WHITE PAPER ON CLEAN ENERGY:

Clemson University’s Commitment to Green Economic Development

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Introduction and Background

Clemson University is launching a major initiative to address one of the great challenges of the 21st century for South Carolina and the nation — energy.

Energy is interwoven with the nation’s economic, environmental and national security interests and affects every citizen on a daily basis. The search for alternative, renewable and cleaner sources of energy and more efficient uses of energy promises to stimulate scientific research and create jobs. As one of the nation’s top-ranked public research universities — with an emphasis on the sciences, engineering and economic development, and a land-grant mission to serve the people of South Carolina — Clemson has the capability and the obligation to tackle this critical issue. For more than 100 years, Clemson has supported the state’s leading industries and nurtured the development of new economic sectors. It is not only appropriate for Clemson to be involved in the development of the green economy, it is mandatory.

In late 2009, the Clemson University Restoration Institute (CURI) — in partnership with and with sponsorship support from GE Energy and South Carolina’s electric cooperatives — hosted a series of events to bring leading energy experts together to share insights and stimulate discussion about clean and renewable energy — discussions that General Electric Chairman and Chief Executive Officer Jeffrey R. Immelt called “exactly the right subject at exactly the right time.”

A symposium on “Building Intellectual Capital for a Green Economy” focused on innovation and work force development. A subsequent summit on renewable energy focused on South Carolina’s “Job Opportunities in the Green Economy.” These two topics are opposite sides of the same coin. Without a well-educated, innovative and entrepreneurial work force, we won’t be able to attract or grow green industries. And if we don’t have the jobs, the work force will go elsewhere, taking their ideas and expertise with them. Both events were video-streamed via the Internet to provide access for viewers from around the globe. A subsequent survey sought direct input and recommendations from energy industry, government, conservation, and academic experts and leaders who were invited to attend the events.

Speakers included Dr. Steven Chu, secretary of the U.S. Department of Energy, General Electric Chairman and CEO Immelt, U.S. Sen. Lindsey Graham (R-S.C.), CURI Director of Renewable Energy Nick Rigas, U.S. Rep. Bob Inglis (R-S.C.) and Jim Turner, president and chief operating officer of Duke Energy. The events were held at the Campbell Graduate Engineering Center on the 250-acre campus of the Clemson University International Center for Automotive Research (CU-ICAR), recently named the Emerging Technology Park of the Year by the Association of University Research Parks.

The week prior to the first symposium, the U.S. Department of Energy (DOE) announced that CURI and its partners would be awarded a $45 million grant — the largest award in Clemson University history — to build and operate a facility to test and enhance the performance, durability and reliability of utility-scale drive trains for the next-generation wind turbines. The grant was matched by $53 million in state and private funding and could position South Carolina as a leader in development of a wind energy industry sector. The facility will be located on the CURI campus at a former Navy base in North Charleston, adjacent to shipyards with access to a deep-water port needed to transport the mammoth drive trains and turbine components.
Defining the Challenge: World Leadership in a Green Economy

The overriding message consistently delivered by speakers at both energy summits is that the United States must act now to regain world leadership status in clean energy, technology and innovation.

“America has the opportunity to lead the world in a new industrial revolution,” Chu told faculty, industry leaders and policymakers at the Symposium on Energy: Building Intellectual Capital for a Green Economy. “This industrial revolution will decrease our dependence on foreign oil, mitigate climate change, and most importantly, ensure our future prosperity.”

Chu said that although America led nearly every energy innovation from the light bulb to the nuclear reactor, “we are falling behind” nations such as China, which is spending $9 billion per month — $12.6 million per hour — on clean energy research and development to diversify its energy supply. “China has passed the United States in high-tech manufacturing,” he said. “There is no reason why the United States should cede high-tech manufacturing to anyone in the world.”

Sen. Graham concurred, “We are going to go to a green economy sooner or later, and my vote is that we lead, not follow.” Graham said the nation is at a crossroads similar to one faced in the 1970s, when oil embargoes led to gas rationing and long lines at the fuel pump. “We complained, but we did nothing. Thirty-something years later we’re more dependent on foreign oil than in the mid-70s.” This time, he said, “the idea of doing nothing is off the table.”

Chu said that the consequence of failing to act now “is that we will forfeit our leadership in the second industrial revolution.”

According to the DOE Web site, the Obama administration’s energy policy aims to stimulate the economy and reduce carbon emissions through investments and incentives in four key areas:

- Increasing energy efficiency and conservation
- Deploying existing low-carbon technologies such as biomass, nuclear, solar and wind
- Improving energy storage technology
- Discovering breakthroughs and new technologies

Chu ended his keynote address by quoting Dr. Martin Luther King, saying that King’s observations about civil rights hold true for the energy challenges facing America today. King said: “We are now faced with the fact, my friends, that tomorrow is today. We are confronted with the fierce urgency of now. In this unfolding conundrum of life and history, there is such a thing as being too late.”

