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TechTalk
SERVING THE MIT COMMUNITY

Initiative leadership guides energy goals

Deborah Halber
News Office Correspondent

The buzz around energy—new ways of making it, saving it, using it—is whirring in Washington, in corporate boardrooms, in governments around the world and out on the street. At MIT, the buzz is closer to a roar.

In late 2006, the MIT Energy Initiative (MITEI) was formed. The initiative resulted from MIT President Susan Hockfield's aspiration to marshal MIT's capabilities to address global energy challenges.

In a Boston Globe op-ed piece in December 2006, Hockfield distinguished the global energy challenge from the space race. Like Project Apollo, she wrote, the energy challenge will require a "similar commitment in funding, policies and passion," but "more than a discrete undertaking with a single goal, the energy project will have to deliver a broad portfolio of solutions, playing out on timetables measured over a few years to several decades."

Hockfield is convinced that MIT has the expertise to help deliver those solutions.

Director Ernest J. Moniz, the Cecil and Ida Green Professor of Physics and Engineering Systems, Deputy Director Robert C. Armstrong, the Chevron Professor of Chemical Engineering, and a six-member faculty Energy Council lead the initiative.

The initiative will channel the talents of MIT students and faculty to help meet the global energy challenge by enhancing energy research opportunities and outcomes, supporting the educational needs of MIT students, promoting sustainable energy values and technologies on the MIT campus and establishing a major campus dialogue on energy and associated environmental challenges.

The initiative will support these objectives by pursuing substantial new funding. "We have been able to utilize initial funding from diverse sources—from the Institute, from industry and from private donors—to seed early-stage activities for each of the initiative's focus areas," Moniz said.

The initiative has funded innovative energy research projects involving four MIT schools. It has supported several graduate fellowships in various energy-related disciplines, supported development of a new energy-focused undergraduate course, established a student fund for cam-

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PHOTO / **STEVEN LANOU**

MITei
MIT Energy Initiative

PHOTO COURTESY / **WIKIMEDIA COMMONS**

PHOTO / **DONNA COVENEY**

Linking science, innovation and policy

The MIT Energy Initiative is an Institute-wide endeavor designed to help transform the global energy system to meet the needs of the future and to help build a bridge to that future by improving today's energy systems. The MITEI program is structured to include research, education, campus energy management and outreach activities. Above, left, Roger Moore, MIT superintendent of utilities, decodes the MIT cogeneration plant for students. The plant has reduced its own greenhouse gas emissions by 30 percent since 1995. At center, geothermal facilities in Iceland are mining the heat that resides as stored thermal energy in the Earth's hard rock crust, the subject of a recent MIT-led study. Right, solar panels like those on the roof of MIT's Hayden Library harness the renewable, carbon-neutral energy that strikes the surface of the Earth.

Twelve MIT faculty are elected to AAAS

Elizabeth Thomson
MIT News Office

Twelve MIT faculty members are among the 203 new Fellows and 24 new Foreign Honorary Members recently elected to the American Academy of Arts and Sciences.

Founded in 1780 by John Adams, John Hancock, and other scholar-patriots, the Academy has elected as Fellows and Foreign Honorary Members the finest minds and most influential leaders from each generation.

They include George Washington and Benjamin Franklin in the 18th century, Daniel Webster and Ralph Waldo Emerson in the 19th, and Albert Einstein and Winston Churchill in the 20th.

The current membership includes more than 170 Nobel laureates and 50 Pulitzer Prize winners. An independent policy research center, the academy undertakes studies of complex and emerging problems. Current academy research focuses on science and global security; social policy; the humanities and culture; and education.

The academy will welcome this year's new class at its annual induction ceremony

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Aero/astro alum wins Annenberg fellowship

Stephanie Schorow
News Office Correspondent

For the first time in its 20-year history, the prestigious Annenberg Fellowship has been awarded to a student from MIT.

Beginning this fall, MIT graduate Katonio A. Butler will spend at year at Eton College—perhaps the most exclusive boys' school in the United Kingdom—where he will act as an American "ambassador" to the 1,300 students, aged 13 to 18.

The annual Annenberg Fellowship, which was established by Walter H. Annenberg, a U.S. ambassador to the Court of St. James, provides a stipend for a graduate from an American college or university to spend one academic year at Eton College. The selection usually alternates among students of Princeton, Stanford and Harvard.

However, this year Eton representatives included MIT students in the application process, and Butler was selected after a lengthy interview process.

Butler, 27, who in January received a bachelor of science degree in aeronautics and astronautics and history, with a concentration in economics, is excited about the opportunity to provide English

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PHOTO / **DONNA COVENEY**

The groundbreaking for the Central Square Theater on Massachusetts Avenue, celebrated by many members of the Cambridge, theater and MIT communities, ended in a parade led by the Second Line Brass Band to Cambridge City Hall for refreshments and a performance.

Central Square Theater breaks ground for new hall

Sarah Gallop
Office of Government and
Community Relations

The Central Square Theater had a lot to celebrate on May Day 2007. With more than 300 supporters and enthusiasts looking on, local officials broke ground at a vacant site at 450 Massachusetts Ave., marking the start of construction of a mixed-use development that includes a state-of-the-art black box theater. The new performance hall will serve as the permanent home for the Nora Theatre and the Underground Railway Theater, now combining their talents as the jointly run Central Square Theater.

The celebration was long in coming, and MIT has been at the table from the very start. The Institute is the owner and site developer of the project.

The 450 Massachusetts Ave. location currently looks like a construction site, but it has an impressive history. One of the two buildings that was previously located on this site was referred to as South Row and included structures from a group of Federal period row houses built in 1806. MIT purchased the buildings in 1979.

For many years, the buildings were occupied by the Bradford Café and the Day and Night Convenience Store. The structures deteriorated with age, until the two establishments could no longer safely operate in the buildings. In the early 1990s, MIT began to examine options

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PHOTO / **DONNA COVENEY**

From left to right: Catherine Carr Kelly, campaign manager, Central Square Theater; Debra Wise, artistic director, Underground Railway Theater; Mimi Huntington, artistic director, The Nora Theatre Company; Carl Barron, president, Central Square Business Association; Steve Marsh, managing director, real estate, MIT Investment Management Company; Jarrett Barrios, state senator; Marty Walz, state representative; and Ken Reeves, mayor of Cambridge. Behind the groundbreakers are various members of the state legislature, Cambridge City Council, and Cambridge School Committee.

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MITei guides campus energy education, programs

PHOTO / **DONNA COVENEY**

Professor Leon Glicksman and Vice President Theresa Stone are heading up the 'Walk the Talk' task force on energy issues.

PHOTO / **DONNA COVENEY**

Professors Jefferson Tester and Angela Belcher are co-chairs of the energy education task force.

Group leads 'greening' of Institute

Nancy Stauffer
MIT Energy Initiative

MIT has launched a plan for greening the campus that enlists the help of the entire community, including the campus itself. The goal: major reductions in campus-wide energy use and greenhouse gas emissions.

Among the activities are energy system upgrades, student-run projects to reduce energy use and emissions, on-campus testing of specific innovative measures, a major multidisciplinary study to look at all options and web postings of resulting guidelines for use by other universities and institutions.

"We're taking a new, wide-ranging approach that includes some important pieces that we think haven't ever been done before," said Leon R. Glicksman, professor of architecture and mechanical engineering, director of MIT's Building Technology Program and co-director of the new Campus Energy Task Force.

The task force, also known as "Walk the Talk," was established under the MIT Energy Initiative (MITEI), the Institute-wide effort aimed at addressing the global energy crisis. The Energy Education Task Force, also part of MITEI, will coordinate MIT-wide educational initiatives.

As part of MITEI, the Campus Energy Task Force is well positioned to draw on the newest technologies and approaches as well as to engage leading faculty researchers.

