A New Energy Crisis

Precarious energy situation demands strategic solutions, prompts new research initiative.

BY JANE M. SANDERS

@ A new initiaitve at Georgia Tech aims to develop economically viable, transitional energy technologies that will help the nation and the world bridge the gap between its oil- and gas-dependent energy infrastructure to one based on a clean, renewable source – a milestone that could be 50 years in the future.

As certain as death, the world's production of oil and gas is limited. But predicting when production of these high-demand energy sources will peak is as difficult as forecasting the hour and date of one's passing.

Experts debate the future of fossil fuels and the potential of renewable sources. Meanwhile, demand is escalating, energy prices are soaring and the United States is becoming increasingly dependent on foreign fuel from politically unstable regions.

This teeter-totter of energy supply and demand has reached a tipping point, and the Georgia Institute of Technology wants to help restore its balance. Challenged by Institute President Wayne Clough to create innovative solutions with value that makes them worth the cost in the competitive 21st century world, researchers recently launched the Strategic Energy Initiative (SEI) at the request of Provost Jean-Lou Chameau.

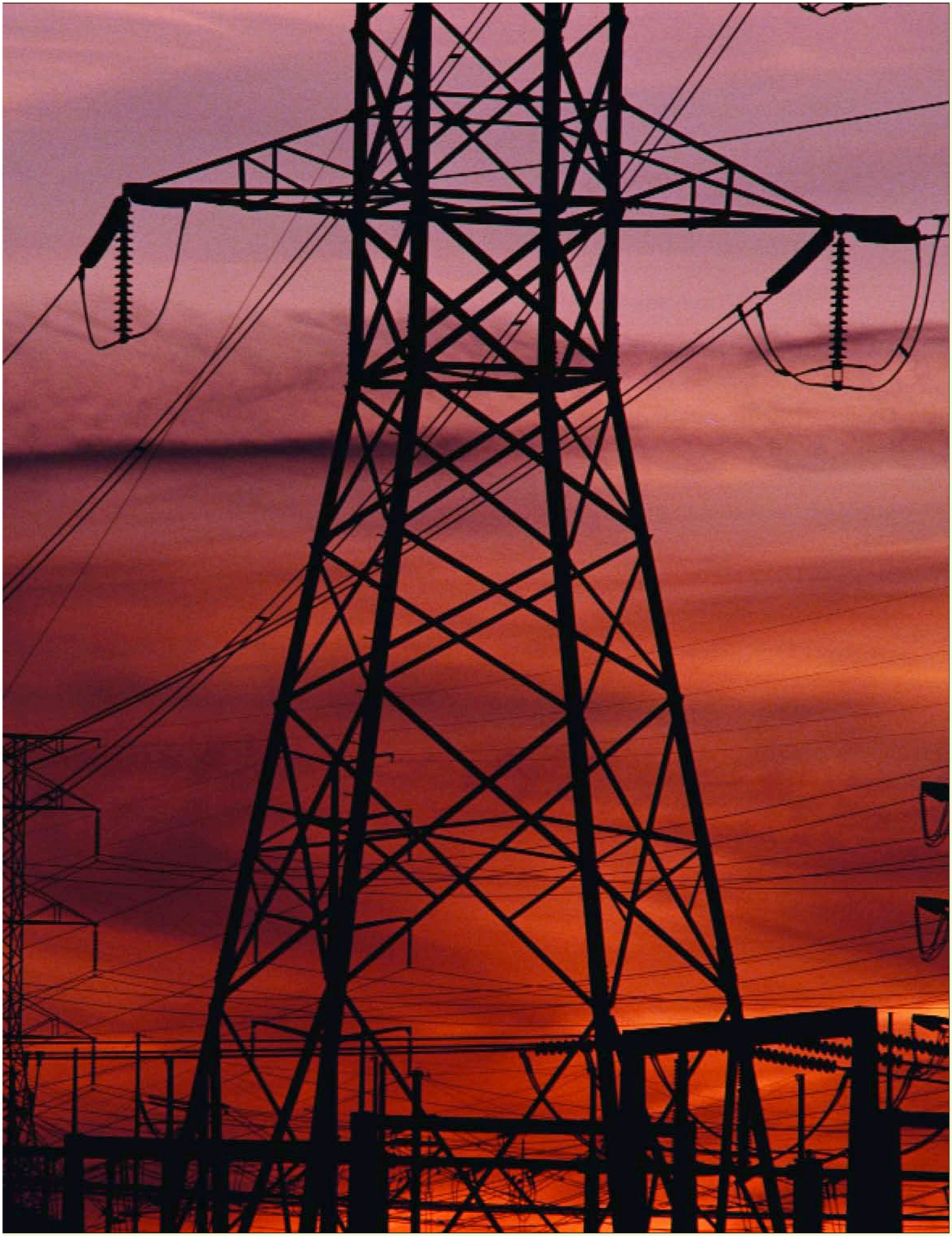
Its goal is to develop economically viable, transitional energy technologies that will help the nation and the world bridge the gap between its oil- and gas-dependent energy infrastructure to one based on a clean, renewable source – a milestone that could be 50 years in the future.