During his keynote address at the summit on renewable energy, Immelt called for a “technological renaissance” that begins with a rededication to engineering and science education and investment in energy technology — an area largely abandoned when oil dropped below $10 per barrel in the 1980s. “Our future, the future of our company and this country, is to become a leader in green technology,” he said.

Immelt cautioned against picking technological “winners” too early. While he said the U.S. will need one or two major baseline technologies such as coal gasification or nuclear energy, significant research and job opportunities exist in such areas as conservation, further domestic exploration, renewables, storage and smart grid technology. “GE invests $10 billion to $15 billion per year in R&D, and we are fuel agnostic. We believe in breadth and depth of technological innovation,” he said, but added that “every technology ultimately has to be cost efficient.”
Duke Energy’s Jim Turner endorsed South Carolina’s balanced “energy portfolio” approach that did not “pit sources against each other.” He said that South Carolina’s strategy of pursuing clean energy, which includes renewables, conservation and nuclear, positions the state to have a significant competitive advantage in the green economy.

Keynote speakers acknowledged that opinions about the impact of carbon emissions on global climate vary, but agreed that the debate is irrelevant in the long run. “The price of oil will go up, and we will live in a carbon-constrained world,” Chu predicted. “The question is, how does America prepare?”

Graham added, “Either we will take action to reduce carbon emissions or the Environmental Protection Agency will.”

Immelt called for taking the discussion out of the context of debate about carbon emissions. “Clean energy should not be a source of controversy. It ought to be a platform for a renaissance of technology and job creation, which I think the U.S. can lead. ... It’s about reducing pollution and creating jobs,” he said.
Economic Development and Job Opportunities: “Green is green.”

A clear and recurring message delivered at both events was that energy offers substantial economic development opportunities from large construction and manufacturing operations to startups and small businesses. Chu noted that DOE studies predict tens of thousands of jobs could be created through development of an offshore wind energy industry, and Immelt said that every job in the energy industry creates six more jobs in the supply chain.

Green jobs include those related to innovation, energy efficiency, energy storage, manufacturing, development of renewable energy projects, construction and operations. They encompass both white-collar and green-collar professions requiring unique skills. Education and work force development will be required to train this new work force in the emerging technologies of energy efficiency, energy storage, solar, wind, bioenergy, hydrogen and others, including how best to deploy, maintain and operate these technologies.

Immelt predicted that growing worldwide demand for electricity and increased prosperity in emerging markets will create enormous revenue potential for energy providers. Both China and Europe are investing now to capture that future market. “If the U.S. would build 15 to 20 nuclear power plants, we would control the supply chain,” he said.

At the same time, demand for engineers and trained professionals in traditional utility industries is expected to rise dramatically and quickly. Based on a 2007 survey of U.S. electric utilities, the Center for Energy Workforce Development estimates that nearly half of all engineering jobs could become vacant by 2012 due to retirements and attrition. While the economic downturn of 2008 may have delayed some retirements, it is a temporary reprieve. A 2009 study commissioned by the Savannah Riversite Community Reuse Organization said proposed nuclear plants and other nuclear-related industries in the Charlotte-Columbia-Augusta region alone may require an additional 10,000 workers in the next 10 years.

Chu said one study showed that energy efficiency and conservation measures could put $680 billion a year back into the pockets of businesses and consumers, while also abating 1.1 gigatons of greenhouse gases — and all with modest investment compared to the cost of other technologies.

Panelist Michael Couick, CEO of The Energy Cooperatives of South Carolina, Inc., said conservation measures such as weather-stripping and replacement of heat pumps could create 2,500 jobs in South Carolina in year one.

Tom French, manager of the Bio Energy, Wind and Carbon Management Program at the Savannah River National Lab and chairman of the S.C. Biomass Council, called South Carolina’s agriculture and forestry industry “a sleeping giant” with untapped capacity for developing biofuels that do not compete with the food chain. “South Carolina is the cellulose capital. We can grow a lot of biomass in this state.” French said South Carolina has 12 million acres of trees, and some portion could be harvested sustainably. He cited a recent Forestry Association study showing that a 5 percent increase in forest utilization could create 4,000 high-paying jobs.