"But tackling MIT's own energy challenge is going to take contributions from an army of people in all departments and

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Task force forges energy curriculum

A primary focus for the Education Task Force, which held its first meeting April 26, is to develop and coordinate a robust energy curriculum for undergraduate and graduate students that integrates expertise and perspectives from all five schools at MIT. "The task force will seek to ensure that outreach to prospective students effectively informs them about opportunities to study and work on energy issues at MIT," said task force co-chair Angela Belcher, the Germeshausen Professor of Materials Science and Engineering and Biological Engineering. "Education task force objectives are strongly aligned with environmental concerns as well as burgeoning 'walk the talk' activities on campus," she said.

The members of the Education Task Force, co-chaired by Belcher and Jefferson Tester, the H.P. Meissner Professor of Chemical Engineering, are:

Marilyne Andersen, assistant professor of building technology in the Department of Architecture; Ahmed F. Ghoniem, professor of mechanical engineering; Michael W. Golay, professor of nuclear science and engineering; Steven B. Leeb, professor of electrical engineering and computer science and mechanical engineering; Donald R. Lessard, Epoch Foundation Professor of International Management in the Sloan School; F. Dale Morgan, professor of geophysics in the Department of Earth, Atmospheric and Planetary Sciences; Dava Newman, professor of aeronautics and astronautics; Donald R. Sadoway, John F. Elliott Professor of Materials Chemistry; Susan S. Silbey, professor of anthropology; Jeffrey I. Steinfeld, professor of chemistry; Washington Taylor, professor of physics.

Michelle D. Christy is named director, Office of Sponsored Programs

Michelle D. Christy, current director of the Office of Research and Project Administration at Princeton University, has been appointed director of MIT's Office of Sponsored Programs (OSP), effective July 16.

Claude R. Canizares, vice president for research and associate provost, made the announcement in an e-mail to the Institute community this morning.

Christy's appointment will "continue a strong tradition of outstanding leadership in the Office of Sponsored Programs," Canizares wrote.

PHOTO / **LAUREL M. CANTOR**

Michelle Christy

She brings to her new role "extraordinary experience, knowledge and skill across a broad spectrum of research administration activities. She has enormous energy and enthusiasm for the job, as well as an ability to balance the needs of faculty and other principal investigators with the legal and fiduciary requirements under which we must operate," Canizares wrote.

As director of OSP, Christy will have responsibility for "all aspects of pre- and post-award administration, compliance, indirect cost analysis and sub-award administration, and will head the dedicated and capable OSP staff. A nationally respected leader in the field, her appointment will ensure that MIT continues to play its long-standing role as a leader in research policy," Canizares wrote.

Christy began her career in research administration at Tulane and Rutgers universities. She was named associate director in the Office of Research and Project Administration at Princeton University in 1995 and held that position until 2001, when she was appointed director of the office. She holds a B.A. in English literature and an M.B.A. with a concentration in finance from Rutgers University.

In his letter, Canizares expressed his gratitude for the "excellent work of the search committee," which was co-chaired by Executive Vice President and Treasurer Theresa M. Stone, and whose members included, from the faculty, Professors Rohan Abeyaratne, Martin A. Schmidt and Timothy M. Swager and, from the staff, Robin C. Elices, Deborah L. Fisher, Ronald E. Hasseltine, James L. Morgan, Doreen Morris, William Peters, Charlene Placido, Anthony P. Sharon and Cecilia Wardle.

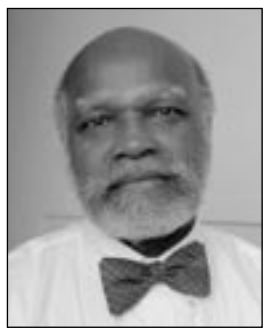
Canizares wrote that he was also "profoundly grateful to Julie T. Norris for her willingness to return to OSP to serve as its interim director, and to OSP's leadership and staff for the tremendous effort they have expended to assure smooth continuity of operations. OSP has continued to move forward under Julie's leadership, including adapting to the challenges of the new grants.gov electronic submission system, and everyone in the office deserves our thanks."

MLK urban planner seeks viability for inner city

Deborah Halber
News Office Correspondent

William M. Harris pictures revitalized inner cities where ethnically, socially and economically diverse residents live, work and educate their children in vital, stress-free communities.

Harris, professor of planning in the Department of Urban and Regional Planning at Jackson State University, is an MIT Martin Luther King Jr. Visiting Professor for 2006-2007.



William M. Harris

"I don't see utopia," he said. "I see viable living arrangements in the inner city. One of the problems with housing patterns in the U.S. is that they are vigorously and fiercely segregated by race, social status and, to some extent, religion and ethnicity. I'm here at MIT to try to write a strategy, a proposal for rebuilding inner cities around issues of race and class and ethnicity.

"This will require a new direction and innovative strategies for African-American community and economic development in the 21st century," he said.

He is hopeful that with planning, it can happen.

It has happened, he said, in Columbia, Md., where a diverse, socially integrated, racially desegregated community exists. It has happened as well in East Lake, near Atlanta, where "people live in reasonable harmony and educate their children in the same milieu."

Both, however, are primarily bedroom communities. Harris's vision includes public and private economic development enterprises that would not only invest in various levels of housing stock but also provide jobs "close to home so people can earn a decent living and not have to resort to underground activities to make ends meet."

Although Harris acknowledges that his view sounds utopian, he is a realist. Change will be incremental and painstaking, and not everyone will be happy with the pace. Communities may have to take on more responsibility for their own revitalization than in the past, he said, and attitudes of both poorer and more affluent residents may have to change radically.

But the alternative—gentrification without consideration for the existing population—is worse. Boston's South End is an example of what happens when residents are forced out of their neighborhood because they cannot afford climbing rents. "Gentrification is like stepping on a balloon," Harris said. "You blow air from one place to another. All the issues are moved to another area. Public-private investments in economic development and housing are key to benefit the people in place as well as to bring in new blood, new vitality and to stabilize the public schools."