"Even if peak production doesn't happen for 15 to 20 more years, you can't rebuild the energy infrastructure in less time than that," says initiative director Sam Shelton, an associate professor of mechanical engineering. "So you've got to start now developing transitional technologies, especially those for the oil-dependent transportation system."

In addition to energy technology development for the transportation, building, manufacturing and electric

PHOTO COURTESY GEORGIA DEPT. OF ECONOMIC DEVELOPMENT

INSET: *The nation's energy infrastructure could take decades to rebuild. Transitional energy technologies, such as wind power, will have to fill the gap between peak oil production and renewable energy technology, researchers say. Here, a power plant lights the nighttime sky in Georgia.*



> "We will do research and learn from this and pass on that knowledge to clear a path for other offshore wind energy projects in the future."
>
> **Susan Stewart,**
> SEI research engineer

PHOTO BY GARY MEEK

RIGHT: Georgia Tech's new Strategic Energy Initiative is led by Associate Professor Sam Shelton, top left, who is assisted by research engineers William Bulpitt and Susan Stewart, bottom right, and special projects coordinator Mary Hallisey Hunt.

power sectors, the Strategic Energy Initiative (SEI) is working with faculty members across campus conducting technology assessments, coordinating demonstration projects and providing policy guidance based on scientific research, engineering principles and economic realities. Georgia Tech is collaborating on these efforts with industry and government partners.

At the heart of this effort is its emphasis on strategic solutions, Shelton notes. Does an energy technology not only meet efficiency, environmental and safety criteria, but is it also economically viable? Can it make a significant impact?

"There are all kinds of ideas – like geothermal, solar and wind -- for renewable energy technology and ways to reduce energy consumption," Shelton says. "The winners will be the ones that are economically viable in our capitalistic, free market society. If oil is the cheapest, then it will continue to win as long as we have it."

Shelton bemoans the nation's lack of focus on transitional energy technologies -- such as higher efficiency air conditioners, advanced hybrid vehicles, wind power, and biomass and coal gasification — that could fill the gap until renewables are readily available and economically viable.

"Sometimes I feel like we as energy researchers are working to build the streets of San Francisco, but there's no highway to get anybody there," he says. "Why build the streets if you can't ever get to San Francisco? Why would you create hydrogen energy technology, for example, if you have no path to get there and the economy is going to collapse before you get there?"

Hoping to "help build the highway," the SEI has begun its quest with studies of two potential transitional energy solutions that could have a significant impact, especially in the southeastern U.S.

Blowin' in the Wind

The answer, my friend, may be blowin' in the wind, as the old Bob Dylan song goes. More specifically, offshore wind energy may have much more potential in the southeastern United States than once believed.

A feasibility study conducted by SEI revealed that the average annual wind speed of 16 miles an hour 40 miles off Georgia's coast makes the region a Class 4, or "good," wind energy source on a scale of one to seven. A "Class 7" source is rare, while most land-based wind energy projects rate as Class 5 or 6. A 1981 study by Pacific Northwest

> "The platforms that will support wind energy turbines are designed like those for oil rigs. They can withstand Category 5 hurricane winds of 150 to 165 miles an hour for a short period. The wind turbines are designed to stop rotating after wind speeds reach about 50 miles an hour to prevent damage."
>
> — **Susan Stewart**, SEI research engineer

PHOTO COURTESY GEORGIA DEPT. OF ECONOMIC DEVELOPMENT

A demonstration project of three to five offshore wind turbines near Savannah, Ga., could generate 10 megawatts of power for about 6 cents per kilowatt hour, a cost competitive with natural gas fuel costs, according to a recent study by Georgia Tech.