Immelt offered the most succinct assessment of the direct connection between clean energy and economic development: “Green is green. We can solve climate problems and make money at the same time. A green environment can be profitable.”
The Clemson Advantage

Clemson faculty are involved in a broad range of energy-related research projects encompassing both new energy sources, technologies and materials along with better, more efficient use of existing ones. Renewable energy in particular is an area where Clemson has both substantial strength and untapped capacity. Here are a few examples of projects currently under way.

- A collaboration between researchers at Clemson and Savannah River National Laboratory (SRNL) is developing new advanced materials that can withstand the high temperatures and harsh conditions used to produce hydrogen for fuel cells.
- Biosystems engineers are exploring ways to create biofuels by harnessing a bacterium that converts sugar in overripe peaches to hydrogen.
- Physics faculty are exploring carbon nanotube-based superconductors for use in developing more efficient composite wire that could eventually replace copper wiring in power lines.
- Mathematical sciences and physics faculty and an undergraduate Creative Inquiry team are working to help develop smarter and more efficient electric power networks through mathematical modeling.
- Civil and automotive engineering faculty are studying ways to make plug-in hybrid electric vehicles more efficient by integrating the vehicles with technology that generates continuous traffic data to help the driver optimize fuel during a trip.
- Chemists are studying a new class of materials that conduct electrical currents and could be used in thin-film solar cells.
- The Restoration Institute is a partner in Palmetto Wind, South Carolina’s pioneering offshore wind-farm initiative, and is a founding member of the S.C. BioEnergy Research Collaborative.

Clemson's strategic plan identifies eight areas of emphasis, developed with faculty input and based on existing or emerging academic strengths, alignment with state work force and economic development needs, and opportunities for external funding. Emphasis areas are designed to be interdisciplinary, to encourage collaboration with partners inside and outside the University, and to support the competitiveness of the state’s key existing industries (such as agriculture, automotives and manufacturing) as well as emerging economic sectors.

Three emphasis areas — sustainable environment, automotive and transportation technology, and advanced materials — tie closely to energy technology and innovations. Three others — general education, communication and information technology, and leadership and entrepreneurship — support these by providing enabling technologies, research infrastructure and core educational programs.

By focusing resources on a few key areas, Clemson has launched three major research-driven innovation campuses that can help support a green economy:

- The Clemson University Center for Automotive Research (CU-ICAR), located in Greenville near the state’s automotive industry cluster (p. 7)
- The Clemson University Advanced Materials Center, located in Anderson County near the main campus, which boasts one of the nation’s most advanced and versatile electron microscope facilities and is home to one of Clemson’s most productive research centers — the Center for Optical Materials Science and Engineering Technologies (COMSET)
- CURI, located adjacent to a working shipyard and deep-water ports in North Charleston and soon to be the home of the $98 million wind turbine drive-train test facility (p. 8)
Several strong niches with potential for supporting a green economy have emerged from the sustainable environment emphasis area centered at CURI, including renewable energy, water resource protection and management, and marine conservation.

- A renewable energy team is studying the feasibility of small- and commercial-scale wind energy installations and the integration of renewable energy sources such as wind, solar and hydrogen.
- Research at a planned bioethanol pilot plant will aim to find the best way to produce plant-based fuels and reduce our dependence on imported gasoline using plants easily grown in the state, such as switchgrass, trees and sorghum, which do not compete with the food supply.
- Research on the conservation of the recovered Confederate submarine H.L. Hunley is yielding processes to protect submerged materials from rust and barnacles and wind-resistant construction materials and methods, which could have applications for offshore wind turbines.

Clemson also is consolidating and growing many of its business resources at a new 33,000-square-foot facility adjacent to a riverside park in downtown Greenville. Clemson at the Falls will provide greater access to MBA, professional development and continuing education programs, as well as resources for entrepreneurs, startups and small businesses through the Spiro Institute for Entrepreneurial Leadership and the Small Business Development Center.
The CU-ICAR Model: Research-Driven Economic Development

CU-ICAR is an advanced-technology research campus where academia, industry and government organizations engage in synergistic collaboration. Launched in 2003 and opened in 2006, the 250-acre research campus off Interstate 85 in Greenville is an engine for innovation in education and research, from advanced manufacturing processes to transportation planning and vehicle safety.

CU-ICAR has generated more than $215 million in public and private investments and created more than 500 jobs, a number that soon will significantly increase. American Titanium has announced plans to build an engineering technical center at CU-ICAR and a manufacturing plant in Laurens County, bringing 40 jobs to Greenville and another 320 at the plant. In early 2010, zero-emissions bus manufacturer Proterra announced it would locate an R&D and assembly facility at CU-ICAR, bringing 1,300 “green” jobs to the Upstate.