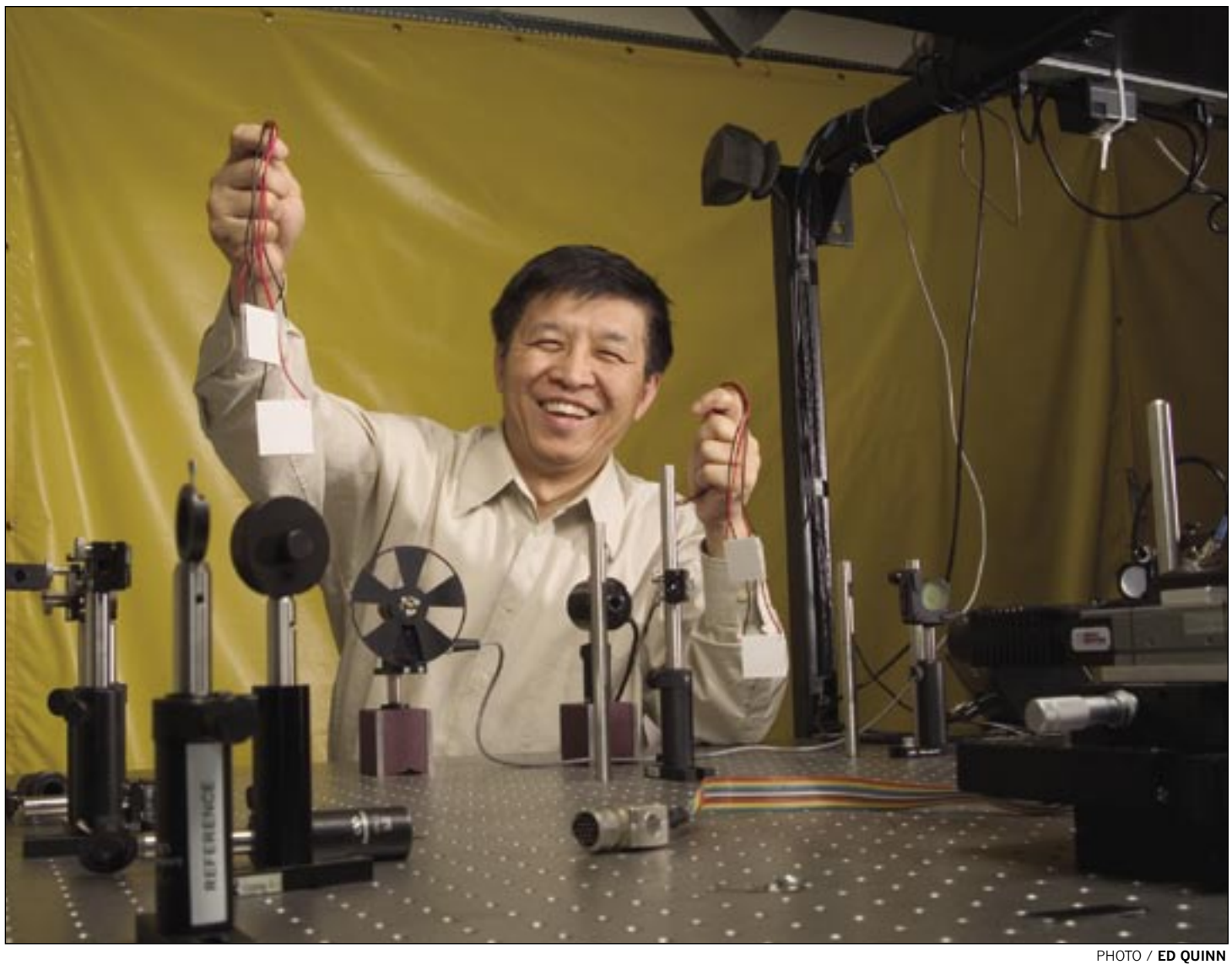


PHOTO / **ED QUINN**

Gang Chen, professor of mechanical engineering, studies how nanotechnology might expand the role thermoelectricity plays in energy efficiency.

Nanotech gives thermoelectricity a new glow

Richard Anthony
MIT Spectrum

Gang Chen's research with nano-scale materials gave him a head start in the field of nanotechnology when it was still brand new. Today, nano-materials, in which dimensions are measured in billionths of a meter, are the foundation for a fast-growing approach to energy saving.

That approach involves thermo-electricity, which is based on a long-ago finding that some metals and, especially, semiconductors (the best known of which is the silicon used in computer chips) can generate a voltage when heated. The system also works in reverse: One common use of thermoelectricity relies on juice from the battery to rapidly cool the seats in some luxury car models.

To those familiar with thermoelectricity in the mid to late '90s, Chen, a professor of mechanical engineering, had an interest that might have seemed odd. The technology was a niche player in the energy arena. But he'd worked in closely related areas: In his Berkeley studies, he notes, "I showed that heat does not travel well in nanostructures." At about the same time, the first intellectual seeds for a vastly expanded role for thermoelectricity were being planted. Some ideas from that era, in fact, have combined with society's energy worries to propel thermoelectricity into the limelight.

How promising is it? Chen says thermo-electricity has "game changing" potential. One likely application: harvesting waste heat in cars, including hybrids, by converting it into electricity. "Cars are about 20 percent efficient," notes Chen, "and turning some of the energy wasted into electricity could increase that figure by as much as one-third."

But that's just for starters. The U.S. government has predicted thermoelectric generators could replace conventional engines in some cars before mid-century. Chen is striving to further such advances.

Mini-power plant

Thermoelectric devices are energy converters. When they're producing electricity, this puts them in the same broad category as power plants and solar-generating systems. When outputting heat or its opposite, meanwhile, they're like heat pumps and air conditioners, respectively.

In design terms, thermoelectric devices have key pluses. For one, they're solid state: no liquid fuels, no moving parts. They're also easily scalable up or down.

This last feature explains many of thermoelectricity's current uses. "If you need a small-scale device," says Chen, "you don't really have any other choices." That's why many deep-space probes use radioactivity-driven thermoelectric generators.

There have been efforts to make the technology more mainstream. "In the '40s

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Daylight device lightens electricity cost

Nancy Stauffer
MIT Energy Initiative

By combining a tilting platform, an acrylic dome and a light source that mimics the sun, MIT researchers are creating a device that will help manufacturers design window systems that bring more daylight into buildings while controlling incoming solar radiation. The result should be significant energy savings and more contented occupants.

More than a third of the energy used in the United States is consumed in buildings, and 25 to 40 percent of that is used to run electric lights. In many cases, daylight could be used instead. "Depending on the building and how it's used, a good daylighting strategy can reduce the need for energy-consuming electric lighting by 20 to 80 percent," said Professor Marilyne Andersen of the Department of Architecture.

The trick is to redirect incoming sunlight so that, for example, it bounces off a bright ceiling, bringing daylight farther into the room. Blocking the infrared component—the heat—or redirecting it to heat-retaining concrete structures in the ceiling can reduce the need for air conditioning and heat, adding to the energy savings.

Companies now make window coatings, solar blinds and other systems that redirect or selectively filter incoming sunlight. "But for such products to be effective, building experts need to know exactly where the light rays go after they've passed through the coated glass or reflected off the blinds," said Andersen. Getting it wrong can lead to glare and overheating. Down comes the shade, cutting out both daylight and the view of the passing day and changing weather—factors believed to improve productivity, well-being and even health.

PHOTO / **DONNA COVENEY**

Marilyne Andersen

Determining how a piece of coated glass affects light seems simple. Just shine a light beam through it and use a light meter to measure intensity at various locations on the other side. But seeing how all the light is dispersed requires measuring at thousands of points—and still there are unmeasured spots in between. Moreover, since the sun moves and the brightness of the sky varies over time and space, the process must be repeated with the light source at different incident angles.

In the MIT HelioDome project, Andersen and her students are developing an innovative system that can measure the

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Energy research

Elizabeth Thomson
News Office

Even as MIT ramps up its commitment to energy research, several projects have already made international headlines over the past year.

They range from genetically modified yeast that could boost the speed and efficiency of ethanol production to a major study touting geothermal energy's potential for supplying a substantial amount of electricity in the United States. Samples of media coverage for these and more follow.

Microengine

Imagine putting a tiny gas-turbine engine inside a silicon chip about the size of a quarter. Then imagine that the resulting device could run 10 times longer than a battery of the same weight, powering laptops, cell phones, radios and other electronic devices. A team led by Professor Alan Epstein of aeronautics and astronautics is working to that end.

According to a September 2006 BBC News story, Epstein, "who has lived and breathed his project for the last 10 years" with a team of some 50 staff and students, expects that the device could be available commercially within three to five years.

"A laptop that will run for three hours on battery charge will run for 15 to 20 hours using the microengine and it should end up costing no more than current batteries," Epstein said.

Another MIT team is developing a half-sized gasoline engine that performs like its full-sized

MITei–E

Energy initiative w

The MIT Energy Initiative (MITEI) today launches a new web site (web.mit.edu/mitei) that will enable users inside and outside the Institute to learn about the full range of MIT's energy research, education and campus activities. Features include a database of energy-related classes that current and prospective students can browse and a comprehensive overview of energy research at MIT and initiatives to be launched by the education and campus energy task forces.

The site includes information on all MIT laboratories, centers, programs and departments with a focus on energy and links to student groups around campus.

To keep things fresh, the MITEI site has frequently changing news articles on its home page. The articles, which spotlight research, students or events, will be available through archives on the site. The site will alert the community to upcoming energy-related events and provide news coverage of those events and links to video coverage.

