents the majority of the forest, but local farmers also cultivate orange groves.

Tea oil seeds, shown here, are grown at the Qainyanzhou Agricultural Experimental Station. The seeds provide oil for cooking, soaps, and cosmetics but may soon also be used as a feedstock for the production of biodiesel.

A shopkeeper in rural Taihe County in southeastern China offers basic items like duck eggs, cooking supplies, and medicinal products, as well as homemade rice wine.

ISSE Director Randall Gentry, ORNL’s Paul Hanson, ISSE Research Director Jie (Joe) Zhuang, and ORNL’s Virginia Dale and Keith Kline make an entry in the Qainyanzhou Agricultural Experimental Station’s official guest book, expressing gratitude for the hospitality and a commitment to continued collaboration with their Chinese hosts.

ISSE’s Randall Gentry and ORNL’s Virginia Dale pause while climbing part of the 138-foot tower at the Qainyanzhou Agricultural Experimental Station. The tower is part of the China-FLUX system of 20 monitoring sites across the nation. The tower, situated in a conifer forest, features air monitors placed at various heights to study the exchanges of carbon dioxide, water vapor, and energy between terrestrial ecosystems (whose plants absorb carbon dioxide and release oxygen) and the atmosphere. The AmeriFLUX network conducts similar studies in the United States.

After long days devoted to science, the Chinese delegation hosted lavish banquets featuring 20 or more dishes. All are presented on the lazy susans that serve as the centerpieces of traditional Chinese banquet tables.
Beyond pursuing environmental gains, China and the United States also seek to reduce dependence on foreign sources of energy—chiefly petroleum products—through increased domestic production of biofuels.

“The farther that we can move from the fossil-energy loop, the more effective we will be in avoiding the many security and environmental problems associated with our current energy systems,” said JIBS Director Gary Sayler. “Bioenergy and biofuels cannot solve all of our problems, but they may give us more time to develop new, sustainable technologies, including methods for capturing and storing carbon.”

Expanded use of biofuels, along with other renewable energy sources and increased energy conservation, has significant potential to enhance energy security while protecting the environment and spurring economic growth, according to conference keynote speaker Alan Hecht, director of sustainable development at the US Environmental Protection Agency’s Office of Research and Development.

“Cooperative US-China research aimed at identifying affordable energy and safe and abundant food, while avoiding unintended environmental and human-health consequences, would greatly enhance worldwide sustainable biofuel production,” said Hecht.

Dale noted the importance of identifying metrics that “quantify environmental and socioeconomic changes in land use and landscape dynamics” associated with cultivation of biofuel feedstocks, including switchgrass.

Switchgrass and other biomass materials—including wood, leaves, stalks, yard trimmings, and other nonedible parts of plants—are abundant and renewable and present an alternative to corn and other grains as feedstocks for ethanol production.

Conversion of these lignocellulosic materials to ethanol requires more extensive and complex processing than the relatively simple process of rendering ethanol from corn, sugarcane, and other food products through fermentation.

“Cultivation of switchgrass could have both positive and negative environmental effects, depending on where it is planted and what vegetation it replaces,” said Dale, noting that large-scale cultivation of switchgrass could affect water quality and stream flow, among other natural systems.

Farmers’ attitudes regarding change will also play an important role in the future of biofuels production, said ISSE Research Leader Mary English. If farmers determine that cultivation of bioenergy crops is undesirable because of risk, for instance, they might opt not to grow the feedstocks that are essential for biofuels production.

“When we evaluate farmers’ willingness to embrace production of switchgrass or other energy crops, it’s important to understand the economics, but we must also take into account social factors,” English said.

“The current efforts in developing LCA models could eventually lead to tools that quantify the potential of biofuel technologies for improved energy security and reduced environmental degradation, which have been the two major concerns associated with the current transportation fuels system,” said Zhao.

Among them, she said, are farmers’ values concerning personal risk and personal change. In this case, values would influence farmers’ decisions to alter cropping patterns to include switchgrass and other biofuel feedstocks.

