LFEE
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2003

# INITIATIVES IN ENERGY *and the* ENVIRONMENT

*a publication of MIT's Laboratory For Energy and the Environment*



# *Science, Industry and Society: Partnership for Sustainable Development*

On March 23-26, the Alliance for Global Sustainability (AGS) held its annual meeting at the University of Tokyo (UT) to explore ways in which multi-disciplinary research can advance world-wide goals of sustainable development. Leading scholars, the presidents of the AGS member universities, and thought leaders from around the world met to examine how the integrated research paradigm developed by the AGS is bringing about change in their own institutions and contributing to sustainable development around the world.

The annual meeting, hosted by UT, was led by the four member institutions of the AGS—the Massachusetts Institute of Technology (MIT), the Swiss Federal Institute of Technology at Zürich (ETH-Z), UT, and Chalmers University of Technology in Sweden (Chalmers). Through three panels and 11 working groups, participants considered ways in which the AGS can evolve effective means to address complex global sustainability issues.

The keynote addresses were made by Professor M.S. Swaminathan of the M.S. Swaminathan Research Foundation in Chennai, India; and Hironori Hamanaka, Vice Minister for Global Environmental Affairs at the Japan Ministry of Environment. Roundtable discussions on water, energy, mobility, and urban systems allowed participating researchers to discuss ongoing work, potential synergies, and integration.

The AGS research portfolio currently supports 75 projects on 35 issues, over 200 faculty, and over 400 students. The AGS has developed new knowledge on critical issues in focus areas, presented through over 190 published journal articles and theses on AGS results and through 16 books or sections of books, including four complete books in the AGS book series.

AGS projects most successful in moving through the full research sequence engage stakeholders at an early stage. Successful programs in this regard are the Mexico City Program, the China Energy Technology Program and the China Coal and Coke-making projects. Over 70 masters and doctoral theses have resulted from AGS research.

Under the direction of principal investigators Dr. Joanne Kauffman (AGS Co-Executive Director) and Professor Nazli Choucri (MIT), the AGS is, for the third time in five years,

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laboratory for energy and the environment

## CALENDAR

**july 12-26**

Youth Encounter on Sustainability (YES), Multidisciplinary, multicultural, and interactive approaches to sustainability. First Session: July 12-26, 2003, Hotel Alpenblick, Braunwald, Switzerland. Contact: Dr. Amanda Graham, tel.: 617-253-8995. (Email: agraham@mit.edu).

**august 9-23**

Youth Encounter on Sustainability (YES), Multidisciplinary, multicultural, and interactive approaches to sustainability. Second Session: August 9-23,2003, Hotel Alpenblick, Braunwald, Switzerland. Contact: Dr. Amanda Graham, tel.: 617-253-8995. (Email: agraham@mit.edu).

**march 21-24**

Alliance for Global Sustainability, Annual Meeting 2004, Gøteborg, Sweden, March 21-24, 2004. hosted by Chalmers University of Technology. For further information, contact Ms. Karen Gibson, tel.: 617-258-6368. (Email: kgibson@mit.edu).

All events are held at MIT unless otherwise noted. For the most current listings, see the LFEE website: http://lfee.mit.edu/

Please send MIT sponsored event listings to Nancy Stauffer, stauffer@mit.edu.

using a mapping approach in order to examine its portfolio and to assess progress towards attaining goals in research, education, and outreach. The report of this initiative which included examination of all 75 projects supported by the AGS over five years and interviews with principal investigators and board members was delivered at the meeting.

**Key questions for the mapping project included:**

1) **What does AGS contribute to sustainable development?**
2) **What is unique about AGS and how does it compare to others working in this domain?**
3) **What are challenges to AGS today? and,**
4) **What recommendations for the future of AGS emerge from this analysis?**

The study compared AGS to peer programs around the world. The AGS is unique in being multi-institutional—through four universities, across three continents, with research partners around the world and global student networks—and in having an International Advisory Board comprised of "agents of change" in industry, government, and stakeholders throughout the world.

The objective of AGS research is to develop cutting-edge knowledge and innovative tools to address complex issues in global sustainability through multi-disciplinary research teams that transcend traditional intellectual and geographic boundaries.

> *The AGS education agenda is to prepare a new generation of leaders who are focused, competent and decisive in their efforts to implement sustainability.*

In an education panel, students, teachers, and a representative from industry described their expectations regarding sustainability education and identified possible approaches to closing gaps where their expectations differed. The AGS education agenda is to prepare a new generation of leaders who are focused, competent, and decisive in their efforts to implement sustainability.

In addition to thesis work on AGS research projects, AGS education efforts include the summer institute, YES (Youth Encounter on Sustainability, *see Calendar, left*), and the Martin and Wallenberg Fellowship programs in sustainability at MIT. AGS has been described as a "learning laboratory" which furthers the evolution of AGS research criteria, improves education opportunities, and increases opportunities for interactive, integrated learning with external partners.

**AGS Mapping Study: Summative Recommendations**

- **Enhance recognition of AGS identity and contributions**
- **Improve interactions with AGS International Advisory Board members and institutions for value added**
- **Develop an AGS strategy for synergy**
  - **Strengthen linkages among research, networking, leadership goals and contributions to policy**
  - **Build collaboration across projects**
  - **Increase interactions with mission oriented organizations and potential "competitors" to build community**

During a principal investigators' research forum at the annual meeting, researchers affirmed that the AGS is helping them to broaden their own views and address research questions in a more holistic way. In addition to offering networking opportunities for people who might not necessarily meet to work together, the AGS acts as a facilitator for researchers facing language, culture, scientific vocabulary, and cross-discipline challenges.