The site highlights four areas of MITEI research focus: innovations, transformations, global systems and tools. Within these categories are more specific topics such as nuclear energy, wind, carbon manage-

n projects win media notice

sin but offers fuel efficiency approaching of today's hybrid engine system—at a h lower cost. The key? Carefully controlled ction of ethanol, an increasingly common uel, directly into the engine's cylinders n there's a hill to be climbed or a car to be ed.

hese small engines could be on the market in five years, according to Daniel R. Cohn, or research scientist in the Plasma Science Fusion Center (PSFC) and the Laborato- or Energy and the Environment, John B. wood, the Sun Jae Professor of Mechanical ineering and director of the Sloan Automo- Laboratory, and Leslie Bromberg, a princi- researcher at the PSFC.

he work was featured in an April 2007 e of the Boston Globe Sunday Magazine, ng other publications. In the piece, David , chair of the nonprofit Center for Automo- Research, told the Globe: "This has really rmous potential. This is a big deal. It's not re thing; nothing ever is until it's executed. when you've got guys of this capability, different than some guy coming in off the et and saying he had a dream during the t about some new technology."

ineered biofuels

thanol is often touted as a potential solu- to the growing oil-driven energy crisis. there are significant obstacles to produc- ethanol: One is that high ethanol levels are c to the yeast that ferments corn and other t material into ethanol.

o MIT researchers made headlines when engineered a new strain of yeast that can tolerate elevated levels of both ethanol and glucose, while producing ethanol faster than unengineered yeast.

"The fact is that science had run out of methods to increase (the) alcohol tolerance" of yeast, Professor Gregory Stephanopoulos of chemical engineering told New Scientist magazine. His colleagues on the work included MIT professor of biology Gerald Fink of the Whitehead Institute.

Geothermal power

The first study in some 30 years to take a new look at geothermal power, which involves mining the huge amounts of heat inside the Earth's hard rock crust, generated scores of stories in the press.

MIT's Jefferson W. Tester, the H.P. Meissner Professor of Chemical Engineering, who led the study, told the New York Times that "there were many new justifications for aggressively pursuing this kind of energy option.

"Back then, we weren't worried about carbon dioxide and climate, we weren't running short of natural gas, and now energy is a national security issue in the long run. While there's no guarantee it's going to work, this is not an unreasonable investment and it's a good bet on the future."

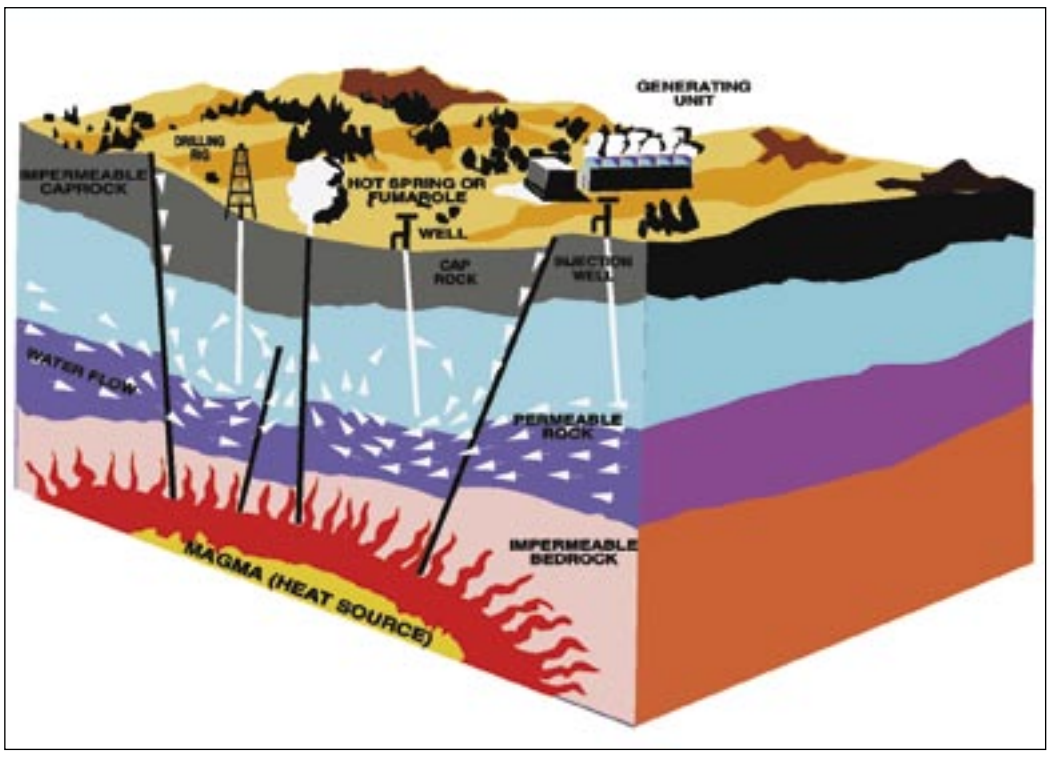
Coal

MIT also released a major report on the future of coal as an energy source. That, too, made news around the world.

Led by co-chairs John Deutch, Institute Professor in the Department of Chemistry, and Ernest J. Moniz, the Cecil and Ida Green Professor of Physics and Engineering Systems, the report states that carbon capture and sequestration is the critical enabling technology to help significantly reduce coal's carbon dioxide emissions while also allowing the fuel to meet the world's pressing energy needs.

"If we don't have carbon capture and sequestration, coal has a very bleak future," Deutch told Reuters news service.

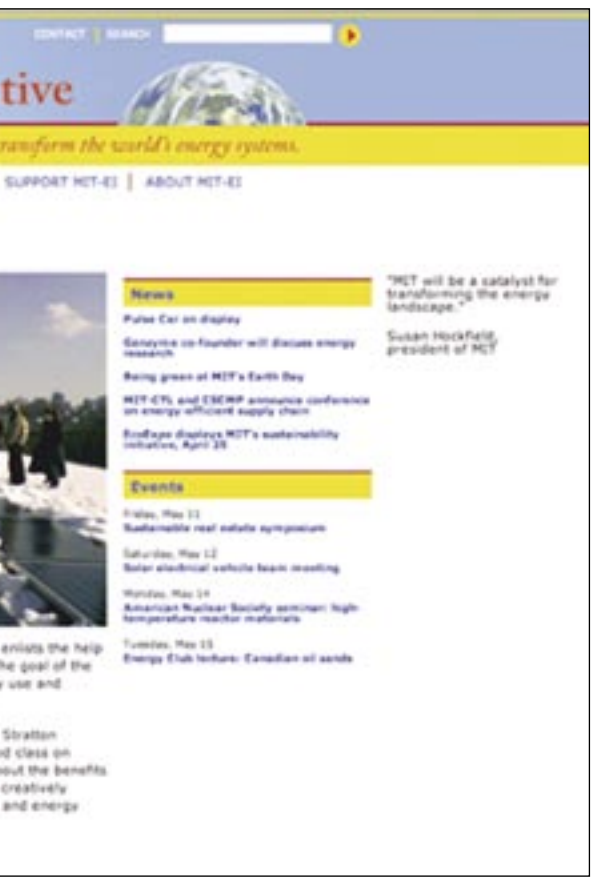
In an interview with the Boston Globe, Moniz said that the report found "a lack of urgency in many directions on U.S. policy related to coal, including implementing a program to capture emissions and store them underground."



GRAPHIC COURTESY / **U.S. DEPARTMENT OF ENERGY**

This illustration shows how geothermal power may be generated by mining the huge amounts of heat inside the Earth's hard rock crust.

Envisioning and engineering our global energy future



Multidisciplinary work engages individuals, industry

From science and technology to systems analysis and economics, management and social science, MIT pursues the energy-environment agenda in more than 40 laboratories, programs, departments and centers.