Farmers’ beliefs in the future prospects of biofuel production, based on information they regard as reliable, will also affect their decisions. “Among those beliefs are attitudes regarding the viability of the biofuels economy and the influence of emerging technologies and governmental policies,” English said.

Dale’s colleague, ORNL Distinguished Scientist Paul Hanson, is studying the cycling of atmospheric carbon into surface biomass, the humus layer, subsurface soils, and the plant root systems of natural and managed forests. Carbon that is stored—
or sequestered—in soil is relatively stable, Hanson said, and is thus resistant to release into the atmosphere, unless the soil is disturbed.

“Ultimately, it’s the imbalance between the earth’s net natural intake of carbon and anthropogenic emissions that led us down the path of increasing greenhouse gas concentrations, which, in turn, drive anthropogenic climate change,” said Hanson.

In 1999, a licensed incinerator on or near the Oak Ridge Reservation burned wastes containing the radioactive isotope carbon 14, which was subsequently released into the atmosphere and incorporated into the local forest vegetation.

Though the nearly undetectable background enrichment posed no threat to humans or the environment, it provided Hanson and his research team with a unique opportunity to study the cycling of atmospheric carbon in soils using state-of-the-art measurement methods.

Because the released carbon bore a distinctive isotopic signature, the scientists were able to track its movement from enriched surface litter—chiefly leaves produced by trees that had taken in the radio-tagged carbon—into humus and mineral soil layers and roots.

“From our research, we determined that depositing labeled carbon on the surface, whether it’s in the form of coarse woody material or leaf litter, has little effect on mineral soil carbon storage in the acidic temperate forests in East Tennessee,” said Hanson.

Hanson’s team concluded that carbon delivered directly to the mineral soil through root growth and turnover would likely provide the most effective pathway to accumulate and protect carbon in mineral soils.

John Bickham of Purdue University’s Center for the Environment noted the global decline in biological diversity as a result of overfishing, poaching, deforestation, and climate change and suggested that increased cultivation of bioenergy crops could exacerbate the current species extinction crisis by introducing a new agriculture paradigm.

“To prepare for this eventuality, systematic studies are needed for a wide range of organisms, including studies of taxonomy, biogeography, and genetics,” Bickham said.

**FOOD OR FUEL?**

A chief concern among scientists and policymakers is large-scale use of food grains to supply biofuel production facilities and the resultant impact on arable lands, food prices, and food availability.

In 2007, both China and the United States enacted policies to limit biofuel production from food grains, such as corn and wheat. China’s Agricultural Biofuel Industry Plan calls for increased production of sugarcane, sweet sorghum, cassava, and rape seed for use in the production of biofuels while restricting increased production of fuels derived from food grains.

“With China’s large population, growing economy, and limited amount of arable land, the nation’s food supply remains somewhat fragile, especially in the southeastern region,” said Gao-Di Xie, a scientist with CAS’s Institute of Geographic Sciences and Natural Resources Research. “For that reason, the government is exploring the use of deforested lands and degraded agricultural lands for production of biofuel feedstocks. According to Xie, these lands, along with lands currently not in agricultural production, comprise more than 15 million hectares in China.

In the United States, the 2007 Energy Infrastructure and Security Act (EISA) requires a renewable fuel standard of 36 billion gallons a year by 2022, up from 4 billion gallons in 2006. EISA also caps future corn-based ethanol production at 15 billion gallons per year.

“That means the 21 billion gallons will have to come from advanced cellulosic material and other advanced biofuels,” said Hecht.

Further, EISA requires that renewable fuels produced from new biorefineries reduce lifecycle greenhouse gas emissions by 20 percent relative to life-cycle emissions from gasoline and diesel.

**LIFECYCLE TOOLS**

According to Fu Zhao of Purdue University’s school of mechanical engineering, the most widely used lifecycle assessment (LCA) tool to evaluate the environmental impacts of alternative transportation fuel technologies is the Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) Model developed by Argonne National Laboratory.