Laboratory had ranked the Southeast's coasts as a Class 2 resource.

"People had written off the Southeast as a wind energy source, and we're finding this is absolutely not true," says SEI research engineer Susan Stewart, who conducted the feasibility study. "It was a huge surprise. And it seems economically feasible based on our cost estimates."

In fact, a demonstration project of three to five wind turbines near Savannah could generate 10 megawatts of power for about 6 cents per kilowatt hour, a cost competitive with natural gas fuel costs, the study shows. This amount of electricity – 27 million kilowatt hours per year — could meet the annual energy needs of about 2,500 average homes — a significant number to power with renewable energy, Stewart says.

The study was based on six years of wind data taken from meteorological equipment mounted 50 meters above the ocean waters on several platforms about 40 miles off Georgia's coast. This equipment, operated by the University System of Georgia's Skidaway Institute of Oceanography in Savannah, records wind speed and direction information.

SEI's Shelton became aware of the data's existence through David Frost, director of the Georgia Tech Savannah campus, who is on Skidaway's Marine Science Foundation Board. Frost is also a co-principal investigator on a National Science Foundation grant for InfinitEnergy, a public/private alternative energy partnership that initiated the wind energy feasibility study. *(See "Power Surge" sidebar article on page 10.)*

"If it hadn't been for this data, no one would've ever believed that this is an economically viable place for a wind turbine," Shelton says.

In addition to its favorable wind speeds, another factor that makes Georgia's coast an attractive location for offshore wind power is its 80-mile wide continental shelf, the largest in the Southeast. The shelf provides the relatively shallow ocean waters needed to build wind turbine platforms 20 to 40 miles off the coast, where they aren't visible to coastal residents, Shelton explains.

With the Georgia coast's potential documented and other supporting studies in hand, Shelton and the SEI team, including

Land-based wind farms, such as this one, are growing in number in the United States as utility companies seek out "green energy" sources.