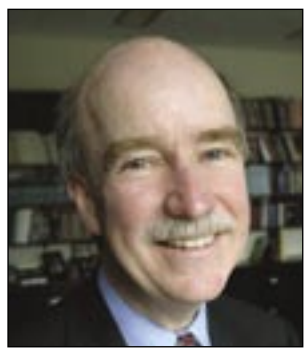
"What the MIT Energy Initiative is really about is multidisciplinary, multifaculty, multiyear sustained research efforts," said Robert Armstrong, deputy director of MITEI.

The initiative creates new opportunities to leverage MIT's multiple strengths in ways that make it value-added to corporations, donors and government sponsors. "If we work broadly enough and well enough, we will have a major impact in the marketplace and in government policy," Armstrong said. "It's important for a place like MIT to develop 'gee whiz' technology, and it's also important to place it in a context so it gets deployed by industry. That's what a lot of companies look to us for."

Armstrong highlighted the initiative's scope, flexibility and range. "We're going to have a mix of technology thrusts, from interesting smaller-scale applications to some at very large scales," he said. "We're also unusual because we can cover the supply side as well as the demand side in a wide range of areas such as efficiency in heat management, buildings and transportation."

A newly identified MITEI research thrust is enabling science or "tools" that, instead of looking at a particular energy system or technology, explore basic science through fields such as catalysts, multielectron-transfer chemistry important for solar and fuel cells, and methane chemistry.

Ernest Moniz



Robert Armstrong

George M. Whitesides of Harvard, speaking at a May 1 MIT energy colloquium, emphasized for the student audience the importance of basic research. A focus on tools and basic energy research could provide the answers for many of today's seemingly intractable problems and could, in the longer term, fundamentally transform how we produce, distribute and consume energy, he said.

Underscoring the global nature of energy, Armstrong, MITEI Director Ernest Moniz and others have been traveling around the world to secure support from sources ranging from industry giants to entrepreneurial startups and individuals who are passionate about solving global energy problems.

Armstrong said he and Moniz have been heartened to find that there is "an extraordinary amount of interest" in what MIT has to offer. Faculty research teams have been involved by presenting overviews of their work to companies and by identifying multidisciplinary research challenges that can have considerable consequence in the supply, delivery and use of energy and in mitigating environmental consequences.

MITEI will have a four-tier system in place for corporate and individual involvement, including sponsored research programs and an Institute-wide research seed fund program for novel approaches to meeting energy needs. Depending on the type of membership, donors can earmark funds for education, undergraduate research opportunities, graduate fellowships in industry, seed funding for alternative energy research and support for various MIT laboratories and centers engaged in energy research.

University-industry consortia and partnerships will be established around flagship projects of mutual interest. "We're engaged with a broad range of energy companies, from oil companies to utility providers to automobile manufacturers. If they work in energy, we've probably been talking to them," Armstrong said.

web site launches

ment, policy, siting and climate change. This section will soon feature the names and web sites of individual MIT researchers working in those fields.

Over the next few months, the site will add features pertaining to energy-related UROPs and efforts to improve campus energy use.

Student proposals sought

A new initiative provides mini-grant funding for student energy and environment projects. The Campus Energy Task Force of the MIT Energy Initiative is calling for proposal submissions from students working on projects related to MIT's campus energy and environmental footprint. This call is for activities for summer and fall 2007. For more information, see sustainability.mit.edu/CampusEnergyTaskForceRFP.

Former secretary of state is external advisory chair

MIT and the MIT Energy Initiative (MITEI) have geared up for the next phase of the initiative. George P. Schultz, MIT alumnus and former faculty member, secretary of state in the Reagan administration and now professor emeritus at Stanford's Graduate School of Business, has agreed to serve as chair of MITEI's External Advisory Board. The high-level board, now being formed, will consist of as many as 25 people; it will provide high-level strategic direction for the initiative and review MIT's progress in energy fields.

Melanie Kenderdine joined MITEI in March 2007 as associate director for strategic planning. Previously a vice president at the Gas Technology Institute, she was involved in initiatives to increase natural gas supply and to enhance energy efficiency and security. Earlier, she was a senior U.S. Department of Energy official, serving as director of the Office of Policy and as senior policy advisor to the secretary of energy on oil, gas, coal and nuclear issues. She is a frequent speaker at international energy conferences, including the World Petroleum Congress and the International Energy Administration's International Energy Experts Conference.

Robin Elices, director of the Administrative Services Organization for the Departments of Chemical Engineering and Materials Science and Engineering and the Center for Biomedical Engineering, will join MITEI later this month as executive director. Elices will work with the director, deputy director and associate director in managing and coordinating MITEI activities. "I'm looking forward to working with this broad-based initiative, which encompasses important interdisciplinary research and educational programs involving all five schools, and improved campus energy management," said Elices, who has 28 years of management experience in higher education, 19 of those at MIT.

Institute serves as honest broker of energy reports

Deborah Halber
News Office Correspondent

MIT energy reports are making a difference in policy debates.

In January, an 18-member panel led by MIT Professor Jefferson W. Tester released an in-depth study titled, "The Future of Geothermal Energy." Sponsored by the U.S. Department of Energy, it was the first study in some 30 years to take a new look at geothermal resources. The technology roadmap in the report, however, goes beyond "your mother's geothermal," that is, the mature and limited energy resource that relies on very shallow, active geothermal resources. Instead, the report focuses on developing very significant renewable energy supplies from novel "geothermal energy systems" that, by taking advantage of new drilling technologies, enable the circulation of water through hot rock very deep underground.

In March, an interdisciplinary MIT panel issued a report examining how the world can continue to use coal—an abundant, inexpensive, environmentally challenged fuel—in ways that mitigate instead of contribute to climate change. The study, "The Future of Coal—Options for a Carbon-Constrained World," advocates a global leadership role for the United States, endorsing a program that, through the adoption of significant funding and policy actions focused on the design and implementation of large-scale, long-term carbon dioxide geological sequestration, enhances energy supplies, reduces global warming and increases energy security. A 2003 MIT interdisciplinary study took a similar look at nuclear power.

These MIT energy reports are already making a difference, providing Congress and the executive branch with detailed recommendations to shape and influence the policy debate and responses. Tester, the H.P. Meissner Professor of Chemical Engineering; Ernest J. Moniz, director of the MIT Energy Initiative (MITEI); Institute Professor and MITEI council member John Deutch; MIT Washington, D.C., Office Director William B. Bonvillian; and several other faculty have testified before Congress numerous times over the past few months on topics ranging from coal use and carbon sequestration to geothermal energy and energy technology innovation policy.

In producing such reports, MIT plays a key role as an "honest broker," providing neutral ground to explore socially, technologically and politically weighted issues, said Robert C. Armstrong, deputy director of MITEI. Funded by entities without a political ax to grind or business to promote, these studies "allow us to make objective statements about what should be the priorities," he said.

Also in January, MIT organized an energy session at the World Economic Forum Annual Meeting 2007 in Davos, Switzerland. In addition to Hockfield, several MIT faculty were in attendance, including Angela Belcher, the Germeshausen Professor of Materials Science and Engineering and Biological Engineering and co-head of the MITEI Energy Education Task Force. Belcher spoke at the forum on how improvements in efficient use, materials and processes are key for the scalability of alternative energy technologies.

In February, Cambridge Energy Research Associates (CERA), a leading advisor to international energy companies, governments, financial institutions and technology providers, cosponsored with MITEI a daylong event on technological innovation and energy at CERA's annual conference in Houston. A number of MIT contributors participated.

MIT faculty members are collaborating with governments and organizations in Cyprus and Portugal on broad energy initiatives. President Olafur Ragnar Grimsson of Iceland visited MIT April 4 to discuss geothermal energy, climate change and other energy topics.