The GREET model takes into account the consumption of total energy (petroleum, coal, and natural gas) as well as greenhouse gas and regulated air emissions (including volatile organic compounds, carbon monoxide, nitrogen oxide, and particulate matter) over the fuel’s entire life cycle.

“The current efforts in developing LCA models could eventually lead to tools that quantify the potential of biofuel technologies for improved energy security and reduced environmental degradation, which have been the two major concerns associated with the current transportation fuels system,” said Zhao.

Both nations’ research into sustainable liquid biofuels complements other joint research on alternative energy sources including direct combustion of biomass, hydrogen fuel cells, wind and solar systems, and biomethane production from farm wastes.

*(Biofuels, continued on page 14)*
North Carolina State University’s Jason Shih reported on construction of a prototype biogas production unit that uses a high temperature bacterial culture to convert poultry waste into methane, the major combustible constituent of natural gas.

The prototype “digester” produces biogas that is 80 percent methane and also provides several additional ecological benefits. Nutrients in the digester effluent can be recycled and used as animal feed. The digester destroys pathogens present in the fecal matter and eliminates the odor associated with raw poultry waste. And the capture of biogas reduces emissions of methane, a greenhouse gas, into the atmosphere. Large-scale application of the technology could contribute significant amounts of biogas to the global energy mix while reducing the environmental impacts associated with continued extraction and use of natural gas.

Neal Stewart of the UT Institute of Agriculture’s Department of Plant Sciences discussed the role of biotechnology in improving the quality and yield of switchgrass, which is native to most of the United States.

“It is widely considered that biotechnology will be useful both to rapidly improve bioenergy crops as well as to provide tools to genetically manipulate them for scientific evaluation,” said Stewart. Among other research goals, Stewart and colleagues hope to genetically alter switchgrass to make its lignin easier to process into liquid fuels, increase the plant’s sun-gathering leaf surface, and increase the capacity of the plant’s roots to sequester carbon underground.

Both China and the United States face similar challenges in making biofuel production sustainable within significant physical and economic constraints. Chinese legislation promoting biomass energy is under development, while EISA guides US biofuel production. In October, the US Biomass Research and Development Board released its National Biofuel Action Plan, which outlines key research and institutional barriers to address in achieving sustainable biofuel production. (Access the report here: http://www1.eere.energy.gov/biomass/pdfs/nbap.pdf)

For information on the conference or the China-US Joint Research Center for Ecosystem and Environmental Change, visit the Web site (http://isse.utk.edu/jrceec/) or contact the center coordinator Jie (Joe) Zhuang at 865-974-1325, email jzhuang@utk.edu

of possible actions to offset the effects of GHG warming primarily by reflecting a small portion of the solar radiation back to space. Many technologies have been proposed for this strategy, including mirrors in space, small reflective particles deposited into the stratosphere, and whitening low hanging clouds over the ocean by spraying fine sea water droplets into them from remotely controlled unmanned ocean sailing vessels.

TOOLS TRIPARTITE

It’s interesting to note that each of these strategies can be pursued more or less independently of the others. That doesn’t mean that the strategies don’t influence each other. Mitigation actions can reduce the intensity with which adaptation measures need to be pursued, for example. Still, adaptation actions can be taken independent of mitigation actions. The same applies to geoengineering.

These three strategies give us a rich portfolio of tools for managing climate change. The adaptation and the geoengineering strategies obviously can apply to both anthropogenic as well as natural climate change. Mitigation and geoengineering must be applied globally—or nearly globally—to be effective. Adaptation, on the other hand, can be effectively applied regionally and even locally in many circumstances.

How should these tools be used to improve the well-being of humans and the ecosystem? I can’t answer conclusively, but a variety of plausible scenarios should be assessed in terms of costs, relations among nations, and technical feasibility.

Unfortunately, the problem of climate change is not being treated as an integrated management problem. The fact that the three strategies can
be pursued independently is part of the reason. Meanwhile, there is a real imbalance in the application of resources. Mitigation is the primary focus of most of the R&D and policy measures. This is reasonable, considering that, to fully address climate change, the whole energy system must be reinvented. But it doesn’t really matter what we do in the United States unless China and India begin to curtail their emissions as well.