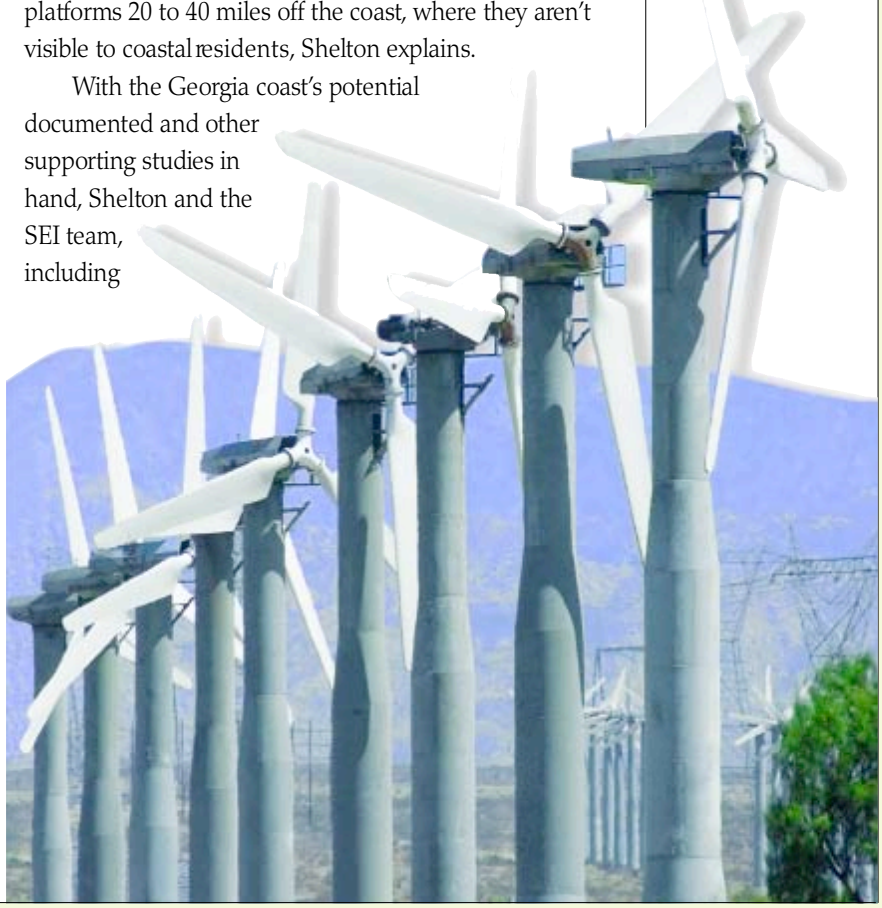


PHOTO GLENN SNTRENT/ISTOCKPHOTO.COM

A NATIONAL RENEWABLE ENERGY LABORATORY STUDY SHOWED THE POTENTIAL FOR WIND ENERGY FROM AREAS 5 TO 50 NAUTICAL MILES OFF THE U.S. COAST IS ABOUT 907 GIGAWATTS OF POWER — AN AMOUNT GREATER THAN THE TOTAL INSTALLED ELECTRICITY-GENERATING CAPACITY IN THE NATION. ADDITIONAL RESOURCES IN THE GULF COAST AND GREAT LAKES REGIONS HAVE YET TO BE FULLY CHARACTERIZED AND HAVE NOT YET BEEN QUANTIFIED.

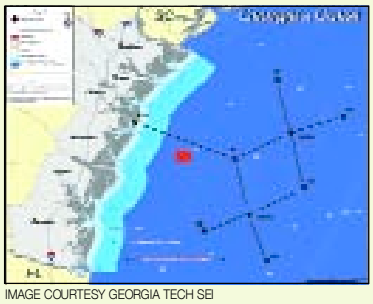


IMAGE COURTESY GEORGIA TECH SEI

BELOW: *Switchgrass is one of the most promising energy crops in the southern United States. Now that gasification is being developed to turn feedstocks like switchgrass into electricity, farmers have the option to plant these hardy grasses to restore eroded land and gain flexibility in crop planning and rotation.*

PHOTO BY WARREN GRETZ, COURTESY NATIONAL RENEWABLE ENERGY LABORATORY

consortium of industry, academic and government organizations. It will spearhead a research, development and demonstration project to build and operate a small wind energy farm to produce 10 megawatts of electrical power off Savannah's coast. Shelton hopes construction will begin in early 2006, but points out many hurdles ahead. These include environmental and engineering studies, as well as federal permitting. The effort would involve Skidaway researchers, as well as scientists and engineers from numerous Georgia Tech academic units.

The turbines would most likely be owned and operated by a private company that could use or sell wind energy to meet its standards for providing "green" energy, Shelton notes. If the demonstration project proves successful, it could be expanded, he adds.

Power Surge

Coastal consortium advances alternative energy.

BY T.J. BECKER

If InfinitEnergy has its way, Savannah, Georgia's, reputation for being the South's "hostess city" may soon give way to the "alternative energy city."

Launched in 2003 with National Science Foundation funding, InfinitEnergy is a public-private partnership based at Georgia Tech Savannah. It promotes the understanding and innovative use of alternative energy. Also known as "green energy," alternative energy is derived from either clean or renewable power sources such as the sun, wind, water, hydrogen and biomass (organic matter such as wood or agricultural waste).

About 72 percent of the United States' energy comes from coal and petroleum while alternative energies account for less than 6 percent, according to government statistics.

"Yet it's only a matter of time before alternative energy becomes the mainstay of our country's power mix," says William K. Dodd, president of Atlanta-based Biltmore Communications Inc. and industry liaison for InfinitEnergy.