The heart of the campus is the 90,000-square-foot Carroll A. Campbell Jr. Graduate Engineering Center, which houses Clemson’s master’s and doctoral automotive engineering programs and boasts world-class design and testing facilities and equipment, including automotive testing resources valued at more than $10 million. A faculty team led by four endowed chairs has developed a distinctive educational and research program — including the nation’s first doctoral program in automotive engineering — that focuses on systems integration, concentrating on product design and development, manufacturing and electronic systems.

A new initiative called “Deep Orange” has students design and build automobile prototypes, transforming the Campbell Center into a model original equipment manufacturer (OEM) and supplier. Each project will take vehicles from concept to completion, focusing on leapfrogging existing vehicle technologies. The novel approach to engineering education sets the Clemson program apart, according to Imtiaz Haque, executive director of the Campbell Center. “Deep Orange provides entrepreneurs and industry partners with an open-innovation platform to showcase future technologies through intensive proof-of-concept collaboration involving our graduate students. The resulting experience will prepare them to lead the future of the industry.”

“The car of the future will be built at CU-ICAR,” said Sen. Graham.

The campus also includes private-sector R&D facilities and access to Clemson’s cyberinfrastructure, which offers modeling and simulation capabilities. Private partners include BMW, which has a research and development facility on the campus; Michelin; AT&T; Sun Microsystems; JTEKT; and numerous others. The physical campus and high level of engagement of corporate partners create unmatched opportunities for research, access to real-world problems and applications for graduate students, and sharing of facilities, equipment and resources.

The core components of the CU-ICAR model are guiding plans for development of CURI. The goal is to make CURI the University’s “energy campus” just as CU-ICAR is its automotive engineering campus. Critical factors for CU-ICAR’s success include:

- Building on faculty strengths and interests with a strong and distinctive academic anchor (systems integration)
- Alignment with state economic needs and external funding opportunities
- High level of partner engagement and collaboration
- Ideal location for industry engagement, technology transfer and growth
The Next Opportunity: The Clemson University International Center for Wind Energy Systems

On Nov. 23, 2009, the U.S. Department of Energy awarded a $45 million grant — the largest single award in the University's history — to CURI and partners to build and operate a facility capable of full-scale, highly accelerated testing of next-generation drive-train systems. With private and state investments of $53 million, the project positions Clemson and South Carolina to be leaders in the wind energy industry. “What Clemson has been able to achieve in this area of what I think is going to be the new economy for the United States is incredibly impressive,” said Sen. Graham. The facility will anchor a proposed international center for wind energy systems, which is currently in the development stage.

The offshore wind industry represents a rare economic development opportunity for South Carolina. Wind power has emerged as the world’s fastest growing renewable energy market, with global installations of wind farms achieving 27 percent annual growth over the past seven years. It now accounts for approximately one-third of new electricity-generating capacity.

Job growth at the facility will begin with construction workers to build the drive-train testing facility and technical engineers to conduct the tests. More jobs are expected as private industries locate in South Carolina to manufacture turbine blades, electronic components, gearboxes, generators and towers, and potentially to install, operate and maintain wind turbines. In March 2010, the German-based company IMO Group, a manufacturer of parts used in wind turbine blades among other applications, announced that it had selected the Charleston region for its first U.S. facility, which will ultimately employ 190 workers and generate $47 million in capital investment. Company officials acknowledged that the drive-train testing facility reconfirmed IMO’s decision to locate in the Charleston region.

According to DOE estimates, the manufacture of wind turbines and associated components eventually could generate up to 20,000 jobs in the state, which offers assets beyond the Clemson project. South Carolina meets three important cost drivers for developing offshore wind farms: strong winds in shallow waters, access to commercial port facilities and large coastal energy demand. As larger turbines are developed — making overland transportation physically demanding and cost prohibitive — South Carolina could become an industrial hub for this growing industry by capitalizing on Clemson’s research, engineering and supercomputing capability; a strong existing manufacturing cluster and renewable energy industry; and South Carolina’s deep-water ports. There also is a business opportunity for local utilities or other investors who will buy the turbines but deploy them elsewhere in the U.S. or overseas.

The testing facility — to be housed in Building 69, an 82,264-square-foot vacant warehouse on the former Charleston Naval Base — will test advanced drive-train systems for wind turbines at the 5 to 15 megawatt capacity with 30 percent overload capacity. Planning and construction of the facility began in the first quarter of 2010 with a targeted operational date in the third quarter of 2012. The University’s partners in the project are the Charleston Naval Complex Redevelopment Authority; the South Carolina Department of Commerce; the state of South Carolina; the city of North Charleston; South Carolina Public Railways; the South Carolina State Ports Authority; Savannah River National Laboratory; and private partners RENK, Labeco, Fluor, EcoEnergy LLC, SCE&G, CMMC LLC, Tony Bakker and James Meadors.