The developing world is growing rapidly and its emissions will likely be the major determinant of increases in GHG concentrations in the future. Consider, for instance, that China’s carbon dioxide emissions recently exceeded those of the United States.

Two quotes from the recently released National Action Plan on Climate Change of the Indian government illustrate the challenge:

Maintaining a high growth rate is essential for increasing the living standards of the vast majority of our people and reducing their vulnerability to the impacts of climate change (p.2). [But]…India is determined that its per capita greenhouse gas emissions will at no point exceed that of developed countries even as we pursue our development objectives (p.2).

For India, poverty trumps climate as the dominant issue, but further, for India, relieving poverty is an adaptation measure. In my opinion, this is a perfectly reasonable point of view. The Indian plan is clear and well written and it lays out an approach that focuses on adaptation as well as advanced energy systems.

Actions that strengthen adaptive capacity at all geographic scales need to be studied and sensibly undertaken. Yet, we do not have a comprehensive adaptation plan.

**GEOENGINEERING GAINS SUPPORT**

The geoengineering strategy is not currently being considered seriously by the US government. But during the past year, interest in it has grown enormously in the popular and scientific press and among climate modelers and scientific and technical communities around the world.

An active Google Group exists (geoengineering@googlegroups.com), with daily exchanges of information and ideas and even rather heated arguments. This huge interest derives from the concern that mitigation will not be effective soon enough and that geoengineering schemes may provide effective offset technologies that can be implemented quickly, not to the exclusion of mitigation but in conjunction with it.

Geoengineering may be the only way to avoid the loss of Arctic summer sea ice, for example. We might achieve an effective reversal of sea ice loss by putting the right kind of reflective micro particles in the stratosphere at high latitude. Furthermore, the cost of such schemes is estimated crudely to be quite small compared with the cost of mitigation measures.

In a sense, geoengineering is an insurance policy. Most who have looked at this strategy say it deserves serious R&D funding. It may ultimately prove to be inoperable or too risky, but we should nevertheless support the R&D investment to determine if this strategy might work.

I am a participant in the summer Seminars on Planetary Emergencies held in Erice, Sicily, and sponsored by the World Federation of Scientists. At the 2007 seminar, the following recommendation was approved by a workshop on managing climate change that involved scientists from some 10 countries:

Although the largest parts of the R&D budget on countering the effects of climate change should go to mitigation and adaptation, a significant portion should be directed toward approaches to geoengineering, including stratospheric aerosols. Both the effectiveness and the side effects of these approaches must be evaluated theoretically and by field experiment before they can be seriously considered for use.

As we move forward on these other fronts, we also need to improve understanding of the climate and interacting systems and to apply the tools of climate management wisely. In Erice this past summer a proposal called for establishment of a major international center for climate change research—one built around state-of-the-art super computers—to aggressively test, refine, and improve global circulation models.

This would be a virtual center involving researchers and other centers around the globe. Improved climate models are keys to better evaluating proposed policies and actions.

Despite the gains we have achieved, I suspect that the challenge of managing climate change to advance the sustainable well-being of humanity and ecosystems will consume the students of this and other universities for decades to come. It will provide an infinitely diverse multidisciplinary arena for research in the social, economic, and policy fields as well as in the physical, chemical, and engineering sciences. All of those disciplines—and others—must play a role.

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is not simply the supply of energy that presents this challenge. With concerns rising steadily over the effects of carbon dioxide emissions on climate change, there is increasing momentum behind producing greater amounts of energy from clean sources that do not emit large amounts of carbon dioxide.

To address these challenges to our national security and economic competitiveness, we need to map out a balanced and comprehensive energy policy that diversifies our energy supply and emphasizes conservation and energy efficiency so we are less reliant on foreign sources of oil and traditional fossil fuels. Accomplishing this will require a multilateral approach that includes all available resources: nuclear power, alternative fuels, renewables such as wind and solar, domestic oil, natural gas, oil shale, and coal.