"Today, economic issues are driving alternative energy as opposed to political ones," explains Dodd, a Georgia Tech alumnus who helped spearhead InfinitEnergy. "In the '70s, there was a push toward alternative energy because of the oil embargo. Many of those technologies

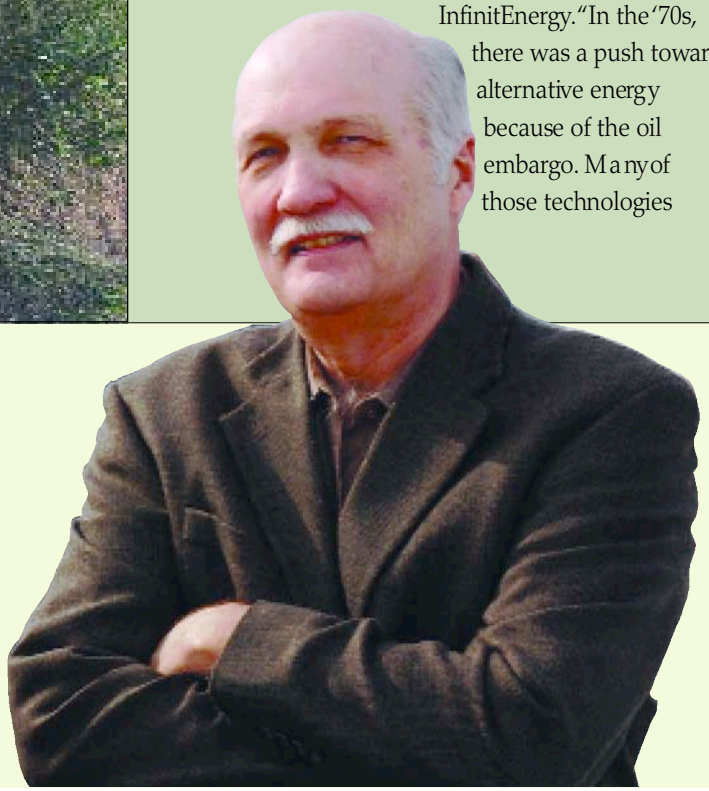


PHOTO BY GARY MEEK

inBrief

"Today, there's more consensus that our natural gas resource is finite – that there's not as much out there as we once thought. It's a highly regarded commodity because of its low environmental impact and there are certain chemical processes that require the molecular structure of natural gas."

— **Bill Bulpitt**, senior research engineer for the Georgia Tech Strategic Energy Initiative

failed because they didn't make economic sense. Today, however, there are many situations where alternative energies, such as wind and solar photovoltaic, are the best economic choices."

Although California is at the forefront of alternative energy development in the transportation sector, no state has become a real Mecca for distributed generation of alternative energy, Dodd says. "Why not Georgia?" he asks, noting that Savannah's abundance of natural resources, including biomass, wind and ocean tides, make it the ideal test bed for a variety of alternative-energy technologies.

Comprised of academic, government and commercial partners, InfinitEnergy operates under the umbrella of the Georgia Tech Strategic Energy Initiative (SEI). Established under the Office of the Provost, one of the partnership's goals is to conduct demonstration projects and build an infrastructure that will attract alternative-energy research and development and manufacturing companies to the Savannah region.

With SEI, InfinitEnergy is proposing an offshore wind farm near Savannah that could be the first of its kind in the United States. A demonstration project of three to five wind turbines could generate about 10 megawatts of power. *(See "A New Energy Crisis" on page 6 for details.)*

In another project, Kevin Haas and Hermann Fritz, both assistant professors of civil and environmental engineering at Georgia Tech Savannah, are researching methods for harnessing tidal and wave energy. "Our waves in Savannah are fairly small, but we have a large tidal range – about 8 feet – which is among the largest in the Southeast," Haas notes.

Tidal energy can generate power ranging from the 20-megawatt capacity of a Nova Scotia plant to the 240 megawatts produced at a facility in France. "In the

PHOTO COURTESY GEORGIA DEPT. OF ECONOMIC DEVELOPMENT

southeastern United States, we would expect to have much less capacity due to the smaller tidal range," Haas explains. "But we could try to exploit energy from the tidal stream, rather than the tidal head, by extracting power directly from currents using underwater devices similar to wind turbines."

In other activities, InfinitEnergy partner Savannah Technical College is developing a solar demonstration project to promote alternative energy and give students experience in installing solar panels. Partner Home Depot has expressed interest in installing solar photovoltaic arrays on the roof of its 37-acre distribution plant. These arrays could potentially produce hydrogen for fuel cells to help power the Georgia Tech Savannah campus.

In addition, InfinitEnergy is engaged in public outreach and education. "For the most part, people either don't know about alternative energy technologies – or it seems like science fiction to them," says Julie Sonnenberg-Klein, InfinitEnergy's project coordinator. "We want to make alternative energy more of a reality."

