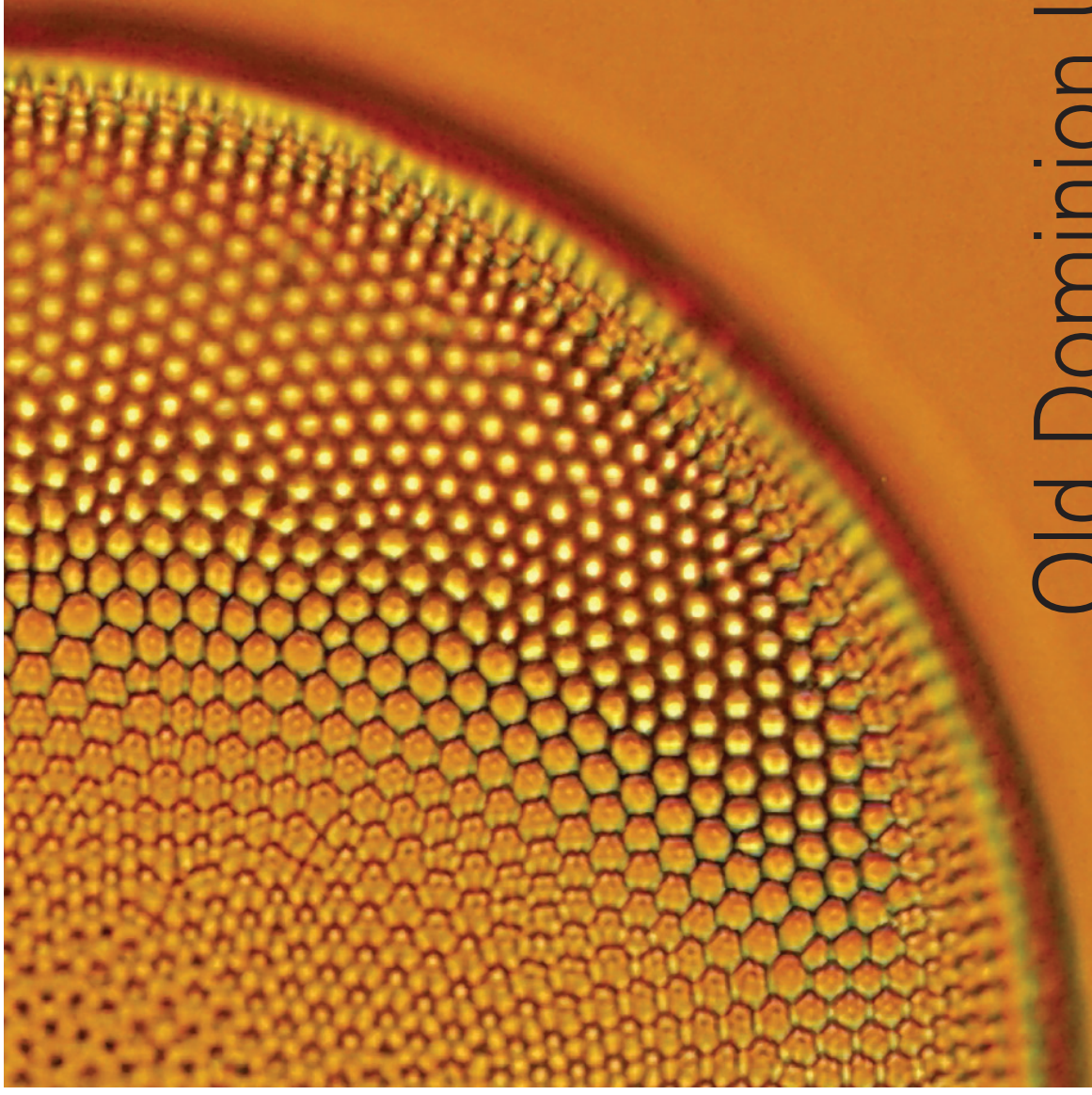
Energy *for* TOMORROW



Old Dominion University

"Our university is pleased to be investing our expertise in the work of the Virginia Coastal Energy Research Consortium. We are proud that the General Assembly asked us to be the host school for the consortium."

–John R. Broderick, *Acting President*
Old Dominion University

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OFF-CAMPUS–Peninsula Higher Education Center, Hampton; Tri-Cities Higher Education Center, Portsmouth; Virginia Beach Higher Education Center, Virginia Beach

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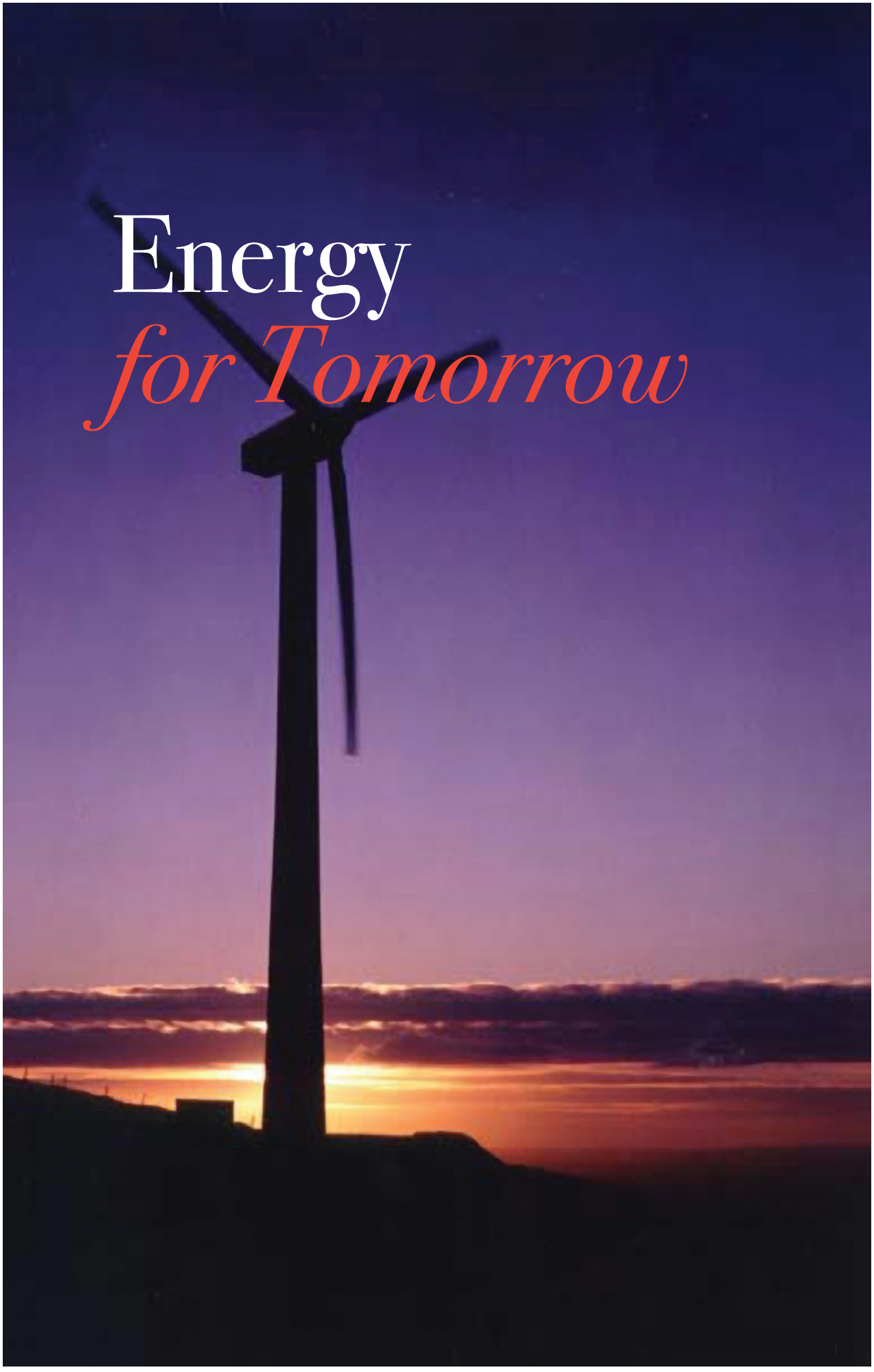

Energy
for Tomorrow

The Initiative of Old Dominion University

When Gov. Timothy Kaine participated in the ribbon-cutting ceremony that opened Old Dominion University's algal farm in Prince George County in September 2008, he noted that this experimental algae-to-biodiesel production facility fulfills the main tenets of Virginia's energy plan. It promotes a reliable new source of energy and creates employment while also protecting the environment.

ODU researchers are growing algae at a rural facility 70 miles west of the campus. The operation was launched with a one-acre pond composed of parallel "raceways," which researchers believe are capable of growing enough microscopic green algae to produce up to 3,000 gallons of biodiesel fuel per year. Furthermore, ponds at the farm have been designed to grow algae in wastewater effluent, stripping the effluent of harmful nutrients while also producing biomass for conversion into biodiesel. If the pilot project is successful, dozens of ponds could be dug at this rural site and the facility could become the first commercial enterprise of its kind in the country.

This project, which Old Dominion is leading as an initiative of the Virginia Coastal Energy Research Consortium, is just one way that we are addressing pressing questions about energy availability and usage. Our scientists, engineers, geographers and policy experts have been working on energy and energy-conservation solutions for decades, and have redoubled their efforts in recent years in response to the needs of Virginia and the country.

Consider these win-win-win results projected for our algal biodiesel program: 1) alternative fuel is produced 2) without increasing the demand for food crops, such as the corn that is converted into ethanol, and 3) while it grows, the algae can actually give wastewater a final scrubbing before it is discharged by treatment plants into our rivers and bays.

Researchers in other fields at Old Dominion have the expertise to help harness the abundant energy of wind and waves for the production of electricity, to perform the chemical analysis required to perfect the fuels of tomorrow, and to address energy supply and demand from the standpoints of economics and politics.

Our university is pleased to be investing our expertise in the work of the Virginia Coastal Energy Research Consortium, and we are proud that the General Assembly asked us to be the host school for the consortium. This is yet another example of Old Dominion employing forward focused thinking to achieve real world results.

John R. Broderick, *Acting President*
Old Dominion University

Exploring Renewable Resources

In a recent issue of Science magazine, chemist George Whitesides of Harvard University and materials science researcher George Crabtree of Argonne National Laboratory, make a straightforward declaration about "Energy for Tomorrow": "Whatever strategy emerges will be a quilt made up of patches representing almost every imaginable technology."

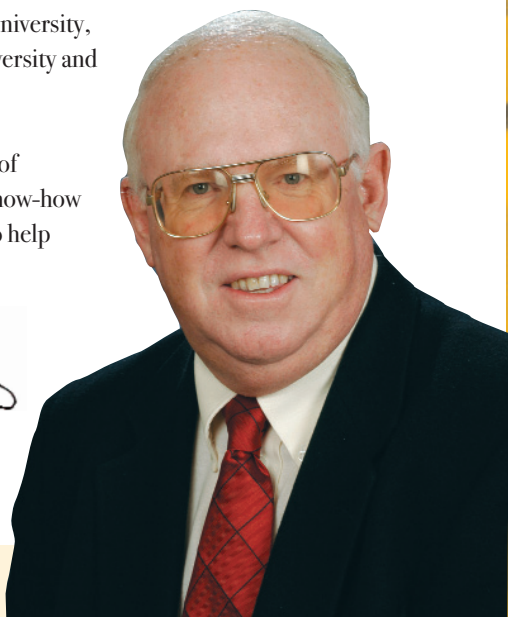
This broad view of energy solutions has long been evident in the research and educational programs at Old Dominion University. Testimony I gave in September 2006 before a Congressional subcommittee on Energy and Mineral Resources suggested an energy policy that incorporates more renewable resources, a "balanced energy portfolio," as I called it. This policy would not only be kinder to the environment, but also serve to prevent an energy disaster should the sources of conventional fossil fuels be shut down or depleted.