Some of these resources already exist, while the future of others is reliant on technological breakthroughs to make them commercially viable and environmentally sound. It would be unrealistic to believe that just one or two of these options will provide the solution. All of them are necessary; without the full portfolio, we cannot hope to protect our national security or economic competitiveness.

The summer brought a vigorous debate about how best to increase and improve domestic energy production. I am sincerely anxious for the day—and I hope it comes in our very near future—when most Americans will be driving affordable vehicles powered by electricity and other nonpetroleum-based technologies like plug-in hybrids, hydrogen fuel cells, and a broad range of biofuels and alternative fuels. But while we’re transitioning to this promising future—with great urgency, I hope—I believe it makes sense to take advantage of all of our domestic resources, including oil and natural gas, rather than shipping billions of dollars overseas to countries that would do us harm.

The US has less than 3 percent of the world’s oil reserves yet consumes 25 percent of the world’s oil, so it is clear that increased domestic production will only provide a bridge to the future. Because of this reality, I joined a bipartisan group of senators to craft a proposal that puts our country on a path toward energy security. The plan contains three major components: targeted, responsible domestic production of energy; an intensive effort to transition vehicles to nonpetroleum-based fuels; and a robust federal commitment to conservation and energy efficiency. Specifically, our proposal advances nuclear energy by accelerating depreciation for nuclear plants and supporting research and development on spent fuel recycling to reduce nuclear waste. We also promote clean coal technology by providing grants and loan guarantees for the development of coal-to-liquid fuel plants with carbon-capture capability. Coal-to-liquid fuel could become a secure source of additional transportation fuel. Furthermore, our bill will decrease demand for energy, particularly for oil, by transitioning our cars and trucks to new technologies such as electric vehicles, hybrids, and alternative fuels and providing incentives to consumers for the purchase of these vehicles. I had hoped that Congress would take a serious look at this proposal before the end of the past legislative session, but it is more likely that we will tackle these issues in 2009.

Congress did take a meaningful step toward opening up more domestic resources of oil and gas by lifting an outdated 25-year ban on offshore oil exploration. Technology has come a long way in making drilling for oil more environmentally friendly; in fact, during Hurricane Katrina no major oil spills occurred in the Gulf of Mexico even as offshore rigs washed up along the shorelines. As we move forward on a comprehensive national energy policy, oil and natural gas will continue to be an important component in making our country more energy secure.

I am also particularly proud of the initiative Tennessee is taking in the energy arena. Our state is playing a role in the revitalization of the nuclear power industry and is also a strong leader in the development of advanced biofuels. Tennessee’s climate and terrain make it ideally suited to produce the kind of feedstocks, such as switchgrass, used in the next generation of biofuels. Plans are moving ahead to position Tennessee as
a leading producer of cellulosic ethanol. I am excited about the partnership the University of Tennessee has developed to construct a cellulosic ethanol pilot biorefinery in Monroe County that will convert corn stover, cobs and fiber, and switchgrass into renewable fuels.

Continued investment in this area will significantly benefit the state’s agricultural community, and I will work to promote more of these business ventures. A robust biofuels industry in the United States must include the production of cellulosic ethanol, which does not compete with food sources for people and livestock or result in as many environmental problems as does the production of corn ethanol.

Congress and the next administration must deal with our nation’s energy crisis with a balanced and meaningful approach. It is time to put politics aside and get serious about an aggressive energy solution that protects our national security and enhances our economic competitiveness. Any approach that sacrifices either of these priorities is shortsighted and puts the future safety and prosperity of our country at risk. While recent drops in crude oil prices will provide some relief to consumers at the pump, it is my fervent hope that this does not result in our country losing its resolve to move away from oil dependence and become more energy secure.

Bob Corker was elected US Senator for Tennessee in 2006 and currently serves on the Energy and Natural Resources Committee. He is the former mayor of Chattanooga and Tennessee Commissioner of Finance and Administration.
ISSE IN THE MEDIA

ISSE researcher Cat Wilt was dubbed a “green goddess” and “environmental friend” in the August 2008 Knoxville edition of Skirt Magazine.