@ Read more at: gtresearchnews.gatech.edu/reshor/rh-w05/infinite.html and infinitenergy.gtrep.gatech.edu

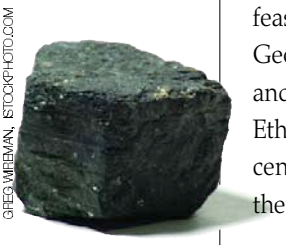
The coastal Georgia city of Savannah has an abundance of natural resources — including biomass, wind and ocean tides — which make it the ideal test bed for alternative-energy technologies, says William K. Dodd, president of Atlanta-based Biltmore Communications Inc. and industry liaison for InfinitEnergy.

CONTACTS

Julie Sonnenberg-Klein at 912-966-7838 or julie.sonnenbergklein@gtrep.gatech.edu

Savannah Electric recently started a solar energy buy-back program. The company will purchase a total of 500 kilowatts of solar energy at 15 cents per kilowatt hour from homeowners who generate it with solar panels installed on their rooftops. The program in Georgia is the state's first. Homeowners in California can also sell solar energy to the state's utility companies.

Read more at: infinitenergy.gtrep.gatech.



GREG WIEDMAN, ISTOCKPHOTO.COM

The United States' energy infrastructure is dependent on oil, gas and coal, with an increasing amount imported from often-unstable foreign sources.

> "It's our goal to provide national energy options and opportunities to achieve a more independent, secure and environmentally sound economy."
>
> **Sam Shelton,** director, Strategic Energy Initiative

Gasoline from Biomass

Another undertaking of the SEI is to determine the feasibility of building a demonstration plant in south Georgia for using woody cellulose – wood waste, trees and switchgrass, for example — to produce ethanol. Ethanol, currently produced from corn, represents 10 percent of the contents of regular gasoline in many areas of the United States.

"The problem is with the energy accounting with ethanol made from corn," Shelton explains. "For every 100 units of energy you get when you burn ethanol, it takes about 75 units of oil and gas to produce it. That's not a big gain. The energy accounting is much better for ethanol produced from woody cellulose. For every 100 units of energy, you only use about 25 units of oil and gas to produce ethanol made from woody cellulose…. So that's a much bigger strategic impact than ethanol produced from corn."

Georgia would be well-suited for a commercial ethanol production facility because of its large forestry industry, say Shelton and power systems expert Bill Bulpitt, who is conducting the feasibility study.

"There are 25 million acres of forests in Georgia, and timber is a cash crop in a lot of ways," Bulpitt says. "But its demand has diminished in the past 10 years as the demand for pulp in paper mills in Georgia has gone down. So much pulp is produced elsewhere now, like in Brazil where they have a longer growing season and cheaper operating costs."

The industry, as well as the Georgia Forestry Commission, is concerned because trees are not being consumed at a balanced rate, Bulpitt notes. He expects the feasibility study will show renewed interest in creating energy from wood waste, such as non-market timber left over after a clear cut, forest thinning operations and sawmills.

An ethanol plant also could be supplied by fast-growing switchgrass, which could be a new crop for south Georgia foresters, Shelton says.

"There is not a single woody cellulose-based ethanol commercial plant in the United States today, but we could work with Georgia Tech faculty and agricultural engineers at the University of Georgia to put together the technology to make this happen and become a national leader in this field," Shelton says.

The feasibility study is expected to be finished by midsummer 2005.

"It is interesting that making ethanol from woody cellulose was a topic of discussion 25 years ago and now we're looking at it again," says Bulpitt, who conducted wood and other biomass energy research at the Engineering Experiment Station, precursor to the Georgia Tech Research Institute, from 1977 to 1985. The energy crises of the 1970s prompted funding of much of that research, but changing federal priorities ended most of the work by 1985.

Now, as natural gas prices have soared again and there's more consensus that supply is finite, interest in biomass – and coal – gasification has re-emerged, Bulpitt says. Coal gasification dates to the 1800s, when its product lit city streetlamps, but created pollution and safety hazards.

Today, newer processes produce gas from coal in an ecologically friendly way, Bulpitt explains. In a conventional power plant with natural gas-powered turbines, a coal gasification facility operates as a mini-refinery next door to make usable gas and chemical byproducts.