From the pages that follow, you can count the ways that ODU's faculty and graduate students are helping to develop alternative sources, processes and policies that will make us less dependent upon fossil fuels.

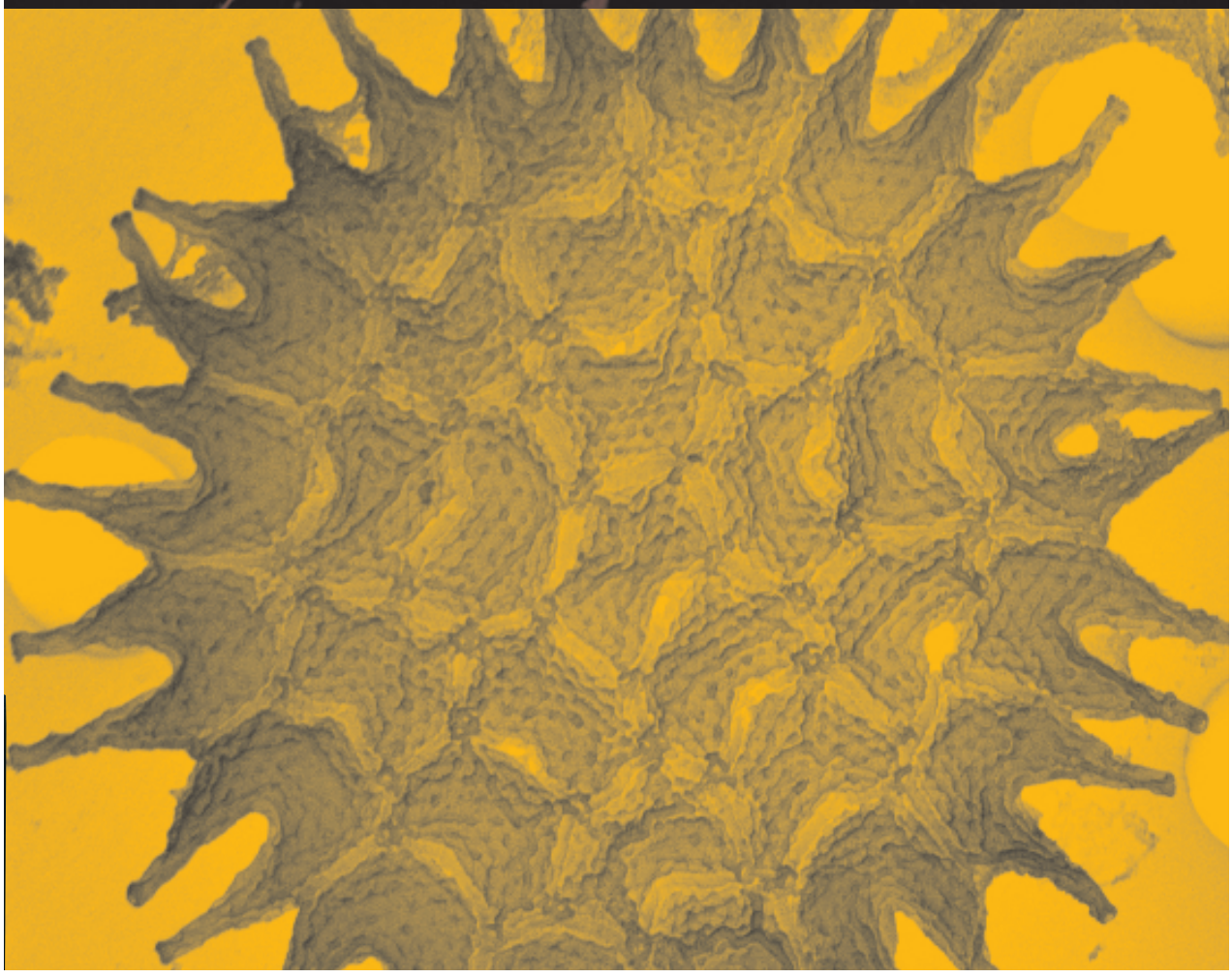
ODU expertise covers the production of biodiesel fuels from algae, as well as from other plentiful base products such as used fryer oils from restaurants. We have experts who can help harness wind, waves and solar energy for the generation of electricity, and who can exploit nanotechnology to make hydrogen fuels a realistic solution. We have a large contingent of faculty looking into societal and environmental issues pertaining to energy. And, finally, we have a unique set of research infrastructures that can support and lead the way to future energy R&D.

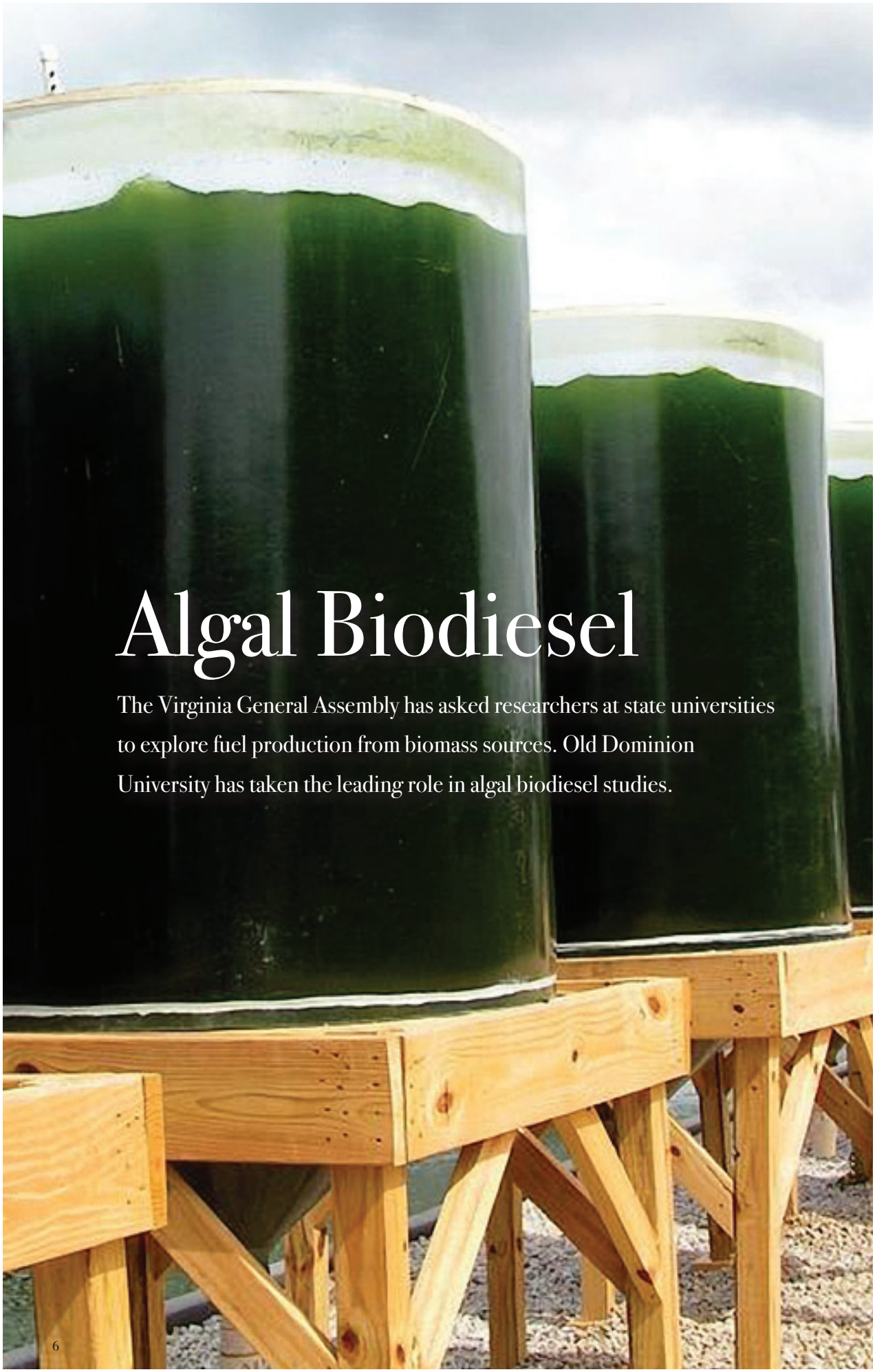
Just as important, ODU is a research university located in a coastal zone rich in alternative energy resources, such as algae, wind and waves, and other raw materials. These are the potential resources that the 2007 Virginia General Assembly had in mind when it created the Virginia Coastal Energy Research Consortium (VCERC). ODU is the lead institution in this consortium, which also includes the Virginia Institute of Marine Science, Virginia Tech's Advanced Research Institute, Norfolk State University, James Madison University, University of Virginia, Virginia Commonwealth University and Hampton University.

I am delighted to serve as the first executive director of VCERC and eager to take advantage of the energy know-how we have at ODU and other consortium institutions to help deliver energy for tomorrow's Virginia.



Patrick G. Hatcher,
Batten Endowed Chair in Physical Sciences
Old Dominion University



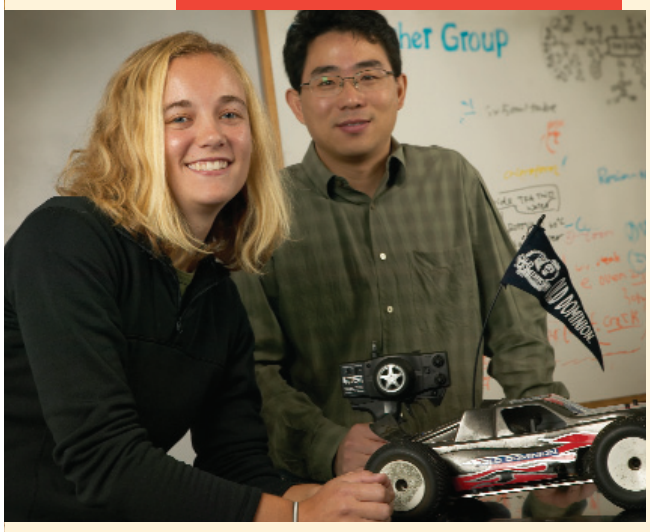


Algal Biodiesel

The Virginia General Assembly has asked researchers at state universities to explore fuel production from biomass sources. Old Dominion University has taken the leading role in algal biodiesel studies.

ALGAL
Growing Facility

Old Dominion University and the Virginia Coastal Energy Research Consortium are developing an algae growing facility 70 miles west of Norfolk near Hopewell. Gov. Timothy Kane participated in the formal opening of this pilot facility in September 2008. Each algae growing pond on the property is capable of producing 3,000 gallons of algal biodiesel per year.