CURI was established in 2004 to drive economic growth by creating, developing and fostering sustainable technologies in South Carolina. The restoration economy — the revitalization of existing urban and natural areas through rehabilitation and redevelopment — offers enormous opportunities for South Carolina. The Restoration Institute’s research campus pairs North Charleston’s materials manufacturing and assembly processes with Charleston’s heritage as the nation’s leading living laboratory for cultural and structural preservation.

In 2008, Clemson and the Restoration Institute were recognized as a Center of Excellence for Watershed Management by the U.S. Environmental Protection Agency. The center was the first in the nation designated to focus on remotely sensed data collection and monitoring.
The South Carolina Advantage

South Carolina is well-positioned — and perhaps uniquely qualified — to assume a leadership role in the green economy because of its abundant natural, geographic, industrial and human resources; a business-friendly climate; and a propensity for public-private collaboration. According to Sen. Graham, “There is no state in the union better positioned to help lead this nation to energy independence and a green economy than South Carolina.”

Tangible assets include:

- A deep-water port and access to commercial port facilities
- Central location between the Northeast and the Gulf
- An underutilized agricultural and forestry base suitable for biomass
- A biomass steam plant at the Savannah River National Laboratory (SRNL)
- A strong existing manufacturing cluster, including GE, the nation’s largest gas turbine manufacturer and world’s largest energy supplier
- Access to supercomputing capacity through Clemson
- A strong and innovative existing power industry cluster, including Duke Energy, a leader in coal gasification; Santee Cooper, a leader in waste-to-energy technology; SCANA, a leader in nuclear power; and the S.C. Electric Cooperatives, leaders in conservation; and Progress Energy, the first utility to receive the prestigious J.D. Power and Associates Founder's Award for customer service
- New Carolina industry cluster groups, including the S.C. Engineering Cluster and Nuclear Cluster
- A network of technology drivers, including three research universities, the S.C. Research Authority and SRNL
- A history of successful state/industry/university partnerships as evidenced by Clemson’s innovation campuses; the state’s successful recruitment of major industry innovators such as BMW, Michelin, GE and Boeing; and strong research university collaborations, such as Health Sciences South Carolina.

The Palmetto State also has a legislature that has shown a willingness to invest in scholarships, research incentives and infrastructure for a knowledge-based economy. Over the past decade, seven legislative initiatives have significantly accelerated the state’s intellectual and research capacity:

**LIFE Scholars and Palmetto Fellows (enhanced STEM scholarships)**

Immelt said the road to energy independence and world leadership “starts with a rededication to science and engineering.” South Carolina has a head start with one of the nation’s most generous state-funded merit scholarship programs aimed at retaining the state’s best and brightest young people and a specific focus on engineering and science disciplines. Clemson is the No. 1 choice of Palmetto Fellows, and virtually all in-state incoming freshmen in the College of Engineering and Science were LIFE Scholars or Palmetto Fellows.

**Economic Development Bond Act**

The Economic Development Bond Act of 2002 enhanced the S.C. Department of Commerce’s recruitment efforts by creating funding opportunities for economic development projects. This bond act provided funding for the Information Technology Research Center and the Campbell Graduate Engineering Center at CU-ICAR as part of an overall incentive package for BMW.

**Research Centers for Economic Excellence Act (Endowed Chairs)**

In 2002, the legislature adopted the Research Centers for Excellence initiative, which set aside lottery funding for endowed chairs at the three research universities in areas that impact economic development, with private-sector matching funds required. Clemson has successfully competed for funding for 15 endowed chairs under the program.

**Research University Infrastructure Bond Act**

In 2004, the S.C. General Assembly adopted the Research University Infrastructure Bond Act, which provided approximately $220 million in research infrastructure funds for the state’s three research universities, with non-state matching funds required. This act provided $70 million for Clemson to develop research infrastructure and promote economic development.
Innovation Centers Act
The Innovation Centers Act of 2005 established three Research Innovation Centers in South Carolina, one associated with each research university. These Innovation Centers will focus on hydrogen and fuel cells; automotive, aerospace and information technology; biotechnology; military and defense technology; chemical products; high-tech fibers; advanced materials; and life sciences. The goal is to move research out of the university and into the marketplace.

Venture Capital Investment Act
In 2005, the General Assembly established the Venture Capital Investment Act to increase the availability of venture capital funds to help strengthen the state's economic base and to support economic development goals. The legislation created the Venture Capital Investment Authority to oversee the program that provides tax credits for private investment companies offering equity, near-equity or seed capital for companies in the state that are emerging, expanding, relocating or restructuring.