PHOTO BY SCOTT CRESSMAN, COURTESY ISTOCKPHOTO.COM

Online

Because of geological conditions (i.e., the flow of oil through soil, rocks and sand), oil production peaks and then reaches a physical limit to how fast it can be pumped out after the source is depleted to less than half its original reserve. Because of this geological principle, the United States now produces 60 percent of the oil it produced in 1970.

-- Georgia Tech Strategic Energy Initiative and U.S. Dept. of Energy's Energy Information Administration

PHOTO COURTESY GEORGIA DEPT. OF ECONOMIC DEVELOPMENT

Georgia Tech researchers are studying the feasibility of building a demonstration plant in south Georgia for using woody cellulose – wood waste, trees and switchgrass, for example — to produce ethanol. Ethanol, currently produced from corn, represents 10 percent of the contents of regular gasoline in many areas of the United States.

"Renewable energy technologies like these have a place in solving our energy problems," Bulpitt says. "They always have. The problem, however, is that it's difficult for them to stand alone without government energy subsidies. But if energy prices stay where they are today, there will be more interest in these transitional technologies."

Bulpitt laments the lessons not learned from the energy crises of the 1970s and says the nation is more vulnerable today than it was then because of its increased dependence on foreign gas and oil.

"We've not fixed this problem as a whole in this country," Bulpitt says. "So now Georgia Tech is trying to plug the hole."

Shelton adds: "It's our goal to provide national energy options and opportunities to achieve a more independent, secure and environmentally sound economy."

@ Read more at: gtresearchnews.gatech.edu/reshor/rh-w05/sei.html or www.energy.gatech.edu

contacts

Sam Shelton at 404-385-0384 or info@energy.gatech.edu

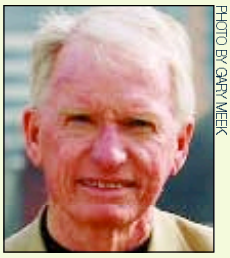


PHOTO BY GARY MEEK

"The fact that the nation doesn't know where it's headed in energy technology is the reason we call this the Strategic Energy Initiative. We need to do strategic studies to ask what technologies can get us through this period of time we need to develop clean, renewable energy sources to drive our economy."

A Sunny Past and Future

Georgia Tech advances solar energy research through the years.

> "Researchers are working to reduce cell-processing cost without compromising efficiency to make PV-generated electricity more competitive with other sources."
>
> **Ajeet Rohatgi,** Regents Professor and Director, University Center of Excellence for Photovoltaics Research and Education

In the mid-1970s, the Engineering Experiment Station (now the Georgia Tech Research Institute) operated a solar energy research program with interests in high-temperature solar thermal energy conversion, electric power generation, and liquefaction and gasification of biomass using solar thermal energy.

At the U.S. Department of Energy-funded Solar Thermal Test Facility on the main campus, Georgia Tech Research Institute (GTRI) researchers developed a method for creating high-grade synthetic fuels with solar thermal energy. In 1980, researchers from GTRI and Princeton University announced a breakthrough in pyrolysis in which highly concentrated solar energy, rather than burning of biomass, provided the heat necessary for pyrolysis reactions. Subsequently, GTRI researchers were instrumental in developing standards for several different types of biomass fuels through the American Society for Testing and Materials (ASTM).

GTRI engineers at the Solar Thermal Test Facility directly produced power-grid quality electricity with a Georgia Tech/Swedish-built Stirling external combustion engine, whose pistons were driven by helium heated by intense sunlight.

By the mid-1980s, interest shifted to photovoltaics (PV), as the efficiency of PV devices increased and the cost of making solar cells decreased. A research program in the School of Electrical and Computer Engineering studied new semiconductor materials and designed innovative devices.

In 1992, that work garnered Georgia Tech a Department of Energy contract to operate the University Center of Excellence for Photovoltaics Research and Education (**www.ece.gatech.edu/research/UCEP**). The center, directed by Regents Professor Ajeet Rohatgi, was awarded to Georgia Tech for its sustained contributions to the science and technology of photovoltaics. Its mission is to give the United States a competitive edge in PV through high-quality research and education on PV materials, devices and systems.