Closer to home, MIT has joined the Cambridge Energy Alliance, a nonprofit organization that aims to reduce significantly energy use in Cambridge. MIT administrators are serving on the group's organizing committee.

ENERGY

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pus energy projects, sponsored colloquia and launched a new web site to spotlight MIT energy activities.

Moniz expressed excitement about the initiative and the growing interest in energy at MIT. "These activities complement many others taking root across the campus. We are deeply engaged in discussions with a range of energy companies—developing research collaborations that will meet both the strategic needs of industry and the educational and research needs of the Institute," he said.

Moniz acknowledged that a lot of work remains. "We are in the building stage, but six months after its launch, the initiative's building blocks are in place and we're getting traction. These early successes point to a robust, well-rounded program by the fall," he said.

New MITEI research seed programs involve novel approaches, such as self-assembling materials for solar conversion, as well as understanding the role of the automobile in global systems and exploring the wide-ranging economic impacts of climate change. "These seed fund programs demonstrate the art of the possible for the initiative by providing the faculty with resources they need to launch exciting research based on new ideas and new capabilities," Moniz said.

The excitement on campus is catching. This year, MIT student energy groups and activities went into overdrive. Students hosted conferences headlined by big names on the local and national energy scenes. They spearheaded efforts to make the MIT campus more sustainable-energy-friendly, winning a national competition to help fund a biodiesel station on campus. MIT students also went global, leading an international consortium on sustainable transportation technologies.

In March, the student-organized 2007 MIT Energy Conference, "Energy 2.0: Solving Tomorrow's Energy Challenges Through Entrepreneurship, Technology & Policy," attracted 550 energy professionals, investors, entrepreneurs, policy-makers, academics and graduate students.

In the past two years, student groups have coordinated events to boost recycling, create a car capable of traveling 200 miles on a single gallon of fuel or build a house powered entirely by the sun.

The members of the Energy Council are: Angela M. Belcher, Germeshausen Professor of Materials Science and Engineering and Biological Engineering; John M. Deutch, Institute Professor (chemistry); Leon R. Glicksman, George Macomber Professor of Construction Management Professor of Building Technology and Mechanical Engineering; Rebecca H. Henderson, George Eastman Kodak LFM Professor of Management; Paul L. Joskow, Elizabeth and James Killian Professor of Economics and Management; Emanuel M. Sachs, Fred Fort Flowers '41 and Daniel Fort Flowers '41 Professor of Mechanical Engineering.

TASK FORCE

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offices," said Steven M. Lanou, a deputy director in the Environmental Programs Office and a task force member.

The task force includes faculty from all five of MIT's schools; representatives of MIT's administrative staff; undergraduate and graduate students; and administrators responsible for essentially all of MIT's major energy-producing and energy-consuming units, from the cogeneration plant and other central facilities to the dorms, the athletic center, teaching labs and computing equipment.

Theresa M. Stone, MIT's executive vice president and treasurer, serves as task force co-chair. "I'm a member in part because I manage all of MIT's new building projects and the maintenance and operations of all of our campus," she said. "I hope my presence demonstrates MIT's strong institutional commitment to energy initiatives here on campus."

That commitment includes opening the campus as a learning laboratory, permitting students, faculty and staff to use it as a tool for teaching and research. MIT's cogeneration plant has already been the subject of class study, and a detailed picture of MIT's energy situation is being developed so that research teams can test the impacts of promising energy-saving measures.

Task force member Ariel M. Esposito, a sophomore in civil and environmental engineering, noted the importance of such incentives. "Students are sensitive to energy issues, but it takes encouragement for them to take time out of their busy lives to make a difference in campus energy use," she said.

Students are already enthusiastic and creative contributors to the effort. A gathering called the Generator spawned about a dozen undergraduate and graduate student projects aimed at reducing the Institute's environmental footprint. Esposito herself helped organize an electricity-reduction competition among MIT dorms, and a student team developed a prize-winning business plan for turning MIT's used cooking oil into biodiesel fuel for campus vehicles.

Near-term measures: This group will identify and promote measures that can be taken in the next few years. Possibilities include installing occupancy sensors and compact fluorescent light bulbs, maintaining and upgrading heating and air conditioning systems and increasing cogeneration capacity.

New construction: During the coming decade, MIT will be spending three-quarters of a billion dollars on new construction. This group aims to ensure that best practices are incorporated. Among the plans: gathering detailed data on the best buildings on and off campus and establishing new metrics and standards to be met.

Long-range campus-wide plan: A major multidisciplinary study of campus energy production and use will examine not just technology options but also economic, institutional and motivational issues. Engineers, architects, economists and urban studies experts will together produce an MIT energy roadmap for the next 20 years, as well as guidelines for other institutions to use.

Next-generation research: Major integrated research projects will focus on components and designs for next-generation buildings and energy systems. A new, flexible research building will be specially designed to permit testing of advanced window systems, new control systems, alternative office designs and other approaches.

Education: This team is working to excite and engage students by increasing the number of energy-related Undergraduate Research Opportunities, encouraging energy-related class projects and assisting with student-led energy groups and activities. The team will collaborate with the MITEI Energy Education Task Force.

Outreach: Plans include launching a web site that will present guidelines and best practices resulting from task force activities—much as MIT's OpenCourseWare makes classes available to the public.

In addition to Glicksman and Stone, other members of the Campus Energy Task Force are:

Vladimir Bulovic, associate professor of electrical engineering and computer science

Robert L. Jaffe, professor of physics

Leslie K. Norford, professor of architecture

John Sterman, Jay Forrester Professor of Management

Christopher P. Zegras, assistant professor of urban studies and planning

Larry G. Benedict, dean for student life

Peter L. Cooper, manager of sustainability engineering and utility planning, Department of Facilities

Diana J. Daigle, public service support associate, MIT Libraries

Richard R. Fenner, director of undergraduate teaching labs, Department of Mechanical Engineering

Lorna Gibson, associate provost

Sherwin Greenblatt, director, venture mentoring services, Office of the Provost

Walter E. Henry, director, systems engineering group, Department of Facilities

Steven M. Lanou, deputy director for environmental sustainability, Environmental Programs Office

Laxmi J. Rao, IT energy coordinator, Information Services & Technology

William C. Van Schalkwyk, managing director of environmental health and safety programs

Jason J. Jay, student, Sloan School of Management

Ariel M. Esposito, student, civil and environmental engineering

NANOTECH

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and '50s," says Chen, "there was a lot of interest in solid-state refrigeration. The goal was to create full-sized thermoelectric refrigerators." But while thermoelectric mini-fridges are increasingly common, the dreams of those early enthusiasts came to naught.

Why? It was mainly an efficiency issue. A key reason this dam began to give way in the early '90s is that MIT physicist Mildred Dresselhaus and a colleague had an idea: Instead of simply testing a long list of different materials, why not change the materials themselves by structuring them internally such that performance improves?

The pair specifically proposed creating nanoscale substructures in the materials. What made the concept intriguing is that the ideal thermoelectric device is one that is great at conducting current and an abject failure at conducting heat.

That's a rare combination. "Nature," says Chen, "doesn't provide many examples of materials that are great electrical conductors and also good thermal insulators." But technical staff member Ted Harman at MIT's Lincoln Laboratory—building in part on Chen's earlier, unrelated work—showed that by using nanostructures, you can create materials that outdo nature: Some of Harman's materials, thanks to their unique heat-impeding qualities, are twice as efficient as their conventional cousins.

It's an astonishing advance—roughly equivalent, if on a drastically smaller scale, of turning a one-megawatt power plant into a two-megawatt one.

Of course, it's tough to turn advances in tiny experimental devices into commercial winners: Don't expect whole-house thermoelectric air-conditioning systems to start turning up at your local HVAC dealers anytime soon.