The Industry Partners Act
This 2006 act established the Industry Partners Fund, which provides revenue to be used by the South Carolina Research Authority and the state's research universities to commercialize university research discoveries. Revenues in the Industry Partners Fund come from contributions by South Carolina businesses, which receive 100 percent credit for their contributions to offset their state income taxes and other fees.

And there's the intangible: Kaydon Corp. Chairman and CEO Jim O'Leary says the state's best asset for economic development is its work force. The custom-engineering products manufacturer has grown its presence and investment in South Carolina every year since coming to the state 30 years ago, and it was preparing to grow again before the 2008 recession. “The people here are our biggest asset. We came here originally for the work force,” he said. “It's a right-to-work state with a highly skilled, very flexible and deep pool of [human] resources. South Carolina ... is where we want to be, and where we would consider expanding.”
CLEMSON UNIVERSITY’S ENERGY COMMITMENT

Create green jobs for South Carolina, prepare people to fill them, and generate innovations to help propel the state and nation into world leadership positions in energy.

1. Provide the intellectual capital and work force for a green economy.

2. Drive energy technology innovation and transfer it to the marketplace.

Providing Intellectual Capital and Work Force

Clemson’s commitment to finding solutions to the energy challenges will start with its core educational mission. Enhancing the skills of the current work force in energy-related industries and preparing the next generation of scientists, engineers, entrepreneurs, industry leaders and policy shapers are primary goals. As noted earlier, job creation and work force development are opposite sides of the same coin. Without a highly skilled and educated work force, the green economy will not reach its potential as a major economic sector for South Carolina.

As the state’s science, technology, engineering and mathematics (STEM) flagship university, Clemson is well-suited to meet the needs of both emerging energy sectors, such as wind, solar and biomass, and traditional baseline power industries, such as nuclear, coal and hydroelectric energy generation.

“Clemson is seen by regional utilities as the go-to university for graduates who are knowledgeable about power technologies,” said Randy Collins, associate dean for the College of Engineering and Science.

Clemson’s power engineering program in electrical engineering has a solid history and is well-supported by electric utility companies in the Carolinas as evidenced by five endowed professorships in electrical and computer engineering, mechanical engineering and management. The University also has an established program in environmental engineering that produces master’s and Ph.D. graduates in areas such as radioactive contaminants in the environment, including health physics, radiation detection and measurements, risk assessment, radioactive waste management and radiochemistry. There also are numerous energy-related courses in mechanical, electrical, chemical, computer and civil engineering degree programs.

These traditional industries — particularly nuclear — are poised for a “renaissance” that could generate thousands of jobs over the next 10 years. Clemson is strategically located in relation to 14 proposed nuclear reactors in the Southeast region, and a recent report from the Savannah River Site Community Reuse Organization (SRSCRO) estimates that the combination of industry growth and anticipated retirements in the Charlotte-Columbia-Augusta region alone could require upwards of 10,000 engineers and trained workers over the next 10 years.

At the same time, the power industry could face the daunting task of replacing nearly half of its engineers within the next few years. Based on a 2007 survey of U.S. electric utilities, the Center for Energy Workforce Development estimates that nearly half of all engineering jobs could become vacant by 2012 due to retirements and attrition. Many of these jobs will require science and engineering degrees in fields other than just nuclear engineering. In fact, the demand for nuclear engineers will be relatively small compared to the need for mechanical, computer, electrical, civil and systems engineers.

To help fill the demand by both traditional and emerging energy clusters, Clemson’s energy commitment includes the following initiatives:

1. **Master of Science in Nuclear Engineering:** The approval process is under way for an M.S. in nuclear engineering, in a cooperative agreement with the Catholic University of Leuven (UCL) in Belgium. UCL is a member of the Belgian Nuclear Higher Education Network, providing access to their faculty and extensive reactor facilities. This program provides executive-style scheduling with instruction in English, and students can earn an M.S. in nuclear engineering in approximately one year.

2. **Certifications:** A series of online energy-related certification courses will help place-bound technical and engineering professionals expand their energy-related knowledge or allow industries to enhance the skill set of their current employees. Current Clemson students can also take the courses to complement their degree programs. Certifications are available or are being developed in renewable energy, systems engineering, power systems and wind energy. Others will be developed based on market demands and expansion of Clemson faculty expertise.