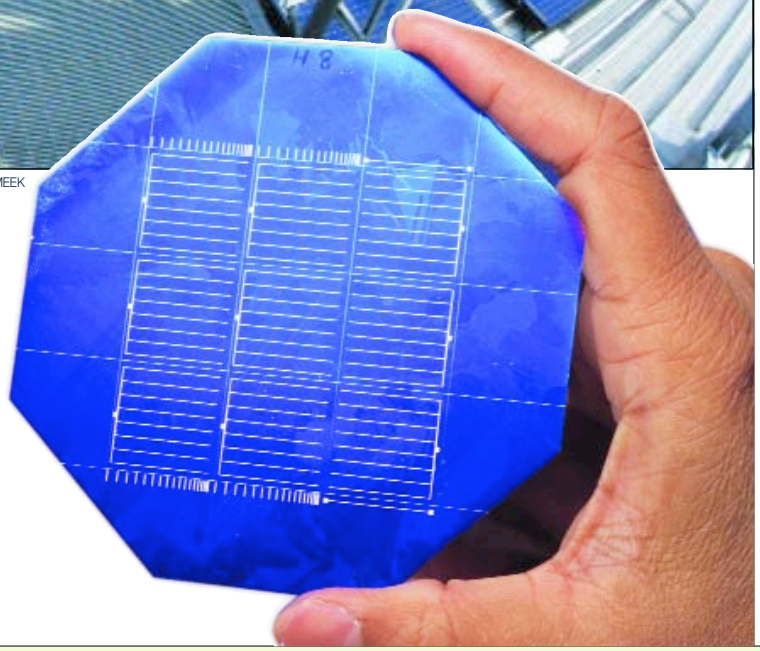
Today, the Center operates a 340-kilowatt PV system installed on the Georgia Tech Aquatic Center, which was built for the 1996 Olympics. It produces enough electricity to provide 30 to 40 percent of the building's power needs – an amount sufficient to energize 70 average homes.

The Aquatic Center serves as a test bed for large-scale PV arrays. It continues to provide a wealth of information about the reliability of large PV systems, how they should be connected to the utility grid for effective, distributed generation and what architects should expect from the growing number of similar systems being integrated into new buildings, Rohatgi says. UCEP is conducting research to improve the design, performance and reliability of PV systems.

Work under way in UCEP also produces basic scientific advances and improvements in manufacturing technologies for silicon solar cells. Researchers are working to reduce cell-processing cost without compromising efficiency to make PV-generated electricity more competitive with other sources, Rohatgi explains. Through computer modeling, UCEP has established cost and technology roadmaps for making PV cost-effective. UCEP has produced record-breaking high-efficiency cells

in brief

> "To support future societies with a continued energy supply, the development of integrated and combined systems that maximize energy efficiency and renewable energy use is essential. The focus should not simply be on developing new technologies, but also evaluating and integrating available technologies and advances in research on a rational basis that will yield maximum societal benefits. This requires the research community to innovate at every level of the energy value chain, including public awareness."
>
> — **Jean-Lou Chameau**, Provost, Georgia Institute of Technology



PHOTOS BY GARY MEEK

A 340-kilowatt photovoltaic system is installed atop the Georgia Tech Aquatic Center, which was built for the 1996 Olympics. The system produces enough electricity to provide 30 to 40 percent of the build - ing's power needs – an amount sufficient to energize 70 average homes.

Work under way in Georgia Tech's University Center of Excellence for Photovoltaics Research and Education produces basic scientific advances and improvements in manufacturing technologies for silicon solar cells.

on various low-cost, multi-crystalline silicon materials through material-quality enhancement and technology development, he adds.

@ Read more from the Spring/Summer 2002 issue of Research Horizons at: **gtresearchnews.gatech.edu/reshor/rh-ss02/e-photo.html**

contacts

Ajeet Rohatgi at 404-894-7692 or ajeet.rohatgi@ece.gatech.edu

The Georgia Institute of Technology operated a Biomass Research Facility on campus in the late 1970s and early 1980s. It tested ways to use waste wood and crop residue to make ethanol and methanol for gasohol, methane gas, char-oil and fuel to generate electricity.

PHOTO © ANDREW HARRIS
CORBIS/STOCKPHOTO.COM