Production of sustainable fuels is required to temper climate change and ensure national energy security. Biodiesel fuel is much like the diesel fuel derived from petroleum, but this renewable fuel is produced from oily biomass such as soybeans, as well as from waste oils. Studies have shown that algae have significantly more oil content than soybeans and are a promising source of biodiesel. Importantly, unlike other biofuel crops, algae do not need to be grown on farm land, and therefore they do not increase the price of food.

ODU researchers and their partners working with algal biomass have:

- Constructed a newly operational 1-acre algal pond near Hopewell.
- Developed a continuous algae-to-fuel conversion technology.
- Identified Virginia waters with high algal biomass and productivity.
- Discovered molecular information about algae that enables better understanding of their potential for conversion to biofuel.
- Identified and cultured indigenous algal species best suited for biodiesel production.
- Begun determining efficient methods for harvesting algal biomass.
- Continued to explore environmentally friendly ways to produce algal biomass while at the same time removing harmful nutrients from effluent at sewage treatment facilities and the greenhouse gas—carbon dioxide—from power plant plumes.
- Is currently using a special diesel engine research laboratory for combustion tests to improve the reliability and efficiency of biodiesel fuels.

Biodiesel fuel also can be produced from used cooking oil from restaurants. ODU engineers have built a small reactor to investigate whether the production of biodiesel fuel from the used oil is environmentally sound and economically viable.

ODU Algal Biodiesel Researchers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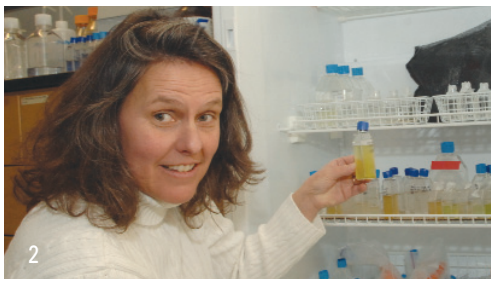
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Patrick G. Hatcher, Batten Endowed Chair in Physical Sciences, professor of chemistry and biochemistry, adjunct professor of oceanography, and director of ODU's College of Sciences Major Instrument Cluster (COSMIC) laboratory, does research related to the chemical composition of various algal species, especially *Botryococcus braunii*, a species of green algae capable of producing more than 50 percent of its mass as biodiesel hydrocarbons.

Harold G. Marshall, Morgan Professor Emeritus and eminent scholar of biological sciences, is a specialist in freshwater and marine phytoplankton. He has been involved in the monitoring of phytoplankton in the Chesapeake Bay and several of its tributaries since 1985, relating their composition and abundance to water quality variables. 1

Margaret R. Mulholland, associate professor of ocean, earth and atmospheric sciences, has conducted extensive algal bloom research and has expertise in culturing phytoplankton and cyanobacteria. She develops continuous methods for evaluating nutrient dynamics and the effects of carbon dioxide on microplankton productivity and is assessing the value of wastewater effluents as sources of nutrients to fuel microbial growth. She is a member of the Scientific and Technical Advisory Committee of the Chesapeake Bay Program. 2

Andrew S. Gordon, professor of biological sciences, has research interests in microbial physiology, continuous culture of bacteria and microalgae, and microbial ecology. His laboratories are equipped for pilot-scale batch and continuous culture of micro-organisms, biomolecule separation and purification, and biomass harvest. 3

Gary S. Schafran, professor and department chair of civil and environmental engineering, investigates biogeochemical processes in lakes, including reactions influencing acid/base chemistry, redox conditions and metal cycling. He is currently the principal investigator of an international study dealing with reservoir management issues, including lake oxygenation and new sensor technologies for phytoplankton/cyanobacteria monitoring. 4

Richard C. Zimmerman, professor and chair of ocean, earth and atmospheric sciences, has been studying the environmental controls on marine primary production for many years. These studies enhance our understanding of energy transfer among trophic levels in natural ecosystems, and the role of light and nutrient availability in regulating the productivity and distribution of primary producers in the sea. 5

Gregory A. Cutter, professor of ocean, earth and atmospheric sciences, investigates the cycling of a number of trace elements that can be incorporated into algal biomass and may be transferred into biofuels. 6

Kenneth Mopper, professor of chemistry and biochemistry and adjunct professor of oceanography, conducts wet chemical analysis of biomolecules, including lipids, which can be used to determine the potential biodiesel yield of algal species and assemblages. He has also studied the role of photochemistry in the enhancement and/or retardation of algal productivity in cultures and natural waters. 7

Robert L. Ash, associate vice president for research and professor and eminent scholar of aerospace engineering, 8; **Taj Mohieldin**, professor of engineering technology, 9; and **Eric Koster**, director of motorsports operations, ODU Langley Full-Scale Wind Tunnel, are developing the Biodiesel Engine Laboratory.

Juergen Kolb is assistant professor of electrical and computer engineering and a researcher at ODU's Frank Reidy Research Center for Bioelectrics. His research in bioelectrics relates to the effects of pulsed electric fields in biological, medical and environmental applications. This work includes the generation and applications of gas discharge plasmas. He is currently exploring the use of bioelectrics techniques in the production of algal biodiesel fuel. 10


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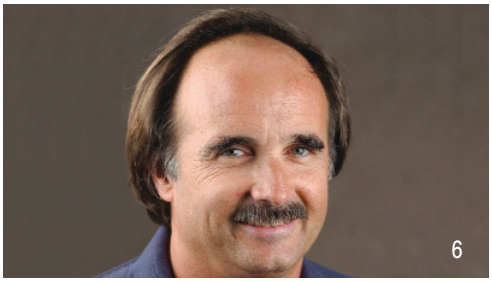
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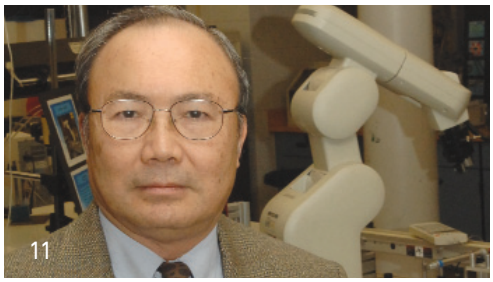
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Han P. Bao, professor of mechanical engineering, is developing a reactor for the conversion of used cooking oil to biodiesel fuel. His research will focus on filtering and removing impurities from the used oil and its subsequent transesterification into fuel-grade biodiesel. 11

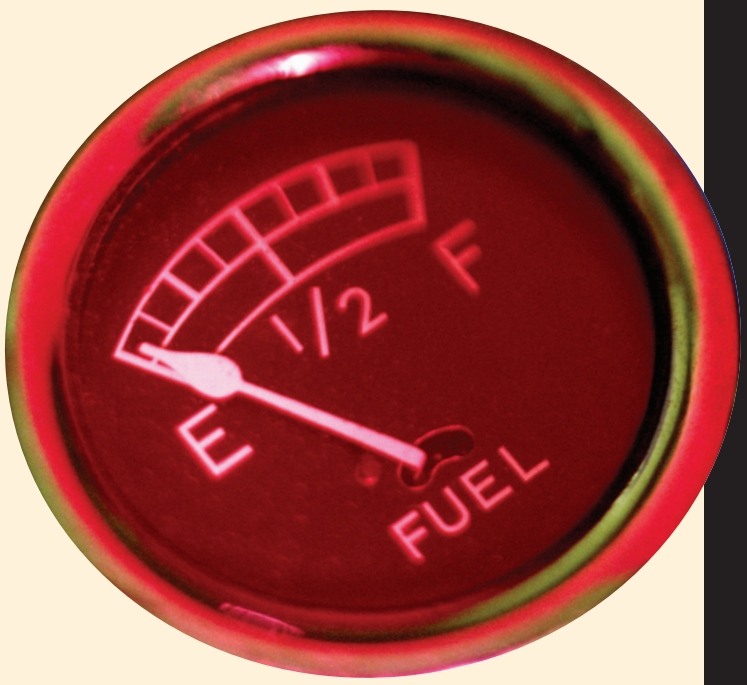
Jingdong Mao, assistant professor of chemistry and biochemistry, investigates the molecular structure and thermal evolution of fossil fuels using advanced solid-state nuclear magnetic resonance techniques. His research into the process of fossil-fuel formation is directly relevant to the industrial generation of biofuels from algal and other biomass. 12

Aron Stubbins, assistant research professor in chemistry and biochemistry, has studied the influence of dissolved organic matter photochemistry upon the uptake of carbon sources by aquatic microplankton. His expertise will also help determine the supply of carbon to algae and the net radiative balance of the algal systems. 13

Christopher Binckley, assistant research professor in biological sciences, investigates how biodiversity gradients are generated and the influence they have upon ecological dynamics. An understanding of the role of diversity in system productivity will be valuable in optimizing algal production for biofuels in aqua cultures. 14

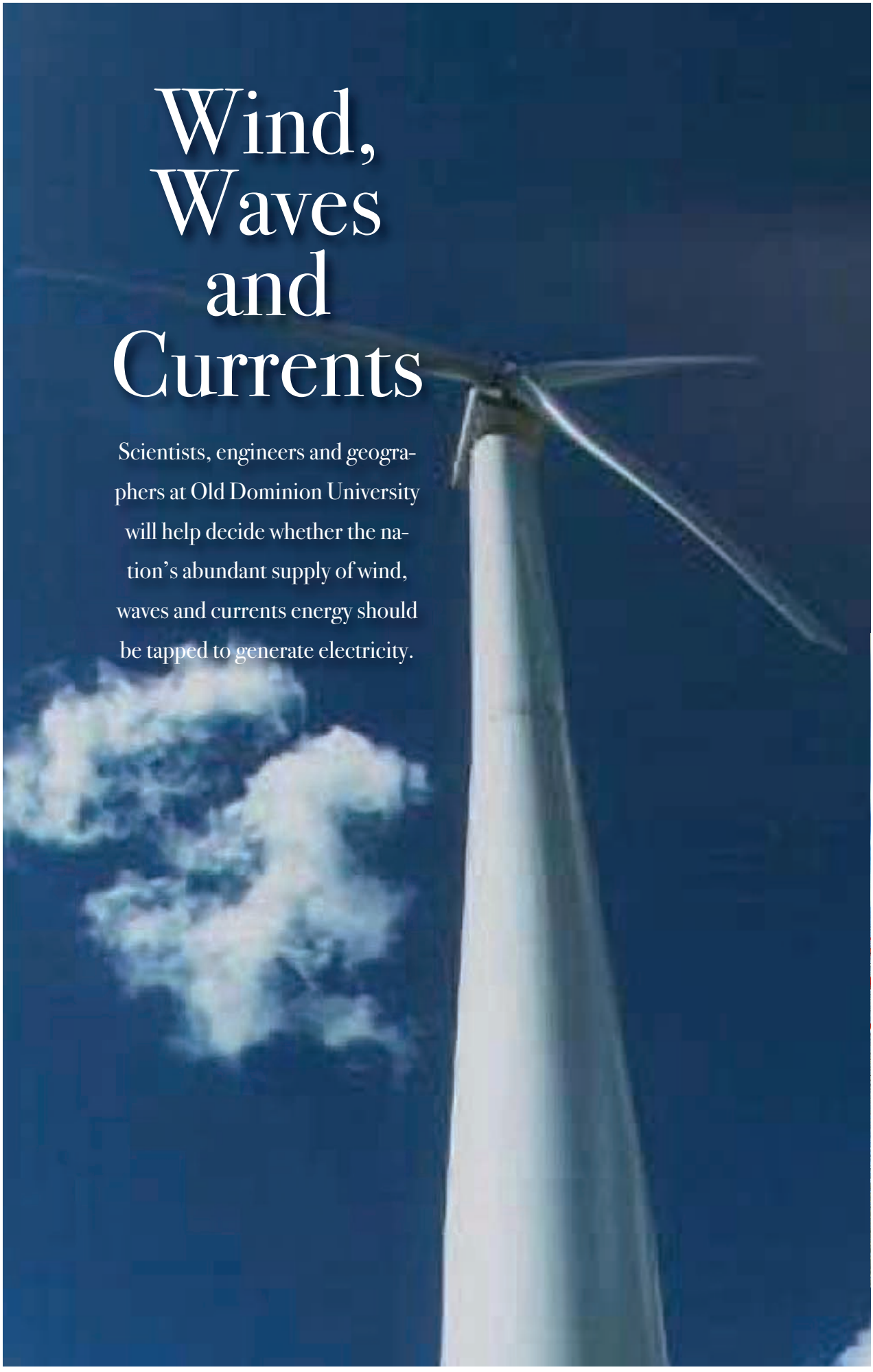
Kneeland K. Nesius, associate professor and assistant chair of biological sciences, is a plant physiologist whose research over the past 15 years has included productivity studies on phytoplankton populations in coastal Virginia waters. 15