3. **Systems Integration:** Regardless of the source, energy systems are typically large, complex and require mechanical, electrical, computer and human systems to work together flawlessly. Just as it did in creating a systems approach to automotive engineering, Clemson plans to capitalize on its distributed expertise and develop certification programs that draw from a wide spectrum of academic disciplines. These certificates could be the first step toward degree programs in energy and power systems engineering.
4. A power systems engineering institute: Between the anticipated “nuclear renaissance” and the aging of the electrical industry work force and infrastructure, the need for power engineers and research is expected to climb significantly and quickly. In a report entitled “Workforce Trends in the Electric Utility Industry,” DOE declared to Congress: “Today, the power engineering education system in the United States is at a critical decision point. Without strong support for strategic research in power systems engineering and without qualified replacements for retiring faculty, the strength of our nation’s university-based power engineering programs will wane, and along with them, the foundation for innovation in the power sector to meet our energy challenges in the 21st century.” A proposed power systems engineering institute at Clemson could help meet the industry’s research and work force needs, developing new minors, degrees, certificates and training tailored to industry needs, serving as a one-stop shop for research activities of interest to the power industry, pulling together teams for large research projects that individual investigators could not achieve, and serving as a liaison with wind, solar and biomass research groups at Clemson.

Discussions also are under way to develop programs to help fill the pipeline with future engineers and scientists by reaching out to middle and high schools. Options may include summer institutes for high-achieving middle-school students to cultivate their interests in energy, summer courses for teachers or an embedded energy curriculum for high schools that could be transferred to Clemson.
Driving Innovation and Technology Transfer

Innovation and technology transfer start with research and graduate education. Clemson’s strategic plan identifies five areas where the University has the opportunity to build world-class research and graduate programs, leverage federal funding priorities and address some of the major challenges of our time:

- Energy
- Sustainable environment
- Transportation
- Health
- Education (science, technology, engineering and mathematics)

Over the next five years, Clemson plans to recruit 10 faculty (two per year) for existing endowed chairs funded through the S.C. Research Centers of Economic Excellence program and 75 faculty “cluster hires” (15 faculty per year). Many of these hires will be in energy-related areas that are aligned with the University’s emphasis areas, external funding opportunities and state economic development needs, such as:

- Wind energy
- Storage technology
- Metals
- Water resources
- Biofuels/biomass
- Sustainable environment
- Power engineering

Continued development of Clemson’s three major innovation campuses — CU-ICAR, the CU Advanced Materials Center and CURI — coupled with expansion of research on the main campus will engage faculty and students with private and government partners in finding energy solutions through development of new materials, automotive and transportation technologies, biomass technologies, energy storage systems, smart grid, power system integration, energy efficiency and nuclear waste disposal technologies.

Construction and development of the proposed international center for wind energy systems is the economic engine for building the offshore wind energy industry (p. 8). Nick Rigas, former director of the S.C. Institute for Energy Studies, has been recruited to provide leadership for the center. Industrial and technical advisory boards will provide industry, academic and government input to help design, commission and operate the facility, ensuring high value testing services for the industry. Executives from 90 percent of the world’s turbine manufacturers gathered recently in Charleston to serve on the industry advisory board — demonstrating the industry’s keen interest in the project. Key vendors and contractors have been selected, master planning and preliminary design work are under way, and construction of the drive-train testing facility will begin in the spring of 2010.

In addition, Clemson’s traditional agricultural research and education centers are being redirected to focus on 21st century opportunities for the state’s $34 billion agriculture and forestry industry, biomass, and research to safeguard water quality, capacity and availability for energy generation.
Net-Zero: Building a National Model Campus for Energy Sustainability

The third component of Clemson’s energy commitment is to transform the University’s main campus into a model for energy sustainability: a “net-zero,” carbon-neutral campus. Rather than initiate a multitude of independent, disconnected projects common to many college campuses, Clemson will take a comprehensive approach, partnering with leaders in the energy industry to utilize its campus as a renewable energy laboratory. In addition to reducing the University’s net carbon emissions to zero, the long-term initiative will engage faculty and students in significant research and educational opportunities and provide corporate partners with innovative solutions, technology testing opportunities and demonstration sites for pilot programs.