On the other hand, Chen says innovations like an exhaust-mounted energy-mining device for vehicles needn't wait until you hit Lincoln Lab realms of efficiency. "If you can reach a 10-to-15 percent conversion efficiency," he says, "that would be attractive for many applications." In fact, results he's had at that level are already drawing interest from companies.

This not only gives Chen hope that thermoelectricity's time may have truly come, it also resonates with the goals he's set for himself as a researcher. "I like to explore things that are fundamentally new and different," he says, "and then see how I can use those findings to make an impact on the real world."

This article is reprinted, with slight changes, from the January 2007 issue of MIT Spectrum.

DAYLIGHT

Continued from Page 4

emerging light at every point, all at the same time—and then easily change the incident angle and repeat the process.

Key to their system is an ellipsoidal acrylic dome coated with a mirror on the inside. Placed on a flat surface, the dome (like all ellipses) has two focal points. A light ray shining upward from one focal point will bounce off the mirrored inside of the dome and return to the other focal point, regardless of the angle at which the ray leaves the first focal point.

To test a sample of, say, coated glass, they place it at one of the focal points. At the other focal point, a fish-eye lens protrudes from the flat surface. A beam of light (including the full solar spectrum) shines through the piece of coated glass from below, and rays emerge at various angles. They hit the mirrored dome at different locations and then all bounce back to the fish-eye lens. With a sample that reflects, the light beam enters through the top of the dome onto the sample, and the reflecting rays bounce off the mirror to the lens.

Because the lens "sees" light coming in at all angles, the camera can take a digital photo of light reflected by the entire dome. Each pixel in the digital image corresponds to a single point on the dome, therefore to light leaving the sample at a single angle, and its intensity indicates how much light came via that pathway.

"So we get complete information in one image instead of making thousands of point measurements," said Andersen. "It's continuous information, and it's obviously much more time-efficient."

Changing the incident angle of the light is also easy. The dome rests on a specially designed computer-controlled 5-foot-diameter platform that can tilt at various angles to the light source. (The platform is also proving ideal for seeing—for a given latitude and season—how sunlight illuminates and penetrates a scale model placed at its center.)

The researchers' next task is to calibrate the system. They need to establish the relationship between pixel location and light angle and between intensity and light quantity. They are also developing analytical methods to determine the pathways taken by light of specific wavelengths—a prerequisite to controlling the heat component.

"Calibrating the device is very complicated, but we only have to do it once," Andersen said. "After that, using the device to test samples will be very fast." The data generated will help manufacturers improve their products and will enable Andersen and others to incorporate state-of-the-art window systems into building-simulation tools used by architects. The result will be better products used to their best effect.

This research was supported by the National Science Foundation.

PHOTO / **MATTHEW KARAS**

Moving day

Dancer Jillian St. Germain demonstrates the expansiveness and precision of works by Rebecca Rice, dancer, choreographer and director of Rebecca Rice Dance in Boston. The company will perform at MIT in a lecture/demonstration recital of dances to music by MIT composers John Harbison, Institute Professor, and Elena Ruehr, lecturer in music. Works by Rice will include 'Echoes' (2004), 'Stratas' (2004) and the Boston premiere of 'Busy Blues' (2007).

The Rebecca Rice event will be held on Saturday, May 12, in Killian Hall at 7 p.m. The event is free to the MIT community, with a suggested donation of $10. A reception will follow.

FELLOWSHIP

Continued from Page 1

students with an American perspective on issues of politics, race and class. Also, "it will serve as an excellent opportunity to learn about their history—the way they perceive the United States," he said.

Eton, situated across the Thames River from Windsor Castle, was established in 1440 by King Henry VI; its graduates have included royalty and prominent leaders in politics, medicine and law. Prince William, the son of Prince Charles and Princess Diana, attended Eton.

Butler, an African-American who comes from the small town of Pritchard, Ala., is the first person in his immediate family to attend college. He believes his unique cultural background will help him be an effective "ambassador" of both the United States and MIT.

"I plan on devoting a good deal of time to discussing issues of race and class—these are very important things, which affect everyone's circumstances," he said. "It's colored my experience throughout my life."

Also, Butler said, the college's science department was eager to work with him as a science teacher. Butler worked in the MIT Space Systems Laboratory from April 2004 to May 2005 as a researcher on the MIT LunarDREEM Project. He also won first place in a NASA in-situ resource utilization competition. Currently, he has been working as an archivist in the Industrial Liaison Program in the MIT Office of Corporate Relations.

As an Annenberg fellow, Butler will also be required to coach one or more sports. Butler, who has a second-degree black belt in tae kwon do, said he would either coach a martial arts class or saber fencing.

By turns soft-spoken and passionate, Butler thinks his keen interest in world events helped win him the fellowship. In his interview with an Eton official, "we spent quite a bit of time talking about politics. Specifically he mentioned how a number of graduates from Eton planned to take up some role in the British military as officers. Something that was at the forefront of the mind of many students was the Iraq war. I'm very much against the war; we talked about where the students stand and the British government's role."

Marsha Orent, project administrator in the MIT Office of the Provost, said that Butler's selection represents the first association between MIT and Eton.

"It is a great honor," Orent said. "We're hoping it is the beginning of a longer relationship."

AAAS

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in October at its Cambridge, Mass., headquarters.

New members of the American Academy of Arts and Sciences from MIT are:

Stephen D. Ansolabehere, Elting R. Morison Professor of Political Science; Rodney Brooks, Panasonic Professor of Robotics and director of the Computer Science and Artificial Intelligence Laboratory; Arup K. Chakraborty, Robert T. Haslam Professor of Chemical Engineering, professor of chemistry and professor of biological engineering; Glenn Ellison, professor of economics; Gregory Chung-Wei Fu, professor of chemistry; Victor Kac, professor of mathematics; Evelyn Fox Keller, professor of the history and philosophy of science; Tomasz Mrowka, professor of mathematics; Whitney K. Newey, professor of economics; Peter C. Perdue, T.T. and Wei Fong Chao Professor of Asian Civilizations and professor of history; Peter H. Schiller, Dorothy W. Poitras Professor in Medical Engineering and Medical Physics, Department of Brain and Cognitive Sciences; James M. Snyder Jr., Arthur and Ruth Sloan Professor of Political Science and professor of economics.

THEATER

Continued from Page 2

for the buildings' recovery and reuse. It was then that the two theater companies approached the Institute about the possibility of locating a new black box theater on the site.

Working closely with the Cambridge Historical Commission and its executive director, Charles Sullivan, MIT set out to restore and rehabilitate historically significant aspects of the buildings in its effort to design the new theater. Unfortunately, the delicate condition of the structure combined with the contaminated state of the urban soil could not allow for the restoration of the buildings. Instead, MIT is developing a replica of the original building as part of a larger development that will include the theater and retail and office space. The designer of the project is Pfeufer/Richardson Architects PC.

At the groundbreaking ceremony, Steve Marsh, managing director for real estate in the MIT Investment Management Company, observed that the development "will be a vibrant tribute to former historic structures" and thanked staff member Michael Owu for his dedicated work in bringing the project to fruition.

Marsh was joined in the program by Cambridge Mayor Ken Reeves, state Sen. Jarrett Barrios, state Rep. Marty Walz, Central Square Business Association President Carl Barron and the Central Square Theater's Steering Committee chair, Marty Blatt. Reeves acknowledged MIT's role in the project as critical and thanked the Institute for its support of the community.

After the speaking program, attendees joined in a parade with puppets, streamers and costume-clad revelers, led by the Second Line Social Aid and Pleasure Society Brass Band, to a community reception including theatrical performances at the Cambridge YMCA.

Construction of the Central Square Theater is now under way, with the first production planned for winter 2008.

PHOTO COURTESY / **FIRST-STEP CORAL PROJECT**

Grad student Gerardo Jose la O' (center) is flanked by members of his team: (left to right) Emzo de los Santos '09, Martin Lorilla '09 and Illac Diaz (MIT SPURS Fellow).