ISSE Director Randall Gentry was interviewed by radio station WKNO-FM in Memphis for a December 2 story titled “The Memphis-Mississippi Water Fight Resumes.” He was also quoted in a June 10 article in the Chattanooga Times Free Press, “Tennessee: Turning methane into power.”

ISSE’s Community Partnership Center (CPC) is part of a consortium of local educational and tourism-related organizations who have established a new wireless Wi-Fi network in the downtown area that will promote Knoxville’s black heritage through digital storytelling. KnoxNews.com featured articles on the project on August 19, “Wireless cultural tour of downtown almost ready,” and on August 20, ”Digital stories share Knoxville history.” knoxvillebiz.com also featured an article on August 19, “Wi-Fi network holds promise for downtown merchants.”

AWARDS, HONORS, AND ACCOMPLISHMENTS

During a trip to China in October, ISSE Director Randall Gentry was invited to become an Honorary Scientist of the Institute of Soil and Water Conservation, Chinese Academy of Sciences and Ministry of Water Resources.

ISSE’s Center for Clean Products (CCP) has been selected to manage the process of creating the next generation of greener electronics. The research grant, in the form of a cooperative agreement with the US Environmental Protection Agency, will allow CCP to build upon the work developed through the Electronic Product Environmental Assessment Tool (EPEAT). The paper, “Temporal variation and persistence of bacteria in streams,” by Shesh R. Koirala, Randall W. Gentry, Edmund Perfect, John S. Schwartz, and Gary S. Sayler from the July-August 2008 issue of The Journal of Environmental Quality, has been selected for inclusion in the Research Highlights program by the American Society of Agronomy/Crop Science Society of America/Soil Science Society of America (ASA/CSSA/SSSA). It was also featured in Science Daily.

The “Clean Water Act Brief” submission on a case now before the Supreme Court, coauthored by ISSE Senior Fellow Milton Russell and other economists, was listed on the Social Science Research Network’s “Top Ten Download List” for both the Public Policy Centers Research Papers category and the Industrial Organization & Regulation Journals category for over two months this summer.

In July, ISSE Research Leader Mary English was reappointed for a third term as a member of the Tennessee Air Pollution Control Board. She was also provisionally appointed to new study committee of the National Research Council: the Committee on Health, Environmental, and Other External Costs and Benefits of Energy Production and Consumption.

PRESENTATIONS


PUBLICATIONS

The Summer 2008 issue of UT’s Tennessee Alumnus magazine contained a story written by ISSE Director Randall Gentry on graduate research done by ISSE Research Associate Amanda McKenna. The story, “From Clouds Come Rain—and More,” discusses testing the waters in a remote Smoky Mountain stream to explore the interaction between the cascades, seeps, and plunge pools on the surface and the catchments of water held within the earth. Gentry also has two new journal articles (both with S. S. Ivey, D. Larsen, and J. L. Anderson): “Case Study of the Sheahan Wellfield Using 3-H/3-He Field Data to Determine Localized Leakage Areas,” Journal of Hydrologic Engineering 13(11): 1011-1020; and “Inverse Application of Age-distribution Modeling Using Environmental Tracers 3-H/3-He,” Journal of Hydrologic Engineering 13(11): 1002-1010.

John Sanseverino and Gary Sayler, both with ISSE and the Center for Biotechnology, published “Screening of potentially hormonally active chemicals using bioluminescent yeast bioreporters” in the November 7, 2008 issue of Toxicological Sciences (an online journal, doi: 10.1093/toxsci/kfn229). Co-authors were M. Eldridge, A. Layton, J. Yarbrough, J. Easter, and T.W. Schultz.


Ted Henry (ISSE and the Center for Biotechnology) published (with R.D. Handy, T.M. Scown, B. D. Johnson, and C. R. Tyler) “Manufactured nanoparticles: their uptake and effects on fish: a mechanistic analysis” in Ecotoxicology 17; and (with M. C. Black) “Survival and development of western mosquitofish exposed to the SSRI fluoxetine HCl” in Archives of Environmental Contamination and Toxicology 54.