Components of the comprehensive system of renewable energy production, distribution and conservation will include:

- Replacing the University’s antiquated coal-fired central energy facility with renewable energy production alternatives
- Developing and deploying more efficient energy distribution systems that reduce the amount of electrical energy wasted during transmission
- Utilizing energy more efficiently through conservation technologies, practices and techniques

Clemson has unique capabilities that will support this ambitious initiative and provide private partners with rare R&D opportunities:

- Single ownership of all buildings and housing facilities on a campus the size of a small city that serves more than 20,000 faculty, staff and students and more than a million visitors a year
- A central energy facility
- Biomass capacity from timberlands, farms and animal wastes
- Faculty expertise and academic programs in energy-related fields
- Supporting administrative policies, such as mandatory minimum LEED Silver certification for all new facilities and the appointment of a President’s Commission on Sustainability
- A strong sense of service among the student body, faculty and staff, and a growing interest in energy conservation

By utilizing the campus as a living-learning laboratory for research, development, testing and demonstration of the most efficient energy production, distribution and conservation systems and practices, Clemson can serve as an energy model — from production to consumption — for college campuses and small- to mid-sized cities. The plan will be completed in 2011.
NEXT STEPS: IMPLEMENTING THE ENERGY COMMITMENT

1. Appoint a Clean Energy Executive Team to provide planning and oversight

   James F. Barker, President
   Doris R. Helms, Provost and Vice President for Academic Affairs
   John W. Kelly, Vice President for Public Service and Agriculture,
   Vice President for Economic Development (July 2010)
   Angela E. Leidinger, Executive Secretary to the Board of Trustees,
   Director of Governmental Affairs
   Brett A. Dalton, Chief Financial Officer
   Vice President for Research (search under way)

2. Appoint leaders to head teams to implement key initiatives

   Wind Energy Campus: Nikolaos “Nick” Rigas, Director and Senior Scientist, Drive-
   Train Testing Facility

   Academic Programs: Edward R. “Randy” Collins, Associate Dean for Undergraduate
   and International Studies, College of Engineering and Science

   Research Programs: Imtiaz Haque, Executive Director of the Campbell Graduate
   Engineering Center, PI on the DOE Grant

   Net-Zero Project: Team leader to be appointed by May 2010
Clemson University

Ranked No. 22 among the nation’s top public institutions, Clemson University is a science- and engineering-oriented research university that maintains a strong commitment to teaching and student success. Clemson is an inclusive, student-centered community characterized by high academic standards, a culture of collaboration, a competitive drive to excel and a determination to make a difference.

The past decade has seen Clemson’s transformation from a respected state institution to one of the nation’s top-ranked public universities because of a laser-like commitment to enhancing academic quality, student support and research-driven economic development. Its ability to focus and remain committed to a multiyear strategic plan has been nationally recognized by the Chronicle of Higher Education.

Clemson’s strategic plan identifies eight cross-disciplinary emphasis areas that will drive resource allocation, program development and faculty hires. Areas were selected with faculty input based on existing academic strength, potential for external funding and alignment with state work force needs and economic development priorities. Emphasis areas are:

- Advanced Materials
- Automotive and Transportation Technology
- Biotechnology and Biomedical Sciences
- Family and Community Living
- General Education
- Information and Communication Technology
- Leadership and Entrepreneurship
- Sustainable Environment

Clemson’s enrollment is about 19,000, and the campus population is carefully managed to maintain small classes and a low student-to-faculty ratio. Students can select from approximately 80 undergraduate and 110 graduate degree programs offered by five colleges: Agriculture, Forestry and Life Sciences; Architecture, Arts and Humanities; Business and Behavioral Science; Engineering and Science; and Health, Education and Human Development.

Clemson is the No. 1 choice of Palmetto Fellows, the state’s top high school graduates. More than a third of Clemson’s incoming freshmen ranked in the top 10 percent of their high school class.

As South Carolina’s land-grant university, Clemson has a presence in every county for outreach and community service, as well as research and education centers at five locations in the state and on the Caribbean island of Dominica.

Part of Clemson’s strategic plan is to grow selected graduate programs and develop research and economic development centers to support a knowledge-based economy. Ph.D. enrollment has nearly doubled since 2001. To support faculty research as well as the teaching and learning environment, Clemson recently made a strategic investment in cyberinfrastructure. The University now ranks in the top 10 among academic institutions in the country on the list of TOP500 Supercomputing Sites and was responsible for connecting the rest of the state to the National Lambda Rail, Internet2 and other national research networks. Research has increased from $69 million in 2000-2001 to more than $141 million in 2008-2009.

Located in a college-town setting in the foothills of the Blue Ridge Mountains surrounded by a lake and its own forest, Clemson University — South Carolina’s highest-ranked institution — is committed to academic excellence, public service, economic development, innovative research and individual student success.

Clemson was founded in 1889 through a bequest from Thomas Green Clemson, a Philadelphia-born, European-educated engineer, musician and artist who married John C. Calhoun’s daughter, Anna, and settled at her family estate in South Carolina. Clemson believed that the way to rebuild his adopted state’s war-ravaged economy was through scientific education, so he left his home and fortune to the state of South Carolina to create the institution that bears his name.