Wind, sun and tides power Biorock, MIT rehab for recovering coral reefs

Deborah Halber
News Office Correspondent

Gerardo Jose la O' left his hometown of Bacolod City in the Philippines almost 10 years ago to attend Berkeley and then graduate school at MIT. Visits home consisted of eating fresh seafood and sweet pastries called boat tarts and lounging on the white sand beaches where he swam, snorkeled and scuba dived as a youth.

Even before he left for college, la O' (known as G.J. to his friends) noticed something about the coral reefs that were as familiar to him as his own room: They were getting harder to find. You had to swim farther out, braving strong currents, to find the reefs and their 1,000-plus species of spectacularly colored fish.

La O' wasn't the only one who had noticed a change. In Sagay City, a major fishing area bounded by the Visayan Sea, three decades of dynamite fishing had decimated coral formations. The habitat for one of the highest concentrations of biodiversity in the world was being destroyed. Fish were becoming scarce.

When la O' steps off a plane in Manila these days, it's not just an escape from New England weather. He's on a mission to save the coral.

With fellowships from MIT's Graduate Student Council and the MIT Public Service Center, la O' and MIT students Emzo de los Santos, a sophomore studying biological engineering, Martin M. Lorilla, a Sloan management student, and former MIT Department of Urban Studies and Planning Fellow Illac Diaz launched First-Step Coral. The students coupled their science and engineering skills with a new technology to promote a low-cost, environmentally friendly way to regrow the Philippine coral reefs.

First-Step Coral recently won a $7,500 award in the MIT IDEAS competition and is one of eight semifinalists in the 2007 MIT $100K Entrepreneurship Competition "development track" for advancing low-income communities in developing countries. Winners will be announced May 16 at an awards ceremony at 7 p.m. in Kresge Auditorium.

"I've seen the natural ecosystem get worse and worse. It's overused, overexploited," la O' said. "The fishermen throw sticks of dynamite into the water and the sonic waves cause the fish to die and make them easier to catch. It also shatters the coral and causes it to slowly die off. It's akin to carving a hole in the center of the Amazon and denuding it, but the coral reefs are less visible because they're underwater."

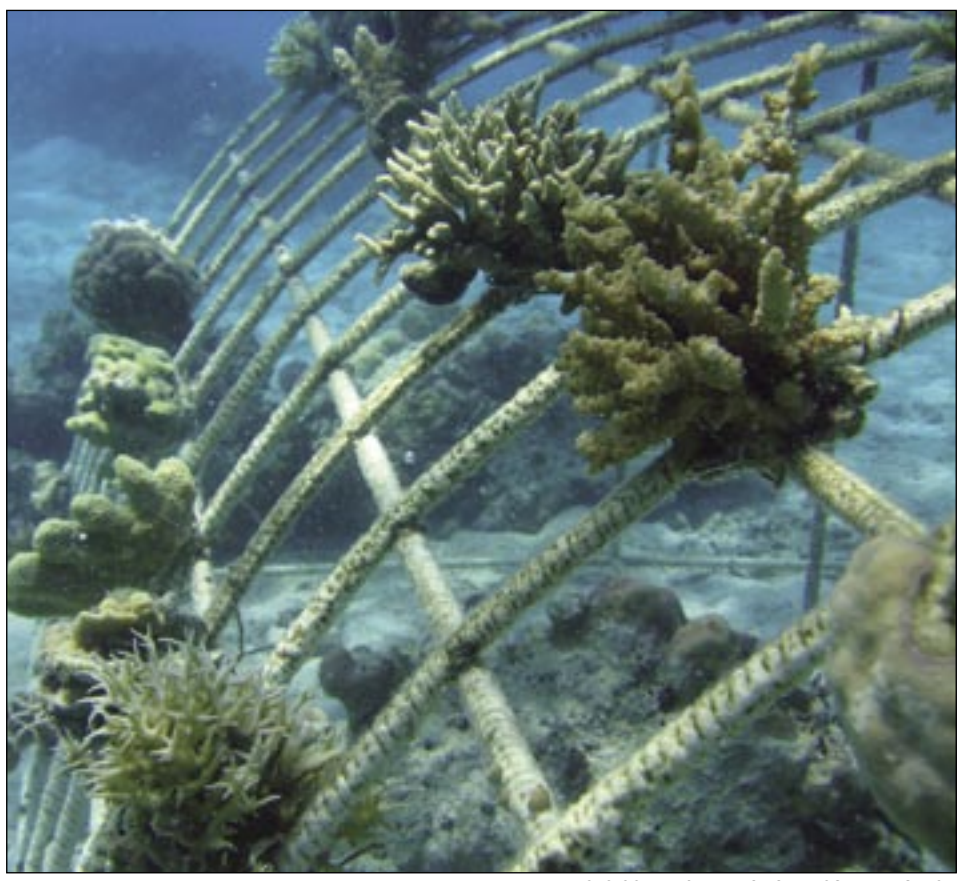

PHOTO COURTESY / **FIRST-STEP CORAL PROJECT**

The MIT team grafts corals onto Biorock in the Visayan Sea.

The coral reefs help provide more than 60 percent of the animal protein consumed by the Philippines' population of 80 million. The declining fishing industry then puts more pressures on the land, which must support more agriculture as people move inland in search of a new food supply.

While at MIT, la O' heard about an MIT alumnus, Thomas J. Goreau, who had invented a way to help renew coral reefs. La O's immediate reaction was, "I know of a place in the Philippines that could really benefit from this technology."

Goreau had started the Cambridge, Mass.-based Global Coral Reef Alliance (GCRA), a small nonprofit dedicated to growing, protecting and managing coral reefs. La O' and others joined GCRA's volunteer scientists, divers and environmentalists committed to coral reef preservation worldwide to find a way to help the Philippines, ranked one of the worst coral "hot spots" in the world by Science magazine.

Goreau's invention, called Biorock, uses an electrochemical process to deposit calcium carbonate, also known as white limestone, onto a common iron building material called rebar. Rebars are used for construction supports and can be fashioned into any shape. The students make it into curved structures that resemble small Quonset huts. After the calcium is deposited on the black metal, it turns white, and clumps of living coral that the volunteers tie to the metal begin to grow and attach themselves to the framework. In trials in the Pacific islands, the Indian Ocean and the Caribbean, corals attached to Biorock grow three to five times faster than native coral and have an increased survival rate.

The MIT students' innovation is to power the electrochemical process with wind turbines, tidal power and solar panels. During a trip to the Philippines in January, the First-Step Coral team installed 500-watt solar panels donated by Shell and Sunpower to power Biorock in the Carbin and Molocaboc Islands in the Sagay Marine Reserve. The team plans to study the effect of the cyclical nature of the renewable sources on the growth and development of the coral.

In addition, the students presented information on the project to local schools and centers—reaching more than 500 schoolchildren and community leaders—and created a partnership with a new marine museum to get schools involved in monitoring the progress of the reefs. They also hope to stop children from breaking off bits of living coral to sell to tourists. "You really need a strong community partner for the long-term success of a project like this," la O' said.

La O's two-week stints at home are much busier these days. "I used to go home almost as a tourist. This time, I'm much more fulfilled, more in touch with the community. Every time I go home now, I have something to check into," he said. He hopes that the reef will make such a dramatic turnaround that it will become a destination for divers and snorkelers, and out-of-work fishermen can drive water taxis to bring eco-tourists to the best sites.

La O', who is studying materials science, plans to pursue a career in high-temperature fuel cells and electrochemical energy systems that could one day be used in cars and stationary power systems, but "that's in the future. Now we've got a more pressing need—the marine ecosystem. It's great to apply my knowledge to something with a positive impact. And who else gets to do a project where you must spend time on beaches in nice coral reef areas?"