Christopher Burbage, a postdoctoral research associate who works with Margaret Mulholland, associate professor of ocean, earth and atmospheric sciences, has research interests in phytoplankton ecology and physiology. He has been a key member of the ODU team seeking to identify and culture algal species best suited for biodiesel production. 16



COUNT *your savings*

Some alternative fuels require expensive new storage and transfer technologies as well as new engines or engine modifications. However, biodiesel fuel can be treated just like petroleum-based diesel fuel and used in diesel engines.



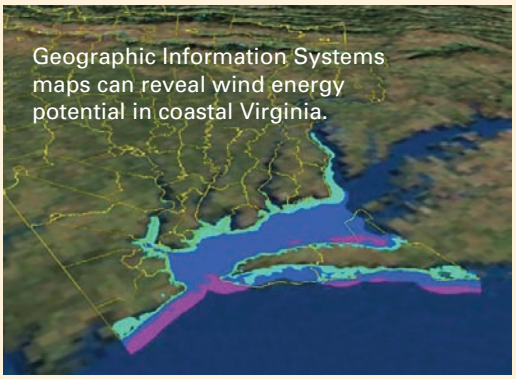
Wind, Waves and Currents

Scientists, engineers and geographers at Old Dominion University will help decide whether the nation's abundant supply of wind, waves and currents energy should be tapped to generate electricity.

Wind turbines are producing electricity throughout the world today. The so-called "wind farm" clusters of modern windmills are now being developed in coastal waters, where winds are stronger and more reliable. Virginians will want assurances that a coastal wind farm will be reliable and not harm the environment. State officials must look to experts such as ODU faculty members for answers.

University experts in ocean sciences are addressing questions about ocean conditions such as waves, winds and currents, bird migration routes, weather patterns and seabed geology, while coastal engineers are looking at ways to anchor turbine towers.

ODU, which has program strengths in fluid dynamics, electrical and computer engineering and modeling and analysis, also can contribute to turbine blade design, wind-power generation predictions and strategies for integration of wind power into conventional electrical power grids.



Geographic Information Systems maps can reveal wind energy potential in coastal Virginia.

Generating electricity by means of waves and currents energy is not a mature technology. Researchers at ODU with expertise in fields such as oceanography, computer modeling and hydrodynamics can help to formulate wave and current-harnessing strategies for the mid-Atlantic coast. Several ODU engineers propose to model design concepts that utilize energy extraction from waves and currents to supplement wind power.

ODU Wind, Wave and Current Researchers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Larry Atkinson, eminent professor and the Samuel L. and Fay M. Slover Professor of Oceanography, is an expert in coastal oceanography and has extensive experience with "observing systems" that monitor the Chesapeake Bay and oceans. He is the secretary of the Mid-Atlantic Ocean Observing Regional Association and a member of the Steering Committee of the Chesapeake Bay Observing System. His research funding from NOAA supports the installation of a surface current radar mapping system in the lower Chesapeake Bay. He collaborates with the U.S. Navy on research involving autonomous underwater vehicles that may be of use in underwater engineering and the exploration of wind farm sites. 17

David R. Basco, professor of civil engineering and director of the Coastal Engineering Center at ODU, can draw on vast experience to investigate physical impacts of wind farms on currents, sediment transport and shorelines along the Virginia coast. He is uniquely qualified to evaluate offshore wind farm sites in the mid-Atlantic region according to legal/governmental, economic, environmental, technological and aesthetic measures and constraints. His Coastal Engineering Center has a Coastal Area Morphodynamic Simulation (CAMS) system that can perform the numerical modeling needed to identify relative physical impacts of wind farms based on where they might be located. 18

Jose L. Blanco, research scientist in the Center for Coastal Physical Oceanography, has considerable experience in physical processes on coastal areas (upwelling, buoyancy, estuaries, bays) and their variability. His research is related to time series and variability for offshore wind, waves and currents resources. He also is involved with the surface current radar mapping system in the lower Chesapeake Bay and other oceanographic observation systems. 19

Malcolm Scully, assistant professor in the Department of Ocean, Earth and Atmospheric Sciences, has considerable experience working in estuarine and coastal waters. His research focuses on circulation and turbulent mixing, with a specific focus on how the wind impacts these processes. In addition to making direct observations of turbulent mixing and circulation, his research employs realistic 3-D numerical models for simulating coastal and estuarine flows. 20

Jennifer Georgen, assistant professor in the Department of Ocean, Earth and Atmospheric Sciences, is a marine geophysicist and numerical modeler. Her research involves collecting and analyzing data sets that explore seafloor and subsurface geology, including bathymetry, gravity, magnetics, seismics and sediment cores. Her numerical models address two- and three-dimensional problems in geophysical fluid dynamics, in both continental shelf and deep ocean environments. She has been involved in preliminary analysis of seafloor geological data from offshore Florida for a wind farm feasibility study. 21

Shirshak Dhali, professor and chair of the Department of Electrical and Computer Engineering, is a senior member of the Institute of Electrical and Electronics Engineers. With funding from the U.S. Department of Energy, he has worked on pollution abatement related to energy production. He also has research interests in power electronics and sensors, and is currently co-principal investigator on a project for the U.S. Navy involving multi-electro-optic sensors for surveillance of coastal areas. Similar sensors could monitor the direction and power of winds off the Virginia shore. His work can predict fluctuations in power produced by wind generation and how the power can best be integrated with existing power grids. 22

Perfect Place

for Wind Turbine R&D

Oktay Baysal, the dean of ODU's Frank Batten College of Engineering and Technology, leads the university's participation in the Lone Star Wind Alliance, a project designed to increase the use of wind turbines for the production of electricity in the United States. The U.S. Department of Energy project can rely on the aerospace and mechanical engineering expertise of Baysal and other faculty members in the design and testing of turbine blades.

Other ODU and regional resources for use in wind energy projects:

- Virginia Modeling, Analysis and Simulation Center for computer-assisted design work and simulated tests.
- Langley Full Scale Wind Tunnel, the largest university-operated facility of its kind in the country.
- Hampton Roads shipbuilding and port infrastructures, and the region's experience with ship and barge transportation of very large structures and instruments. These are readily adaptable to the construction, installation and maintenance of huge offshore turbines.


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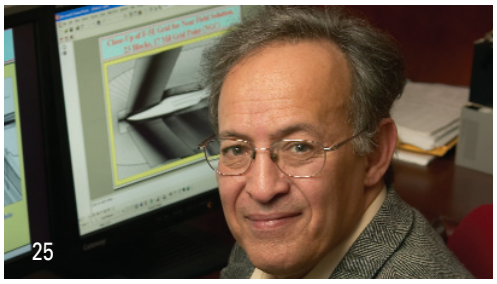
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Vishnu Lakdawala, associate professor of electrical and computer engineering, has worked with the Atomic Molecular and High Voltage Physics group at Oak Ridge National Laboratory. His research interests include electron attach-ment in fluorine compounds, breakdown studies in compressed gases and vacuum, material characterization and simulation studies in compound semiconductors and high-power semiconductor switches. He and collaborators will develop stochastic models to predict wind power generation and strategies for integration of wind power into conventional grids. 23

Ravindra Joshi, professor of electrical and computer engineering, is involved in research broadly encompassing modeling and simulation of charge transport, simulation of electronic devices and semiconductors, non-equilibrium phenomena, breakdown physics and bioelectrics. He is a senior member of the Institute of Electrical and Electronics Engineers and has been a visiting scientist at Oak Ridge National Laboratory, Kirtland Laboratory, Motorola and NASA Goddard. 24

Robert L. Ash, professor and eminent scholar of aerospace engineering, has worked on turbulence problems for NASA and also presided over wind-tunnel tests of a replica of the Wright brothers' famous glider at the NASA Langley Research Center. As ODU's associate vice president for research and economic development, he is responsible for all of the university's economic development initiatives involving research. He oversees the Frank Batten College of Engineering and Technology's Langley Full-Scale Wind Tunnel.

Osama Kandil, professor and eminent scholar of aerospace engineering, conducts research in areas such as computational and theoretical fluid dynamics, high angle of attack aerodynamics, vortex flows and breakdowns, unsteady flows, shock flows, analysis and control of asymmetric flow, and flow and structural control of tail buffet and wing rock problems. He was founding chair of the Department of Aerospace Engineering at ODU in 1993, and he is an Associate Fellow and technical committee member of the American Institute of Aeronautics and Astronautics. His expertise could contribute to the development of more efficient wind turbines. 25