Over the course of the meeting, a number of important questions were raised. Among these was the significance of problems in the large mega-cities compared to those of the rural areas and the fringe cities; population trends and changes in consumption patterns with increases in income; and the quality of life in the developing world with regard to food, water, mobility, employment, health care, and housing.

Panels and subsequent working groups dealt with understanding urban systems, strategies for managing and mitigating environmental risks in the face of scientific complexity and uncertainty, and sustainable consumption, including not only technological innovation but also innovations in social institutions, strategies, and philosophies.

The Proceedings of the annual meeting will be available on line in the fall and by contacting the Alliance for Global Sustainability at BOF, Bolleystrasse 9, ETH Zentrum, 8006 Zürich, Switzerland.

# *"Best Poster" Awards Highlight AGS Annual Meeting*

This year, an award for best poster was established at the AGS Annual Meeting to encourage young researchers involved in AGS projects to submit a poster describing their research. During the poster sessions, posters were evaluated by the Best Poster Award Committee members and other reviewers nominated by the committee. Best posters were selected based on the evaluation results by the committee. During the closing plenary, a panel of the AGS presidents along with AGS Education Coordinator Takashi Mino of UT presented the awards for best posters, a certificate, and a book authored and signed by two AGS board members.

**Awarded "Best Poster" were:**

**1. Introducing Natural Gas as a Cleaner Car Fuel: International Benchmarking and Analyses for Switzerland.**
**Arthur Janssen;**
**S.F. Lienin, F. Gassmann, B. Kasemir, A. Wokaun (Paul Scherrer Institute)**

**Combining international benchmarking and Swiss**

**stakeholder dialogues and using system dynamics methods to analyze different scenarios and find optimal market penetration strategies for natural gas as a cleaner car fuel.**

**2. myclimate—Innovation for Climate Protection Addressing Air Traffic - a Project of the Student Community, ETH-Zürich.**
**Sabine Perch-Nielsen**
**(ETHZ)**

**A student initiative to enable air travelers to compensate for their flight emissions by purchasing a "climate ticket," paying 8 Swiss francs or 5 US dollars per hour of flight.**

**3. Evaluation of Sequestrable $CO_2$ in Coal Seams at Sub- and Super-Critical Conditions.**
**Michael Toribio;**
**Wakana Tsuchino, Sohei Shimada, Yoshito Oshima**
**(UT)**

**Study of how much $CO_2$ can be sequestered and the optimum condition for sequestration, in order to achieve closed-loop energy systems in Japanese coal seams.**

**4. Sustainable Residential Buildings in China.**
**Jonathan Smith;**
**Carl-Eric Hagentoft, Hadi Mozaffari, Alfred Moser, Yunlong Liu, Leon Glicksman, Yi Jiang, Wei Qingpeng, Nie Meisheng**
**(MIT/Chalmers/ ETHZ)**

**Using simple design tools and simple building designs to achieve decreased energy consumption.**

**5. Yellow-Dust Storms: The Socioeconomic-Impact Evaluation Puzzles.**
**Karen Polenske;**
**Chen Xikang, Yang Cuihong, Kazuhiko Takeuchi**
**(MIT/ UT)**

**Conducting a comprehensive study of the yellow dust problem in parts of Asia by developing a system for linking the existing techniques and creating a trans-national monitoring and research network.**

*Photo courtesy Philip Greenspun, http://philip.greenspun.com*

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# *The "Sustain Train"— AGS Students Travel from Zürich to Tokyo in 18 Days*

Eight students from the Swiss Federal Institute of Technology at Zürich (ETH-Z) travelled 12,000 kilometers by train to Tokyo to attend the annual meetings of the Alliance for Global Sustainability and its affiliated student organization. During the 18 days the "sustain train" took to cross Europe and Asia, the students discussed many sustainability issues, prepared themselves for the conferences, and experienced adventures in several cities and sites in the eight countries through which they passed.

The origin of their trip dates back a year to the 2002 annual meeting of the AGS in Costa Rica. The Zürich students had felt reluctant to fly to the event because the greenhouse gas emissions of this one flight would amount to more than half of an average Swiss person's annual GHG emissions. In Switzerland, for every 100 km the equivalent of about 50 kg $CO_2$ is emitted per person by train compared to about 230 kg by plane. Thus it was suggested that the students travel to the 2003 conference in Japan over land. In addition to the reduced climate impact, an extended train ride also presented the opportunity for the students to have organized discussions on sustainability issues, and to gain insight into foreign cultures by visiting cities, talking to locals on the train, and staying in private homes along the way.

On March first, the eight students boarded the train at Zürich heading east. The first stop was Moscow. In the Russian capital, the AGS in Zürich had put the students in touch with Green Cross Russia, an international non-governmental organization devoted to overcoming damage caused by industrial and military disasters as well as the clean-up of contaminated military sites from the Cold War. The students had done some research into this organization beforehand, and on the train they discussed its

*"Sustain Train" students from ETHZ, left to right: Stephan Kölliker, