

## **Laboratory for Energy and the Environment**

The Laboratory for Energy and the Environment (LFEE) supports, coordinates, and conducts research and education on sustainability issues that influence development and welfare worldwide. The LFEE brings together collaborating faculty and staff from 14 departments to address the complex, long-term, multifaceted problems of sustainable development. LFEE multidisciplinary teams work not only on technological solutions but also on the economic, political, and social aspects associated with their realization. As a neutral broker, LFEE aims to foster constructive relationships between industry, governments, academia, and the public to seek solutions to long-range environment and energy issues. LFEE works to build better understanding of the many issues between and among developed and developing nations that arise in the context of meeting global environmental challenges.

A central theme running through all of LFEE's initiatives is the role of science and technology in shaping better environmental policy at all levels in both the public and private sectors. The education program of LFEE is committed to educating the next generation of environmental and sustainability leaders worldwide through joint projects locally and nationally and through participation in international education programs with our partners around the world.

Professor David H. Marks of the Engineering Systems Division and the Department of Civil and Environmental Engineering is director of LFEE. He is supported by Professor Jeffrey Steinfeld (Chemistry), director of the LFEE Education Program; Stephen Connors, coordinator of multidisciplinary research; Dr. Teresa Hill, deputy director for communications and programs; and administrative officer John O'Brien. Professors Marks and Steinfeld help coordinate the research activities at MIT affiliated with the Alliance for Global Sustainability (MIT/AGS). Professor Ernest J. Moniz is director of MIT Energy Studies. The executive committee of the MIT Council on the Environment serves as the steering committee for LFEE.

### **Highlights**

The 2001 founding of LFEE culminated MIT's 10-year effort to bring together researchers from all corners of the Institute to collaborate on problem solving and innovative management in support of a sustainable future. LFEE includes experts in a variety of disciplines studying the complex interrelationships between energy and the environment as well as other global environmental challenges to sustainable development. LFEE scholars look at single technologies in depth and also across technologies to see how their use and improvement might lead to better management and policy formation. Highlights from AY2004 reflect this perspective.

LFEE occupies the fourth floor of Building E40, along with the Center for Energy and Environmental Policy Research (CEEPR), the Joint Program on the Science and Policy of Global Change (Joint Program), and work space for 57 graduate students. In AY2004, LFEE attracted new faculty and additional resources to support multidisciplinary

research programs, expanded its educational initiatives both locally and internationally, identified major challenges in meeting growing global transportation demands, significantly advanced ongoing work on carbon sequestration, and built a consortium of sponsors to support this effort.

LFEE's research volume for FY2003 was over \$6 million, including sponsored research and fund accounts. LFEE research programs engage over 50 MIT faculty members and over 100 students annually.

To build synergy across the Institute, LFEE director Professor Marks cochairs the MIT Council on the Environment with MIT chancellor Professor Phillip L. Clay. In addition, the lab's weekly seminar series on global environment and sustainability issues draws participants from many research groups. The seminar series includes presentations of work in progress on environmental challenges and technology options as well as discussions of timely issues by invited guests.

Internationally, LFEE continues to oversee MIT's participation in the Alliance for Global Sustainability (AGS). This year's annual meeting, held in Goteborg, Sweden, attracted scholars and stakeholders from industry, government, and NGOs around the world. At this meeting, the presidents of the four participating universities agreed on a new research thrust for the AGS in which all campuses and their regional partners will collaborate on a single global-scale issue in sustainability. The 2005 annual meeting will be held at MIT.

The graduate elective on sustainable energy (1.818J, 2.65J, 3.564J, 10.391J, 11.371J, 22.811J, ESD166J) was offered for the seventh time in the spring term of 2004. The course was taught collaboratively by faculty members affiliated with LFEE and the Nuclear Engineering and Chemical Engineering departments. Sustainable energy lectures were broadcast to Cambridge University in support of the Cambridge-MIT Institute's MPhil degrees in engineering for sustainable development and technology policy.

Other highlights of AY2004 included the development of a proposal for the investigation of robust, near-term energy alternatives; development of the Smart Fields collaboration with Shell; the December 2003 ILP symposium on energy; the wind-power initiative; and the activities of the Energy Studies Group, led by Professor Moniz.

LFEE leaders have been working for several months on the development of a proposal for the Alliance for Global Sustainability that would address the potential for developing *robust near- and mid-term energy alternatives*. All campuses affiliated with the AGS would participate, focusing on issues appropriate to their expertise. MIT would focus on sustainable transportation and logistics for people and freight, since transport is an area in which MIT has traditionally been very strong. As the MIT headquarters of AGS, LFEE would coordinate activities relevant to the proposal, including research, educational, and outreach opportunities through AGS and the MIT Industrial Liaison Program (ILP). The near-term energy alternatives proposal is gathering steam at the AGS level and has been received enthusiastically by many prospective participants at MIT.

In October 2003, leading researchers from MIT and Shell met as part of the new *Smart Fields collaboration*. Shell updated the MIT participants on the current state of the art in oil and gas explorations, drilling technology, sensing, and enhanced recovery. MIT investigators presented descriptions of research with potential to further these and other initiatives.

In December 2003, Professor Marks chaired a two-day ILP symposium on *Meeting Future Energy Challenges*, which drew 150 participants. Dr. A. Denny Ellerman, executive director of CEEPR, gave the keynote address. He offered an overview of how US energy policy has evolved over the past 40 years. The symposium showcased MIT research in disciplines relevant to energy sources, uses, and impacts. The broad areas of discussion were mobility and transportation technologies, fuels and knowledge management, and electric power systems and technologies, including efficient utilization.

LFEE is also supporting a wind power initiative, spearheaded by Dr. Edward C. Kern. The *Offshore Wind Energy Collaborative* is designed as an opportunity for Institute-wide participation in renewable energy development. In June 2004, LFEE submitted final proposals to the Massachusetts Renewable Energy Trust (MRET) for two 15-month pilot projects that will incorporate the work of faculty from several departments in the School of Engineering, the Engineering Systems Division, and other labs and centers. The work will incorporate ongoing efforts and spawn new ones. Dr. Kern and Stephen Connors of LFEE will be deeply involved in organizing the collaborative. Dr. Kern, together with the MIT Department of Facilities, received MRET funding for the MIT Solar Power Initiative, a community service project guided by LFEE. Like the solar initiative, the offshore wind collaborative will involve industrial and governmental partners.

Professor Moniz (Physics) served as cochair (with Professor John Deutch) of a pan-MIT study group that published "The Future of Nuclear Power" (2003), an interdisciplinary analysis of the issues facing this potential source of nonpolluting energy. The study concluded that the nuclear option faces significant challenges, including better economics, improved safety, more effective waste management, and reduced risk of producing materials useable for nuclear weapons. Stimuli to develop these technologies depend on how much public policy makers value electricity production that does not emit CO<sub>2</sub>. Copies of the entire report and a 16-page summary report are available from Karen Gibson at LFEE.

In addition, Professors Moniz and Deutch, with colleagues from the Scowcroft Group, have carried out work on how the nuclear fuel cycle should develop globally while addressing nuclear weapons proliferation concerns within the Nonproliferation Treaty framework. The key nuclear fuel services approach was presented in "The Future of Nuclear Power" report, while the new work explores practical implementation.

At present, Professor Moniz is cochairing with Professor Deutch a new study group addressing the future of coal in a greenhouse-gas-constrained world. Their report is anticipated at the end of 2005. Professor Moniz is also directing an Institute-wide survey of energy research at MIT. The objective is to identify areas in which MIT is strong and to provide direction for a concerted interdisciplinary effort.

Professor Moniz is also working with Professor Marks to advance a partnership between LFEE and a developing research center on energy, water, and environment in Cyprus. The center is intended to be part of a larger research and educational institution that will serve as a bridge between the EU and the eastern Mediterranean/Middle East region.

Achievements of the LFEE Education Program are outlined below. Among the notable education-related events at LFEE were the completion of a master's thesis, "A Methodology for Assessing MIT's Energy Use and Greenhouse Gas Emissions," by Tiffany Groode (Mechanical Engineering), directed by Professor John Heywood. The thesis identifies areas with the greatest potential for reducing utility-related emissions at the Institute. In June, EECS graduates Charlene '79 and Dirk Kabcenell '75 funded a new LFEE Future Energy Fellowship. It will provide annual support for two graduate students in alternative energy technologies, an area of interest for many master's and doctoral candidates associated with the lab.

LFEE includes both core component and affiliated programs. The component programs in LFEE for 2004 were the Alliance for Global Sustainability, the MIT/AGS Consortium on Environmental Challenges, the Carbon Capture and Sequestration Technologies Program, the Analysis Group for Regional Electricity Alternatives, and the Political Economy and Technology Policy Group. Affiliated research programs are also supported in the Center for Advanced Nuclear Energy System, the Building Technology Program, the Sloan Automotive Laboratory, the Center for Energy and Environmental Policy Research, and the Joint Program for the Science and Policy of Global Change. The LFEE Education Program develops sustainability curricula and programs at the Institute, local, national, and international levels.

## **Component Programs**

### **Alliance for Global Sustainability**

Research supported by the Alliance for Global Sustainability brings together scholars from the four partner universities (MIT, the Swiss Federal Institute of Technology-Zurich, the University of Tokyo, and Chalmers University of Technology, Sweden) and stakeholders from industry, NGOs, government, and other leading academic institutions to address complex environmental problems that transcend geographical and disciplinary boundaries. In AY2004 the annual meeting of the AGS was hosted by Chalmers University of Technology in Gotheborg, Sweden.

AGS projects have traditionally fallen within three major focus areas: water, energy, and mobility. In addition, some of the projects address crosscutting issues such as urban systems, cleaner technologies, policies and institutions, and communications and outreach for sustainable development. AGS project leaders have raised more than \$20 million in support of these projects and related sustainability research at the partner universities.

This year, the AGS announced its intent, collectively and as collaborative groupings based at each campus, to undertake a large-scale investigation of near- and medium-term scenarios aimed at the reduction of anthropogenic greenhouse gas emissions, including the broad-based deployment of technologies leading to sustainable energy systems applicable to various regions of the world. The AGS has already invested in sustainability-focused energy research and can present a credible world wide analysis while at the same time providing a neutral forum for the development of integrated scenarios that will require political and regulatory action.

In addition to its research programs, the AGS supports education and outreach initiatives to raise awareness of the important role of science and technology in meeting the sustainability challenge to future development and to equip the next generation of leaders with the knowledge and skills they need to address such challenges throughout their careers. Among these initiatives is the ETH/AGS-supported Youth Environmental Summit (YES) in Braunwald, Switzerland. In 2003, the program brought 69 graduate students from 50 countries to two two-week intensive study programs on sustainability with a focus on implementation of Agenda 21.

Professors David Marks and Jeffrey Steinfeld are the MIT coordinators for the AGS.

### **MIT/AGS Consortium on Environmental Challenges**

In 2003–2004, the MIT/AGS created stronger ties with the international AGS program through work of greater international reach and synergy in the programs initiated at MIT, as well as enhanced visibility through the AGS international education and outreach programs. The MIT/AGS focuses on the role of scientific and technological knowledge in environmental decision making and seeks to provide recommendations for improving the scientific foundation for policies and decisions that affect the global environment.

The MIT management team for the program includes Professors David Marks and Kenneth Oye. The goals of the program are to:

- assess global environmental challenges and their impact on ecosystems, economic development, and health
- identify and contribute to the knowledge needed to meet those challenges
- improve policy making through the use of unbiased knowledge—scientific, technological, and socioeconomic

MIT/AGS-affiliated scholars from across the Institute are assessing the state of knowledge needed to effectively meet global environmental challenges by focusing on specific issue areas.

In 2003-2004, MIT/AGS programs focused on energy choices for the future, including sustainable building technologies, safety of nuclear energy systems, and carbon management and sequestration; the automobile and sustainability with an emphasis on options for future road transportation; water for a sustainable future; air quality in the

world's burgeoning megacities (with a case study on Mexico City); and ways to improve decision making under conditions of uncertainty.