Colin P. Britcher, associate professor of aerospace engineering 26

Drew Landman, associate professor of aerospace engineering

Thomas E. Alberts, professor of aerospace engineering

Brett Newman, associate professor of aerospace engineering

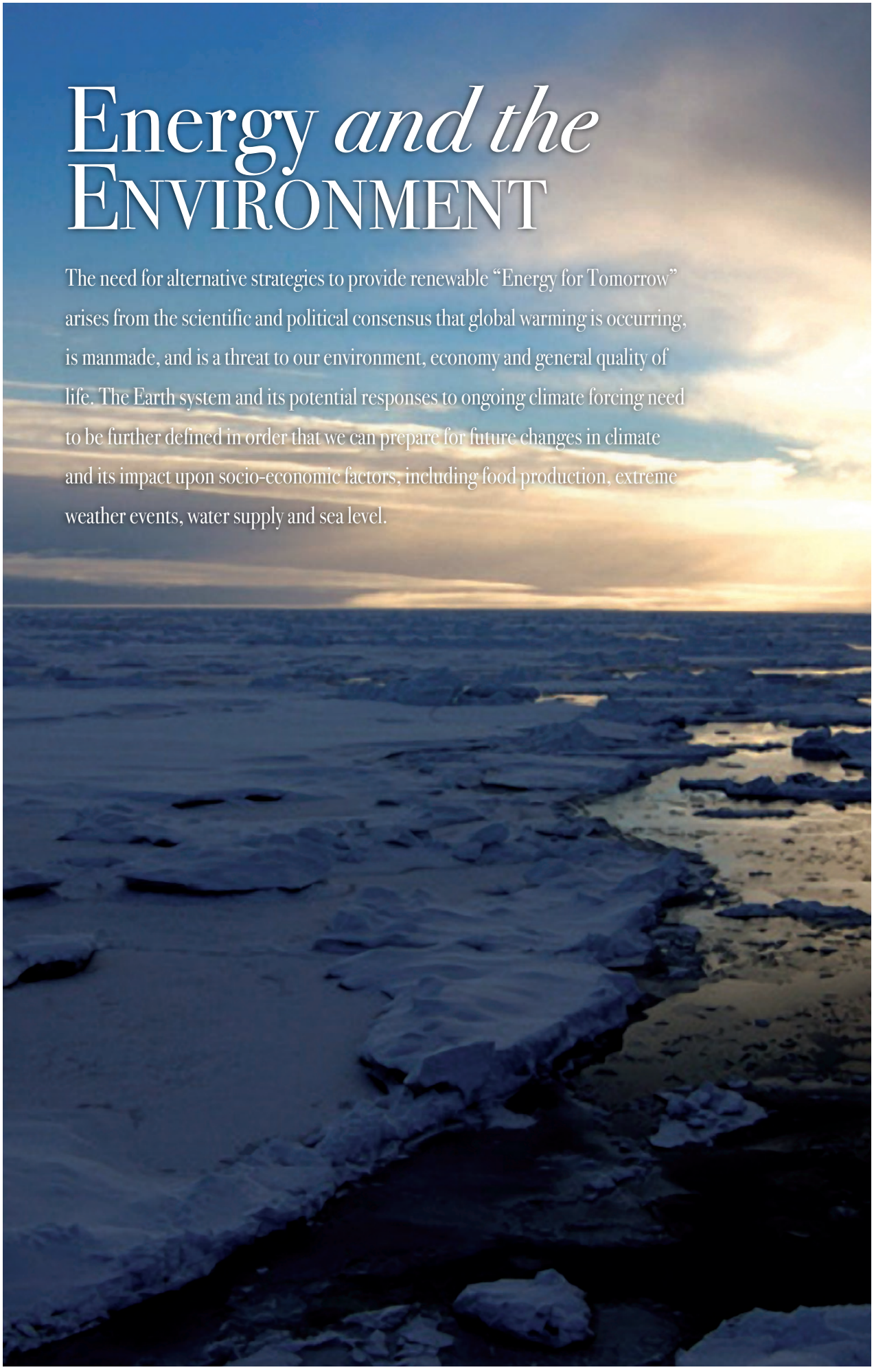
Sebastian Bawab, associate professor of mechanical engineering

With expertise in areas such as experimental aerodynamics, wind-tunnel testing techniques and dynamic modeling and analysis, these ODU engineers can test stabilities and efficiencies of wind and wave power generation schemes. For example, Newman is currently working in the area of large-scale propeller/rotor design applicable to turbine blades, and the group as a whole has the expertise to explore, develop and analyze new technologies for wind, wave and ocean current power generation. One such technology applies to barge-mounted wind turbines.

Teresa Garner, research assistant in the Center for Coastal Physical Oceanography, is working on the harmonic analysis of tides, tidal current prediction and development of a method to determine the largest vertical length scales of turbulent eddies.

WEE BIT *of use so far*

A world energy assessment by the United Nations in 2004 reported only about 0.32 percent of the globe's primary energy supply as being generated by wind power.



Energy *and the* Environment

The need for alternative strategies to provide renewable "Energy for Tomorrow" arises from the scientific and political consensus that global warming is occurring, is manmade, and is a threat to our environment, economy and general quality of life. The Earth system and its potential responses to ongoing climate forcing need to be further defined in order that we can prepare for future changes in climate and its impact upon socio-economic factors, including food production, extreme weather events, water supply and sea level.

Uses of conventional fuels have contaminated our waterways, our fragile coastal areas, and our atmosphere with organic and inorganic pollutants. The Earth system has borne the onslaught of fossil and biomass fuel by-products for more than two centuries. This is well recorded in the geologic record and the impact it has made on living systems.

Scientists at Old Dominion University are leaders in research areas such as bio- and geo-chemical analysis, climate change and carbon cycling that will help to determine the magnitude of future global warming and its socio-economic impacts. These same researchers are providing the next generation of multidisciplinary scientists with training specifically aimed at a better understanding of climate warming, the Earth's biogeochemical cycles, and petrochemical contaminants in soils, waters, sediments and the atmosphere.

ODU faculty members in biology, geology, chemistry, oceanography and atmospheric sciences have led many national and international research projects—including a historic expedition across the Arctic Ocean in 2005—to glean answers about climate patterns and the impact of modern energy consumption on global temperatures.

ODU Energy and Environment Researchers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David Burdige, professor of ocean, earth and atmospheric sciences, is the author of the text, "Geochemistry of Marine Sediments." His research touches on petroleum exploration, the carbon cycle and global warming, water pollution and algal blooms. He has developed an advanced course for science majors, "Global Environmental Change," helping students appreciate the scientific aspects of global change using an Earth systems science approach. The course examines the evolution of the Earth as a habitable planet, and human impact upon the major biogeochemical cycles of the land, ocean and atmosphere. A major component involves studies of the global carbon cycle across a range of time and space scales, along with an examination of the recent rise in anthropogenic CO^2 and its possible future consequences. In 2004, Burdige began teaching a lower-division undergraduate course, Global Earth Systems, which is designated as one of the two core courses in the undergraduate ocean and earth sciences degree program at ODU. Additional details can be found at: www.lions.odu.edu/~dburdige/OCEN310/course home.html. 27

Kenneth Mopper, professor of chemistry and biochemistry with a joint appointment in the Department of Ocean, Earth and Atmospheric Sciences, is a researcher in the fields of organic geochemistry and analytical organic chemistry. His studies are related to the input, transport, cycling and alteration of organic matter in aquatic and atmospheric environments. Dissolved organic matter in the oceans is one of the largest carbon reservoirs on the Earth's surface and, consequently, it is a major component of the global carbon cycle. Mopper's studies address questions about the chemical composition of this dissolved organic matter, and about its origins and impact on biological and chemical processes in the sea.

Frank P. Day Jr., eminent professor of biological sciences, focuses his research on influences of hydrology, nitrogen availability and elevated atmospheric carbon dioxide on vegetation dynamics in forested wetlands and coastal ecosystems. He uses ground-penetrating radar to measure root dynamics and is a member of an international research team studying the effects of elevated carbon dioxide on a scrub-oak ecosystem at Kennedy Space Center in Florida. His research will determine if roots of certain trees can take in and store enough carbon dioxide to curtail the buildup of greenhouse gases. 28

Dennis A. Darby, professor of ocean, earth and atmospheric sciences, is a marine geologist and Arctic specialist with expertise in "reading" ocean sediment samples and other geophysical data to gather clues about the climate cycles. As co-chief scientist for the National Science Foundation-sponsored Healy-Oden Trans-Arctic Expedition (HOTRAX) in the summer of 2005, he presided over extensive core sampling of ocean bottom sediment, which will enable scientists to define Arctic weather patterns over the last 60,000 to 100,000 years. 29

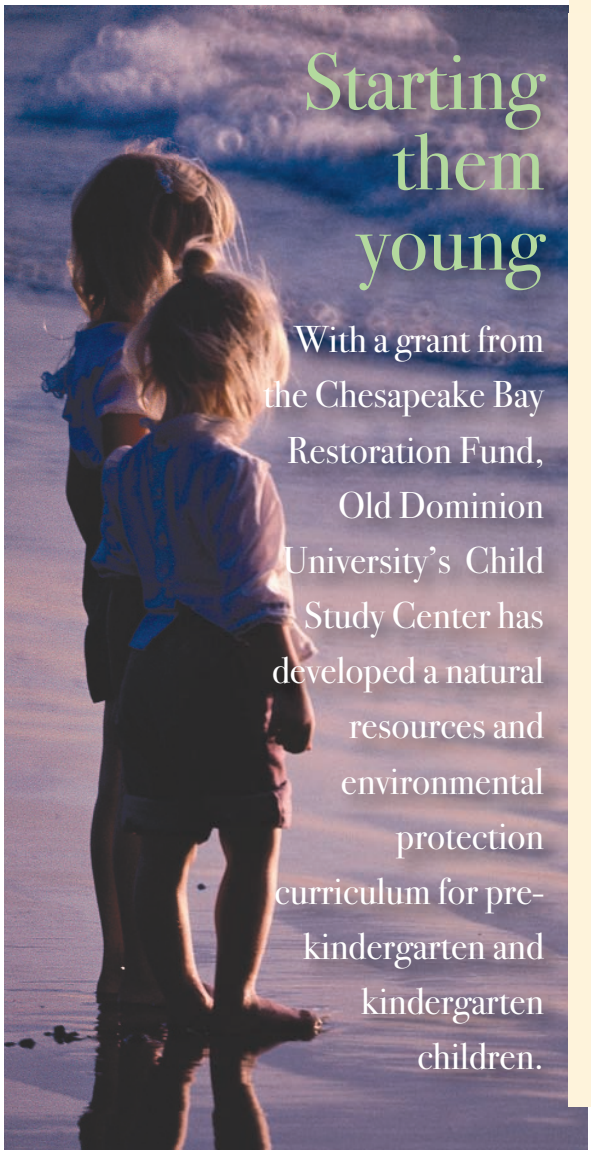
Thomas C. Royer, eminent professor and Samuel L. and Fay M. Slover Chair in Oceanography, has research interests in coastal and deep ocean processes in the North Pacific. He carries out oceanographic sampling in the North Pacific, in addition to local studies in the vicinity of Chesapeake Bay. He is working on freshwater discharge budgets into the ocean and global sea level analyses. He is interested in using these parameters as a measure of ocean climate changes and to determine how they might affect fisheries. His work will continue on interdisciplinary approaches to addressing ecosystem problems. 30

ODU Energy and Environment Researchers

Chester E. Grosch, professor of oceanography and of computer science, has research interests in basic turbulence dynamics and climate change in the northeast Pacific Ocean. He conducts research in collaboration with fisheries scientists, bird ecologists, aerospace scientists and engineers, as well as physicists. 31

Greg Cutter, professor of ocean, earth and atmospheric sciences, focuses on the cycling of trace elements within the aquatic environment (trace element biogeochemistry), particularly the linkages between biologically driven nutrient cycling and those of elements that are both essential (e.g., selenium) and toxic (e.g., arsenic), depending on their chemical forms. Past work examined the cycling of potentially toxic arsenic and selenium in the cooling reservoirs of coal-fired power plants, for which he developed a simulation model to help utilities mitigate toxicity problems in their lakes. More recently, he has been studying the long-range transport and deposition of arsenic, antimony, selenium and silver from coal combustion to the Atlantic and Pacific oceans.