Through the Mexico City Integrated Assessment Project, researchers seek to understand how to increase the role scientific evidence and technological knowledge play or can play in meeting the challenges posed by environmental risks to economic development and social welfare.

The Mexico City Project is an important example of how the best science and technology can be applied to help solve contemporary environmental problems. The program, which is supported by the Mexican government as well as through the MIT/AGS consortium and other sources, is working with public officials and stakeholders on ways to improve air quality in Mexico City and contribute to the solution of related regional and global air quality problems. The project includes identification of sources and effects of air pollution in Mexico City through high-quality science carried out at MIT and with its partners in Mexico and elsewhere. The project was initiated by Professor Mario Molina and Dr. Luisa Molina, now of the University of California at San Diego. More information can be found at the project's web site at <http://eaps.mit.edu/megacities/>.

### **Carbon Capture and Sequestration Technologies Program**

The field of carbon capture and sequestration is attracting much interest due to increasing concerns about global climate change. Our continuing work on carbon sequestration technologies focuses on three areas: assessment, education/outreach, and basic research. Howard Herzog leads this effort.

Some of the key research thrusts are:

- An integrative assessment of carbon sequestration technologies in collaboration with Professor Jacoby and the Joint Program. The focus of the current project in this area is investigating potential penetration rates of sequestration technologies.
- The Carbon Sequestration Initiative, an industrial consortium on carbon management. Our eleven members are Alstom Power, American Electric Power, American Petroleum Institute, Aramco Services, ChevronTexaco, Electricité de France, EPRI, ExxonMobil, Ford Motor Company, General Motors, and Peabody Energy.
- An investigation of social and political factors that will affect the future of carbon capture and sequestration technologies. These factors involve siting, permitting, regulatory, environmental justice, etc.
- An effort to develop a carbon sequestration information system using Geographic Information System (GIS) technology as a platform.
- A survey to determine attitudes toward global warming and climate change mitigation technologies, public understanding of global warming and the carbon cycle, and public awareness of carbon dioxide capture and storage (or carbon sequestration). The survey included a general population sample of more than 1,200 respondents in the United States.

In addition, the program has been involved in many national and international efforts related to carbon capture and sequestration. Specifically, Howard Herzog is a coordinating lead author for the IPCC Special Report on Carbon Capture and Storage (to be completed in October 2005). He has also been designated as one of two US Technical Group members for the Carbon Sequestration Leadership Forum, a ministerial-level agreement between 15 countries to promote research into carbon sequestration technologies.

Funding for the program comes from diverse sources including the US Department of Energy, private industry, NGOs, and the AGS.

Additional information on carbon capture and sequestration technologies can be found on the program website at <http://sequestration.mit.edu/>.

### **Analysis Group for Regional Electricity Alternatives**

LFEE research in the area of strategic planning for energy infrastructures and environmental performance is centered in the Analysis Group for Regional Electricity Alternatives (AGREA), led by Stephen Connors. The scenario-based multi-attribute tradeoff-analysis approach, developed in the 1980s by Energy Laboratory researchers, is the primary tool used by AGREA.

Current group projects include the recently completed AGS China Energy Technology Program, with its AGS Series book, including an interactive results DVD published by Kluwer. AGREA has led or been a major participant in other recent projects, including the integrated assessment of Mexico City's air quality improvement options and a study for the US Environmental Protection Agency (EPA) of hourly fossil power plant emissions and solar electric generation to determine where the avoided emissions from renewables and electricity conservation are the greatest, as indicated by the dynamics of electricity demand, renewable resources, and power plant dispatch and operating levels.

Energy infrastructure "pathways" projects are continuing, including TRANSES (Alternatives for the Transition to Sustainable Energy Services in Northern Europe), which studies Scandinavian energy alternatives, and projects under development for the new Alliance for Global Sustainability Robust Near-Term Steps flagship energy research, education and outreach program. The avoided emissions research is also continuing with a project looking at offshore wind in New England, part of the new Offshore Wind Energy Consortium under formation by the Massachusetts Renewable Energy Trust, GE Wind, and the US Department of Energy.

### **Political Economy and Technology Policy Group**

The Political Economy and Technology Policy Group, led by Professor Kenneth Oye, is a joint program of the LFEE and the Center for International Studies. Its purpose is to identify means to improve the quality of public and private responses to critical environmental problems by combining expertise on problems of political economy with

fundamental understanding of scientific and technical issues. In 2003-2004, the group's research focused on two key areas for improving environmental decision making.

The first area is the use of scientific information in public policy making. The intent is to identify methods for more robust and integrated assessments of policy options and for credible assessments of risks in areas of environmental policy controversy, and to improve the capacity of political institutions to adapt to new information. Lawrence McCray produced papers on third-party assessment of knowledge on environmental risks and on policy environmental adaptation, while Kenneth Oye joined with Professors Daniel Hastings, Dava Newman, and Roe Smith in launching an NSF-funded Program on Emerging Technologies, which focuses on improving responses to the uncertainty associated with the environmental, security, and economic effects of rapid technological change.

The second area is the assessment of the private effects of public environmental policies, with specific attention to the competitive position of firms, sectors, and nations. The group currently is conducting study of links among regulation, the utilization of technologies, and industrial structure. Research associate Dr. James Foster, Professor Oye, and doctoral student Christine Ng worked with the Finnish Environmental Institute, the Swiss Federal Institute of Technology, and the Stockholm School of Economics in a comparative analysis of the implications of divergent national regulatory regimes on environmental performance and competitive positions of the pulp and paper industry. They assessed the potential environmental effects of accelerating the phase-in of cleaner diesel fuels and of applying emerging heavy-duty vehicle engine and after-treatment technologies to light-duty vehicles.

In addition, the group worked closely with the Carbon Sequestration Initiative and other LFEE research projects and with the Mexico City Project to ensure inclusion of policy dimensions in assessments of technology solution options.

## **Affiliated Research**

### **Building Technology Program**

Directed by Professor Leon Glicksman, the Building Technology Program (BTP) has undertaken a major commitment to sustainable building design and technology in developing countries. Program participants are actively cooperating with colleagues at Tsinghua and Tongji universities in China, and with Chinese developers and designers, to create demonstration buildings that use appropriate technologies and designs as teaching tools and examples for future projects in Chinese cities. Current projects include the design of four high-rise residential structures in Beijing, two mid-rise multi-story housing units in Shanghai's Taidong residential quarter, and a low-rise residential community in Shenzhen City. New technologies such as night cooling, solar-driven dehumidification, and ground-coupled heat pumps are being evaluated, as is the incorporation of traditional methods such as shading and natural ventilation. A book on sustainable energy for Chinese buildings detailing the outcome of these studies is being prepared; it will be published as part of the AGS series.



MIT, ETHZ, and Chalmers are cooperating with Tsinghua University and the Ministry of Construction in China to develop new sustainable guidelines for Chinese housing. The proposed guidelines will be included in a web-based tool for designers and developers. Follow-up studies of housing projects in several Chinese cities will also be undertaken.

Members of the building technology group are also cooperating with colleagues at the University of Tokyo in a study dealing with reduction of pollution from megacities such as Tokyo and Shanghai. This technical work is being carried out in cooperation with the University of Tokyo and the Swiss Federal Institute of Technology. In this project, technologies such as ground source heat pumps and advanced facades are being evaluated. Ground source heat pumps use low-grade geothermal energy to improve efficiency for both heating and cooling of buildings. The ground source air conditioner, which stores or extracts heat underground, will significantly reduce urban heat island effects in the summer. Program members have undertaken a comprehensive study of advanced building facades in which air circulates between multiple glazing as well as blinds to control solar input and daylighting. These facade systems, when properly used, will reduce energy for air conditioning as well as for artificial lighting. They will also improve interior comfort and ventilation. The results have been included in a web-based design tool that can be used by designers in the conceptual design stages. New Assistant Professor Marilyne Andersen will continue her research in innovative materials to enhance the use of daylighting in building interiors.

The building technology group researchers have begun a joint study with Cambridge University under the Cambridge-MIT Institute. This research focuses on sustainable commercial buildings in the UK and US. It involves design and technology studies for large new projects; detailed monitoring of existing buildings; and fundamental and applied studies of new energy technologies such as natural ventilation to replace or reduce energy requirements for air conditioning.

### **Center for Advanced Nuclear Energy Systems**

The Center for Advanced Nuclear Energy Systems (CANES) aims to create through research concepts for nuclear energy systems that promise more favorable economics, safety, proliferation resistance, and environmental impact. The center's programs involve development and application of methods for the design, operation, and regulation of current and advanced nuclear reactors and fuel cycles. These efforts require advances in knowledge about traditional scientific and technical disciplines, modern methods of systems reliability, probabilistic safety analysis and decision analysis, together with human interactions and management science. Professor Mujid S. Kazimi is the director of CANES.

Current center programs involve four major thrusts: developing advanced reactor plant technology options; investigating alternative nuclear fuel cycles from the economic and environmental points of view; providing new methods to enhance operations of nuclear power plants in a risk-informed regulatory framework; and assessing the role of nuclear

energy in a sustainable world, such as a provider of the energy need to separate hydrogen from water.

CANES research activities are funded mainly by DOE's programs: the nuclear energy research initiative (NERI) and the advanced reactors or GENIV. Support from DOE and from Idaho National Engineering and Environmental Laboratory led to several projects on advanced reactors, of which the following were active in the past year: Advanced Fuels for Light Water Reactors (LWR), under the direction of Professor Kazimi and Professor Neil Todreas; the Supercritical Water Reactor (SCWR), under the direction of Professor Kazimi, and the Fast Gas-Cooled Gas Turbine Reactor, under the direction of Professor Michael Driscoll.

The center continues its three-year agreement with the Nuclear Regulatory Commission focused on the technology and regulatory approaches needed for advanced reactor systems. Three areas are being supported in the first phase of this agreement: safety analysis of the gas-cooled high-temperature reactor; methods for risk-informing the regulation of new reactors; and modeling the performance of high-burnup LWR fuel during steady-state irradiation and transients. In the past year, a specific task was added for establishing a methodology for assessing safety margins in a probabilistic framework, under the guidance of Professor George Apostolakis.

A collaboration that started in 1999 between MIT and Tokyo Electric Power Company for nuclear engineering continued. The collaboration supported several projects during the past year, including a comparison of the performance of US nuclear power plants and those of TEPCO, the use of annular fuel to enhance safety and economy in boiling water reactors, the conditions of thermal fatigue at pipe junctions with fluids with differing temperatures, and the best regulatory approach to inclusion of low probability severe accidents in safety reviews.

A two-day symposium on "Nuclear Energy and the Hydrogen Economy" was conducted in September 2003 at the Tang Auditorium. Organized by Professor Kazimi and Dr. Walter Kato, the symposium was attended by 70 people.

### **Sloan Automotive Laboratory**

Many of the Sloan Automotive Laboratory's projects involve quantitative and cross-disciplinary study of complex energy and environmental systems. The laboratory is directed by Professor John Heywood, with participation from Professor Wai Cheng, Professor Doug Hart, Professor James Keck, Dr. David Schmidt, Dr. Tian Tian, Dr. Victor Wong, and Professor William Green. It continues to pursue promising research to improve engine performance, efficiency, and fuel utilization in internal combustion engines and to reduce adverse emissions.

Focusing on new engine and fuel technologies, the Engine and Fuels Research Consortium continues to explore critical fuel/air mixture preparation and emission formation mechanisms in developing engine concepts, with potential application to both gasoline and diesel engines. Complementing the engine and fuels studies, the

Consortium on Lubrication in Internal Combustion Engines involves major engine component and lubricant manufacturers in addressing issues in oil consumption and engine friction reduction. Some members in these consortia also sponsor separate research projects on related topics of specific application to the individual sponsors. For example, Professors Wai Cheng and John Heywood work with Ford Motor Company on three projects related to engine transients: fuel/air mixture preparation behavior during start up, emission benefits of engine operation in hybrid electric vehicles, and actual in-use vehicle emissions in stop-and-go traffic.

Sloan Laboratory researchers are also involved in assessing new vehicle and propulsion system technologies for future road transportation use. The Sloan Laboratory engages actively in basic combustion research on advanced engine systems with US DOE support, and in engine emission research. The initial phase of the Clean Diesel Fuel Research Initiative Program, originally a collaboration between the Energy Laboratory and the Chemical Engineering Department under the University of Alaska-MIT Partnership, is receiving increasing industry support. The initial goal is to identify and assess the potential for significantly cleaner diesel fuels. Plans for a longer-term research program have been developed and are expected to be funded shortly. The proposed research will complement extensive fuel-testing programs being conducted elsewhere and will address engine technology/fuels interaction, fuel-processing technology, and special environmental and economic factors.

In a joint project with the Plasma Science and Fusion Center, Professor John Heywood and Sloan Laboratory graduate students are exploring the opportunities for lean-operating spark-ignition engines in which a plasmatron device—an electrical discharge-initiated fuel reformer—supplies hydrogen to enable the lean burn. A license to develop this technology has been taken out by ArvinMeritor, and a substantial cooperative research and development program with DOE and ArvinMeritor funding is in progress.

### **Center for Energy and Environmental Policy Research**

The Center for Energy and Environmental Policy Research (CEEPR) is an activity jointly sponsored at MIT by LFEE, the Department of Economics, and the Sloan School of Management. CEEPR funds policy-related research in energy and environmental economics. The center receives financial support from corporate sponsors, the US Environmental Protection Agency, and the Cambridge-MIT Institute.

CEEPR research is focused on evaluating the functioning and performance of markets created for environmental services and for electricity and associated network services. Most of the environmental research is concerned with emissions trading with particular attention to the US SO<sub>2</sub> Allowance Trading Program and the Northeastern NO<sub>x</sub> Budget Program. The electricity research is concerned with restructuring decisions with respect to how asset ownership, transmission access, and customer choice shape these markets and the provision of electricity to consumers.

## **Joint Program on the Science and Policy of Global Change**

This program, codirected by Professors Henry Jacoby of the Sloan School and Ronald Prinn of the Department of Earth, Atmospheric, and Planetary Sciences, draws on MIT's traditional strengths in science and economics to conduct the serious interdisciplinary work needed to provide a basis for global climate policy. The now 12-year-old Joint Program is one of the world's leading centers for the integrated assessment of climate change. An MIT Integrated Global Systems Model, developed by program researchers, provides a facility for research on the climate issue and assessment of policy proposals. An interdisciplinary team of faculty, professional staff, and graduate students carries out the work and produces a continuing flow of reports, articles, student theses, and professional and public presentations on the science and policy of global warming. Five US government agencies, 20 corporate sponsors in North America, Europe, and Japan, and one foundation support the work.

## **Education and Curriculum Initiatives**

The mission of the LFEE Education Program is to enhance environmental literacy and to strengthen the environmental dimension of educational experiences, particularly among the leaders of tomorrow's science and technology communities. The program is dedicated to increasing awareness of the complexity of environmental and sustainability challenges, and to increasing the multidisciplinary capacity of learners to respond effectively to these challenges. A special challenge of the mission of the LFEE Education Program is to ensure that environmental issues and concerns are part of the education of every MIT student, not just those who will become environmental scientists, engineers, and planners. Professor Jeffrey Steinfeld directs the LFEE Education Program; Dr. Amanda Graham is program manager.

Towards this end, the program has identified three broad constituencies and conducts a range of activities to meet special goals for each group.

## **MIT Community**

LFEE educational goals within MIT are to improve environmental literacy and strengthen education on the environment.

Major campus initiatives during the past year include:

- Coordinating "EnviroForum," a series of environmental networking events sponsored by MIT chancellor Phillip Clay. These four events gathered hundreds of MIT students, staff and faculty to learn about environmental research, education, and operations activities throughout the Institute.
- Offering climate policy education events, including a fall speaker series and a month-long seminar. During the fall semester of 2003, three speakers gave presentations on local, regional, and national efforts to develop sound climate protection policy.

- Offering an IAP course for graduates and undergraduates. Dr. Graham and program coordinator Beth Conlin cotaught the IAP course “Implementing the Cambridge Climate Protection Plan” for the second time. The students developed and presented a proposal to encourage walking to school in the city of Cambridge.
- Expanding and relaunching “EnviroClasses,” LFEE’s web-based environmental class listing, viewable at <http://enviroclasses.mit.edu/index.jsp>.
- Coordinating with the Environmental Programs Office to offer Freshman Advising Seminar 1.A23, focusing on implementation and analysis of MIT’s first waste audit. Daniel Winograd, MIT’s environmental counsel, and Dr. Graham cotaught “Achieving MIT’s Environmental Goals,” an advising seminar that introduced first-year students to environmental activities on their new campus. Students sorted through hundreds of pounds of waste in the fall seminar and presented their findings to the campus community in February 2004. In part a result of the students’ activities, MIT is instituting regular waste audits to better characterize the Institute’s resource consumption patterns and to enhance waste reduction and recycling practices.

In addition, the program continues to:

- Manage fellowship programs for scholars in sustainability, including the Knut and Alice Wallenberg Foundation Post-doctoral Fellowships for the Environment and Sustainability, for promising Swedish scholars, and the Martin Family Fellowship Program in Sustainability, for outstanding upper-level MIT graduate students. Special fellows events this year included a fall induction event for Martin fellows, a retreat at Woods Hole Oceanographic Institution for all environmental fellows at MIT, and a lecture and reception with Ellen Roy Herzfelder, Massachusetts’s secretary of environmental affairs.
- Support efforts by the MIT Council on the Environment to improve coordination and coherence among academic, research, and activity offerings for undergraduates, (including coordinating with Admissions, Career Counseling, and the UROP Office to better serve prospective students and future alumni).
- Support and participate in the development of subjects and programs for environmental majors and graduate students.
- Participate in campus-wide events such as International Development Forum and Earth Day celebrations.

### **Local and Regional Community**

LFEE’s goals in the local community are to promote MIT’s environmental stewardship and to cultivate the improvement of math, science, and technology education, particularly in the Cambridge Public Schools. Major efforts include:

- Coordinating ongoing activities of Urban Focus: MIT-Cambridge Public Schools Collaboration on Education for the Environment, a supplemental environmental project undertaken by MIT as part of its consent decree with the US Environmental Protection Agency and the US Department of Justice. In

collaboration with the Environmental Programs Office, LFEE oversaw the third two-year-long teacher-graduate student partnership of this program, which focused during the 2003–2004 academic year on water quality in the Charles River.

### **International and National Communities**

LFEE is fostering multidisciplinary international environmental education that integrates technological and social perspectives by:

- Partnering with AGS universities to plan and implement the annual Youth Encounter on Sustainability (YES). The “Report on 2003 Sessions of the AGS Youth Encounter on Sustainability” documents the educational innovations of the meeting and cites areas for improvement. Lessons learned from four years of implementing YES were disseminated by the LFEE Education Program to an international educational audience at the North American Association of Environmental Education annual meeting in Anchorage, AK, in October 2003.
- Conducting an education research project, “Delivering Research Results to the Educational Process,” in coordination with international AGS education partners (an AGS-funded project). The LFEE Education Program coordinates website design and content development for this international educational resource, which is scheduled to launch in early 2005.
- Developing instructional modules and professional development activities for instructors of environmental technology and science. The LFEE Education Program and the Advanced Technology Environmental Education Center (ATEEC) continue their collaborations on electronic resources and training workshops on environmental technology for community college instructors.

**David H. Marks**

**Director**

**Morton and Claire Goulder Family Professor**

**Professor of Civil and Environmental Engineering and Engineering Systems**

*More information about the Laboratory for Energy and the Environment can be found online at <http://lfee.mit.edu/>.*