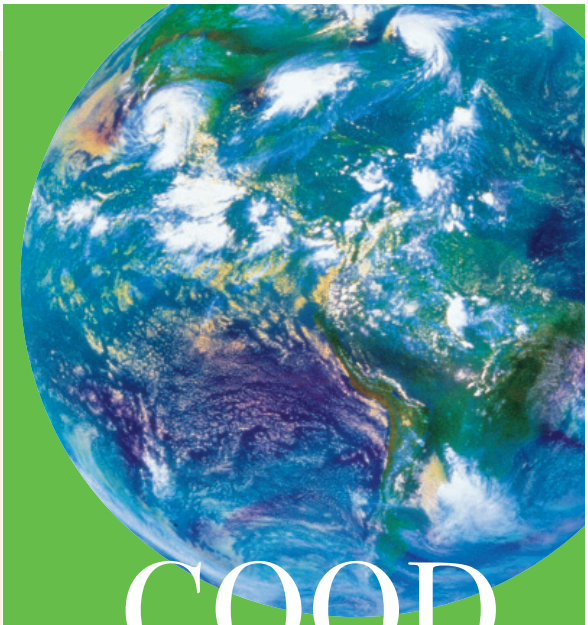
Jens J. F. Bischof, instructor of ocean, earth and atmospheric sciences, studies the process of ice rafting, and specializes in the identification of ice-rafted sand grains that can be found dispersed in glacial marine deep-sea sediments. His research, which included participation in the HOTRAX Arctic expedition in 2005, traces ice movement, ocean currents and climate change through the ages. 32



Richard C. Zimmerman, professor and department chair of ocean, earth and atmospheric sciences, conducts research on the impact of carbon dioxide on primary production of seagrasses in coastal waters. He has shown that seagrass growth can be enhanced by direct injection of carbon dioxide-rich flue gas from industrial sources such as fossil fuel burning power plants. His work with ODU colleague **David Burdige** indicates that seagrasses create a biological pump capable of transferring carbon dioxide from the atmosphere to the relatively stable bicarbonate pool of the ocean by promoting the dissolution of carbonate sediments in which the seagrasses are rooted.

Margaret Mulholland, associate professor of ocean, earth and atmospheric sciences, works on various aspects of carbon and nitrogen cycling in aquatic systems. The biogeochemical cycling of these elements affects the ecology of microbes in marine and estuarine systems. Particular aspects of these cycles being investigated in her laboratory include the uptake and regeneration of specific carbon and nitrogen compounds by a variety of pathways involving phytoplankton and bacteria.

Patrick G. Hatcher, Batten Endowed Chair in Physical Sciences and director of ODU's College of Sciences Major Instrumentation Cluster (COSMIC) laboratory, conducts research in the area of environmental chemistry and geochemistry. He studies the origin and chemical transformations of plant-derived organic matter in natural systems such as soils, peats, marine sediments and oceanic waters. The sources and transformations of organic matter in the natural environment need to be addressed if we are to improve our understanding of the contemporary carbon cycle. Moreover, Hatcher has been involved in many large multidisciplinary efforts to evaluate the contamination of Earth's ecosystem by organic pollutants derived from fossil fuels and combustion of these fuels.



GOOD NEWS *for the planet*

A federal study by the departments of Energy and Agriculture found that use of biodiesel fuels reduces net carbon dioxide emissions by 78 percent compared to use of petroleum diesel. This is due to biodiesel's closed carbon cycle. The carbon dioxide released into the atmosphere when biodiesel is burned is recycled by growing plants, which are later processed into fuel.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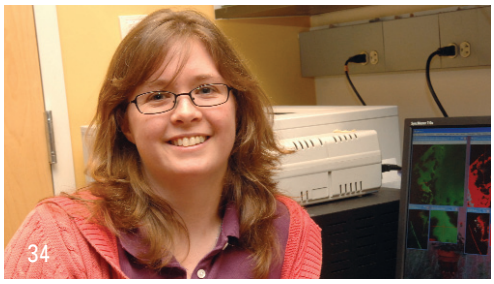
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Stephen Olariu, professor of computer science, and **Michele C. Weigle**, assistant professor of computer science, have formulated an architecture for Notification of Traffic Incidents and Congestion (NOTICE), which would use reliable new equipment and schemes to detect traffic congestion caused by an accident or other roadway incident. Traffic congestion in the United States, more than half of which is caused by roadway incidents, wastes about 8.5 billion gallons of fuel a year. 33

Victoria J. Hill, research assistant professor in oceanography, has research interests in bio-optical oceanography, distribution of phytoplankton pigments, the polar environment, remote sensing and the coupling between climate changes on land and the marine environment. She also studies the input of dissolved carbon to the Arctic Ocean and its effects on solar heating and photosynthesis. 34

Aron Stubbins, assistant research professor of chemistry and biochemistry, studies the carbon cycle, particularly organic carbon cycling, photochemical and microbial carbon processing in rivers and oceans, water-air gas exchange of greenhouse gases and the assessment of potential feedbacks between the global carbon cycle and fossil fuel-induced climate warming.

Peter Sedwick, assistant professor of ocean, earth and atmospheric sciences, has current research interests in the marine biogeochemistry of trace metals, with an emphasis on iron and its role in regulating marine phytoplankton growth; the atmospheric transport of soil dust and the associated deposition of trace metals to the surface ocean; and the paleoenvironmental records contained in marine sediments and Antarctic ice cores. He has recently been involved in field research programs in the subtropical North Atlantic Ocean and in the Antarctic. 35

LEED building

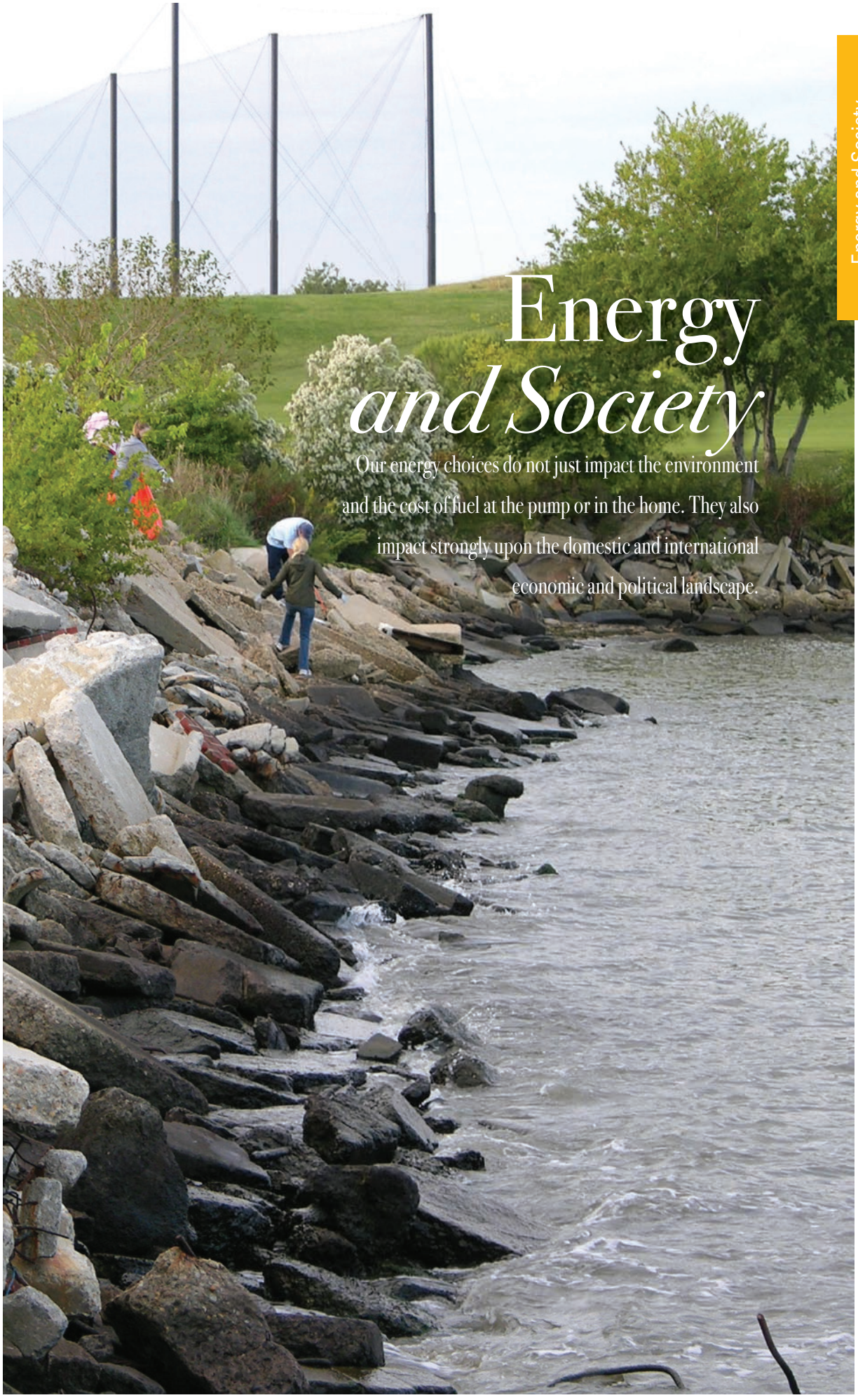
Old Dominion University's E.V. Williams Engineering and Computational Sciences Building opened in 2004 as the first university building in Virginia to win certification from Leadership in Energy and Environmental Design (LEED) for meeting standards set by the U.S. Green Building Council.

Old Dominion University will take these socio-economic and political considerations into account when determining how best to deliver and manage "Energy for Tomorrow."

The Department of Political Science and Geography at ODU is particularly well placed to critically assess these issues and their relevance to energy strategies for Virginia and America. Across the campus, faculty in the College of Business and Public Administration are involved in energy-related forecasts and policymaking.

In 2005 ODU launched a course for freshmen, New Portals to Appreciating our Global Environment (NewPAGE), that reflected the commitment of administrators and faculty to education about the environment. Numerous university outreach events, publications and programs help educate the public about energy science, energy technologies and energy policies.

The university's $20 million E. V. Williams Engineering and Computational Sciences Building, which opened in 2004 as the first LEED-certified higher education building in Virginia, is further evidence of the interest campuswide in improving the environment. The LEED (Leadership in Energy and Environmental Design) certification recognizes buildings designed to meet environmentally friendly standards set by the U.S. Green Building Council.



Energy *and Society*

Our energy choices do not just impact the environment and the cost of fuel at the pump or in the home. They also impact strongly upon the domestic and international economic and political landscape.

ODU Energy and Society Researchers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Glen Sussman, professor of political science, conducts research into environmental politics and energy policy. A major proportion of his work focuses upon the U.S. presidency. In his research about climate change he has focused on George H. W. Bush, Bill Clinton and George W. Bush and their domestic and global environmental policies, with attention paid to the problems resulting from the use of fossil fuels. A significant outcome of this research is an expression of the need for conservation of resources and an increased emphasis on safe, alternative energy sources. 36

Steve A. Yetiv, professor of political science, has appeared on several CNN and C-SPAN one-hour specials about petroleum-related issues, and is regularly interviewed on the topic by the national and international media. He has traveled widely in the Middle East and has published more than 200 editorial pieces. Yetiv has been a consultant to the U.S. Department of State, Department of Defense and the General Accounting Office. He received the Secretary's Open Forum Distinguished Public Service Award from the State Department (1996) for his "contributions to national and international affairs." Yetiv's books focus on the American role in the Middle East and on global energy. "Crude Awakenings: Global Oil Security and American Foreign Policy," which won a 2005 Choice Award, explores global oil security, with a focus on longer run oil market dynamics, OPEC, the Middle East, and global inter-dependence (Cornell University Press, 2004). 37

Christine Drake, professor of geography and director of the geography program, has energy-related teaching and research interests including cultural, political and environmental geography; America in an interdependent world; Asia, Africa, and the Middle East; world resources; and international resource management. Her involvement in these topics has developed into a major interest in resource management, particularly energy conservation. She was director of ODU's Model United Nations Program from 1988 to 1993 and is a past member of the executive board of the National Council for Geographic Education. 38

Wayne K. Talley, eminent scholar and Frederick W. Beazley Professor of Economics, is executive director of the university's International Maritime, Ports and Logistics Management Institute. He teaches courses in transportation economics and port economics and his research investigates determinants of the severity—including oil spillage—of vessel accidents. 39

Eric E. Anderson, associate professor of economics, teaches natural resource/environmental economics and his research investigates economic aspects of natural resource and environmental management. Before joining the ODU faculty, he worked as an economist with the U.S. National Marine Fisheries Service in Seattle. 40

Christopher Colburn, associate professor of economics, studies economic factors that give rise to urban centers and contribute to poverty, poor housing conditions, traffic congestion and fiscal crises faced by modern cities. He has been a theme leader for instruction in environmental decision making for the NewPAGE global environment course. 41

David D. Selover, associate professor of economics, is conducting research on the effect of El Nino upon the business cycle. He has also studied the electric power industry. Much of his research has focused on economic issues in Japan and Mexico. 42

Dwight Allen, eminent professor of educational reform, was launch coordinator for the NewPAGE multidisciplinary course, which asks ODU students to critically examine some of the major environmental issues facing the world today. 43

G. Richard Whittecar, University Professor of ocean, earth and atmospheric sciences, has chaired the coordinating committee for the NewPAGE multidisciplinary course and contributed to instruction sections on the causes and effects of global climate warming. 44


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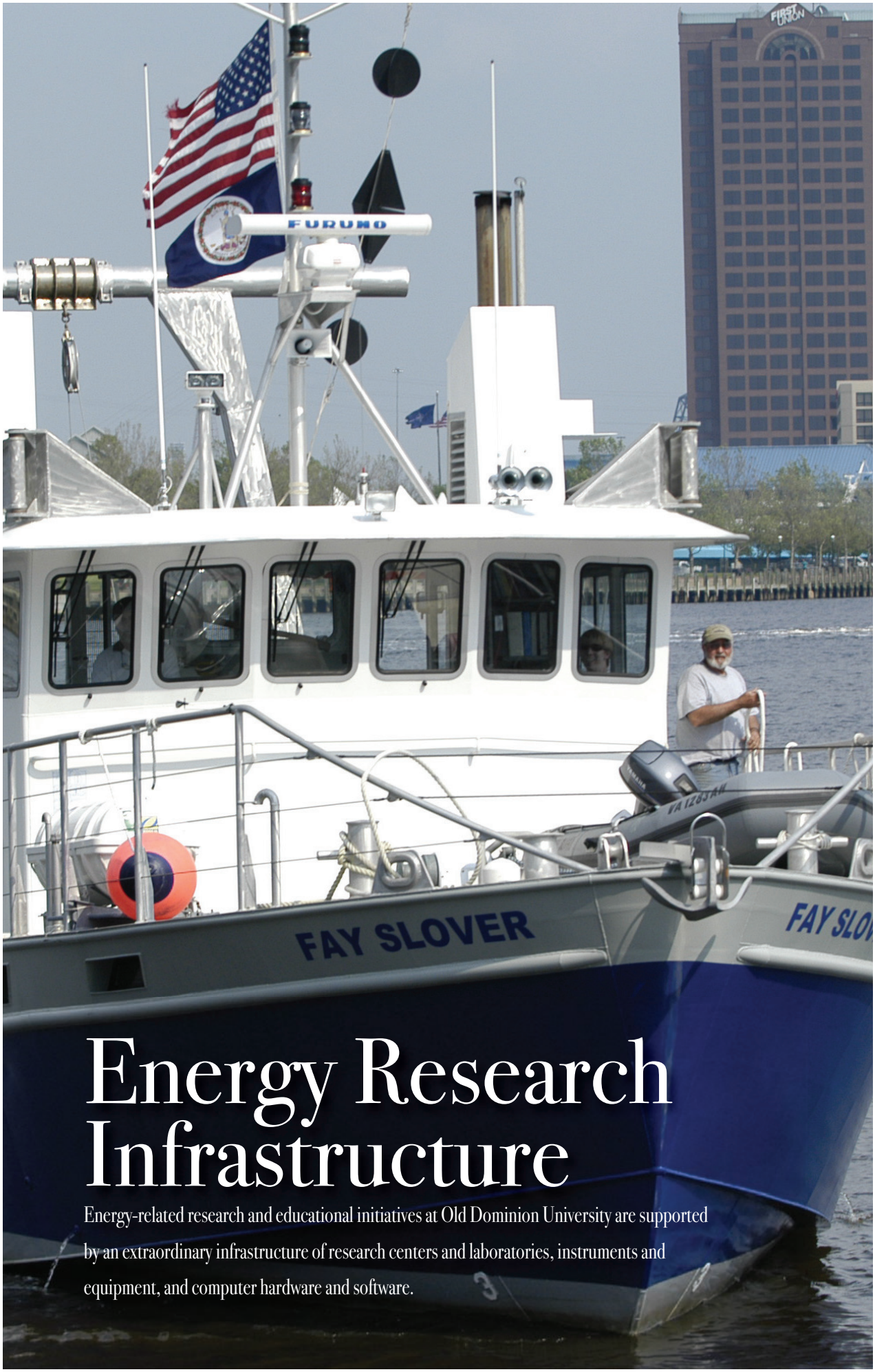


Energy Research Infrastructure

Energy-related research and educational initiatives at Old Dominion University are supported by an extraordinary infrastructure of research centers and laboratories, instruments and equipment, and computer hardware and software.

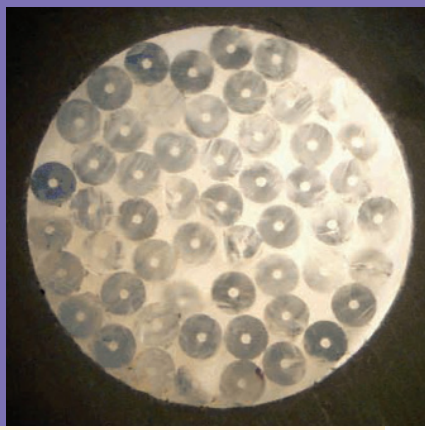
From a modern oceanographic research vessel to one of the nation's best equipped chemical analysis laboratories, ODU has the infrastructure to promote the ideas and expertise of faculty and students.

RV Fay Slover is a 55-foot, all aluminum research vessel that was built in 2002 and features a 200-square-foot dry/wet laboratory. It has twin, 700 horsepower diesel engines and a large fuel capacity that allows a 580-mile range. The "planing/plow" hull design, wide beam and shallow water draft of five feet allows for speed with excellent seafaring capability. **Richard Moody**, a retired NOAA commander, was the first Fay Slover captain and is now ODU marine superintendent with responsibilities for the vessel's scheduling and budget. **Richard Cox**, former boat captain with the U.S. Army Corps of Engineers, is the current Fay Slover captain.

Virginia Energy Digital Library (VEDL) is planned as an offshoot of the Department of Computer Science's innovative work with the Open Archive Initiative (OAI) to facilitate discovery of content stored in distributed archives. Access to online energy-environment-related resources, including technical papers and state incentives, would be much improved by a federated service providing a unified interface to libraries. VEDL would address interoperability challenges, allow the sharing of resources and speed the development of energy solutions. **Kurt Maly**, Kaufman Professor and chair of the Department of Computer Science, and **Mohammad Zubair**, professor of computer science, lead ODU's work with digital libraries.

National Centers for System of Systems Engineering is a research center for ODU to draw together academia, government and industrial organizations to resolve problems and develop technologies via the design, analysis and integration of complex systems of systems. The director is **Charles B. Keating**, associate professor of engineering management and systems engineering. Energy-related risk management research is conducted by **Adrian V. Gheorghe**, Batten Chair of Systems Engineering.

Energy-related **Nanotechnology** is a specialty of **Sacharia Albin**, professor of electrical and computer engineering and leader of the university's Photonics Research Group. Albin is investigating the use of nanocrystal photovoltaics to boost the efficiency of solar power generation. Another nanotechnology initiative of Albin's probes photoelectrochemical production of hydrogen using nanorods. This process involves the use of photochromic nanomaterials in sunlight driven photoelectrochemical cells for the production of hydrogen fuel from water. Yet another of his projects proposes nanotechnological solutions for hydrogen storage, which currently is very expensive and inefficient. This work explores storing hydrogen in activated carbon nanotubules amended with nanoparticles of hydrogen-storing palladium, platinum and titanium. Another hydrogen-storage method under investigation is the production of polymer fibers that contain micro-pores along their length. These pores can be filled with nanoparticles of metals that are hydrogen scavengers. Since polymer fibers are light and flexible, storage and transport of hydrogen under atmospheric conditions would be possible and reduce the costs associated with cryo-transportation and storage.



NOT MANY ARE LIKE IT

The $1.3 million Fourier transform ion cyclotron resonance mass spectrometer in Old Dominion University's COSMIC laboratory is built around a 12-Tesla superconducting magnet nearly 500,000 times stronger than the Earth's magnetic field. Only a handful of universities in the United States have this type of ultra-high-resolution instrument.

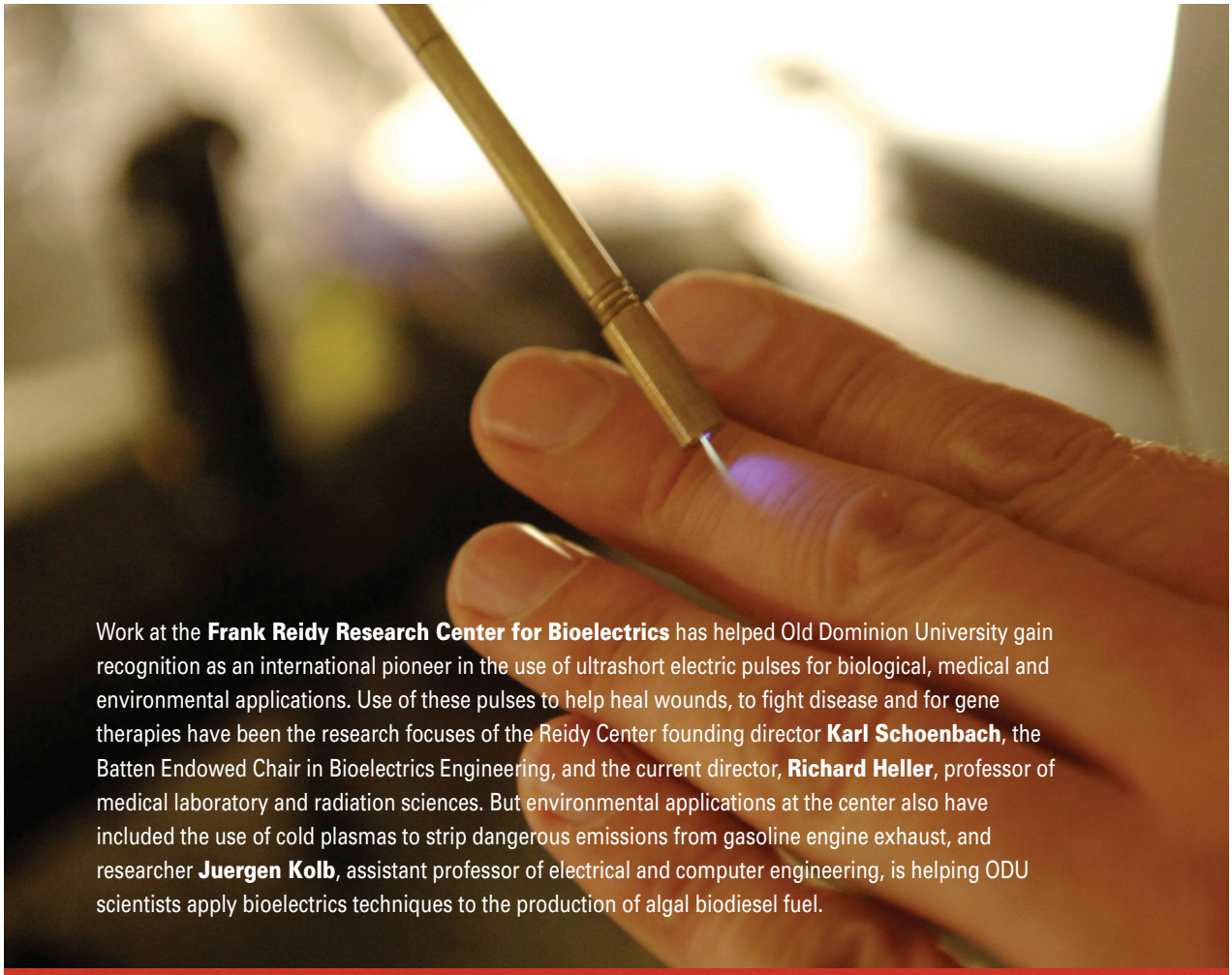
College of Sciences Major Instrumentation Cluster (COSMIC) laboratory has an ultra-high-resolution 12-Tesla Fourier transform ion cyclotron resonance (FT-ICR) mass spectrometer and a 400 MHZ solid-state nuclear magnetic resonance spectrometer with High Resolution Magic Angle Spin capability. COSMIC is directed by **Patrick G. Hatcher**, Batten Endowed Chair in Physical Sciences and 2005 winner of the American Chemical Society's Geochemistry Division Medal. His wife, **Susan Hatcher**, is day-to-day director of the COSMIC lab. The Hatchers' novel applications of advanced analytical techniques are being put to use in tracing the transformations of organic matter in plant remains as they generate fossil organic matter, including fuels. Hatcher's group is examining the formation of oil and gas from algal remains, working collaboratively with individuals from the French Institute of Petroleum.

Center for Coastal Physical Oceanography (CCPO) has faculty with extensive experience in numerical modeling of ocean properties, including properties in Virginia shelf waters and the Chesapeake Bay. CCPO will be research central for studies of offshore winds, wave/current conditions and seafloor properties as ODU oceanographers investigate the feasibility of wind and wave electricity generation in Virginia. Outreach projects of the center include the Blue Crab Bowl, which is the Virginia regional competition in the National Ocean Sciences; Christ the King School Oceanography Day; a Boy Scout oceanography merit badge program; and a ship's ballast water tutorial for elementary and middle school students. **Larry Atkinson**, Samuel L. and Fay M. Slover Professor of Oceanography, leads CCPO.

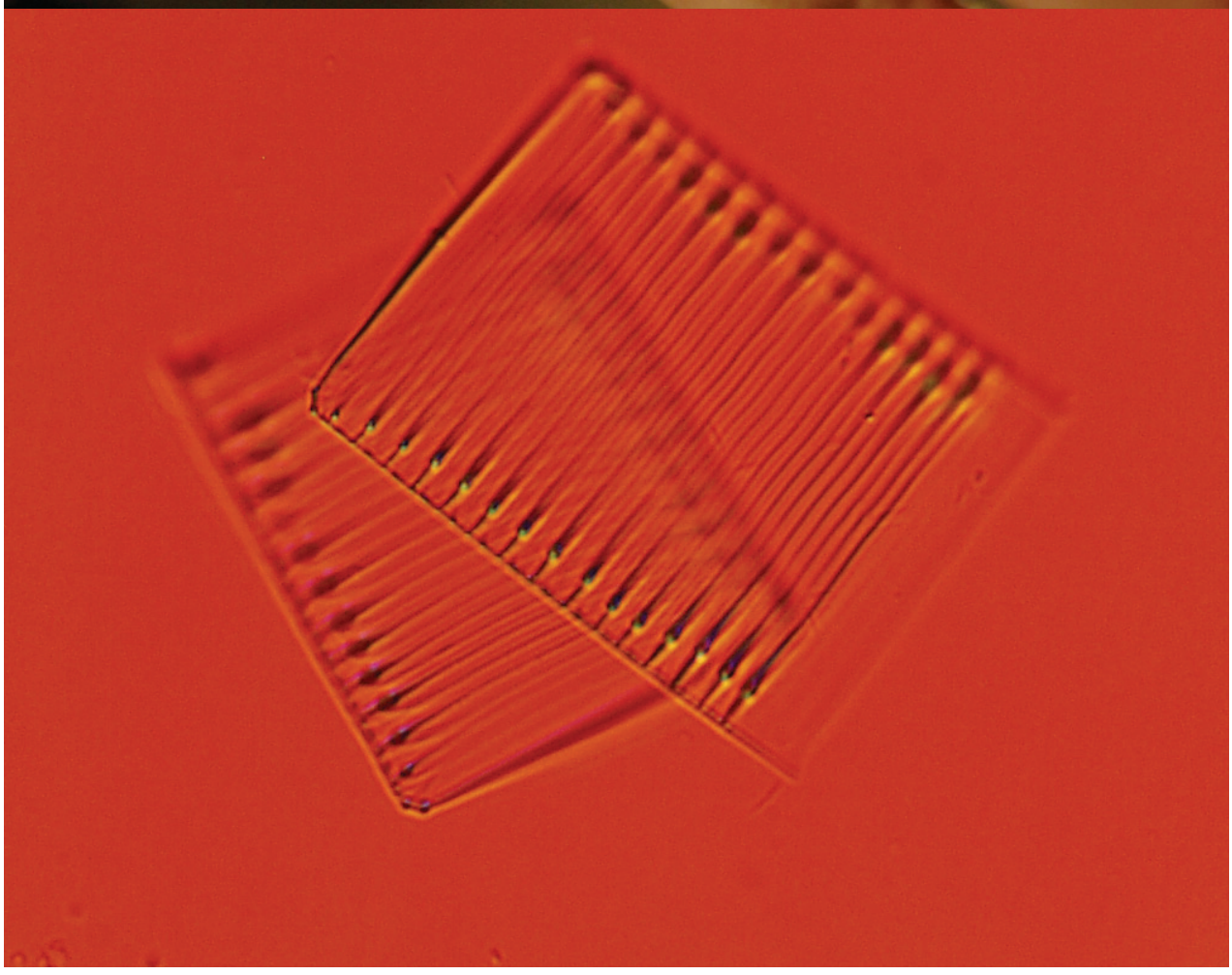
Barrier Island Research Program and its director, **George F. Oertel**, professor of ocean, earth and atmospheric sciences, can serve a renewable energy initiative by investigating physical impacts of wind farms that might be constructed off the Virginia shore. The program has research links with ODU's Coastal Engineering Center and its director, **David R. Basco**, professor of civil engineering. The engineering center has the numerical modeling system, Coastal Area Morphodynamic Simulation, with which to study physical impacts of wind farms and relative potential impacts of various wind farm locations.

Virginia Modeling, Analysis and Simulation Center (VMASC) is in the top tier of facilities in the nation that conduct research and develop tools involving modeling, analysis, simulation and visualization. Transportation studies are a VMASC specialty, such as those aimed at reducing energy-wasting traffic congestion. The center also has projects investigating emergency response to disasters and military practices that touch on political aspects of the nation's energy policies. **Michael McGinnis**, retired Army brigadier general and professor of systems engineering, is executive director of VMASC.

Condensed Matter and Material Physics Research Group specializes in research on corrosion. The group's work influences the design, construction and preservation of major steel structures such as offshore oil refineries and near-shore and offshore wind farms. **Desmond C. Cook**, professor of physics, leads the group. With support from NOAA, he has led corrosion studies on salvaged portions of the Civil War ironclad USS Monitor.



Work at the **Frank Reidy Research Center for Bioelectrics** has helped Old Dominion University gain recognition as an international pioneer in the use of ultrashort electric pulses for biological, medical and environmental applications. Use of these pulses to help heal wounds, to fight disease and for gene therapies have been the research focuses of the Reidy Center founding director **Karl Schoenbach**, the Batten Endowed Chair in Bioelectrics Engineering, and the current director, **Richard Heller**, professor of medical laboratory and radiation sciences. But environmental applications at the center also have included the use of cold plasmas to strip dangerous emissions from gasoline engine exhaust, and researcher **Juergen Kolb**, assistant professor of electrical and computer engineering, is helping ODU scientists apply bioelectrics techniques to the production of algal biodiesel fuel.



Virginia Coastal Energy Research Consortium at Old Dominion University

Overdependence on fossil fuels is not sustainable and has become the single biggest threat to our environment, economy and national security. Based upon the central role of fossil fuels in greenhouse gas emissions and global warming, a renewed emphasis on alternative, non-fossil fuel energy research has emerged. Basic and applied research is needed to provide the technical and economic solutions that will deliver an energy future beyond fossil fuels.

The Commonwealth of Virginia has assigned Old Dominion University the leadership role in the Virginia Coastal Energy Research Consortium (VCERC), with the mission to seek out and develop new alternative energy research directions and evaluate renewable energy sources for Virginia. VCERC is composed of ODU and its Virginia university partners: Virginia Tech, William and Mary, Norfolk State, James Madison, Virginia Commonwealth and Hampton universities and the University of Virginia. This statewide, inter-university network is destined to become a leader in the research and development of numerous alternative energy projects that will be of direct benefit to local employment, manufacturing groups, state institutions and the public.

Virginia, with its vast coastline, natural waterways and abundant sunshine, is ideally suited for a number of alternative-energy applications, most notably, biodiesel fuel production from algae and offshore wind farms. VCERC at ODU will focus at first on these two technologies. The research projects and capabilities listed in this booklet describe the "Energy for Tomorrow" efforts of ODU, but we realize that collaborations with other university partners are essential and will become part of an overall plan for the VCERC effort.

In addition to the researchers mentioned elsewhere in this book, ODU representatives on the VCERC founding work group included Mohammad A. Karim, vice president for research; and Richard V. Gregory, chair, Department of Chemistry and Biochemistry.

For more information about VCERC, visit www.vcerc.org

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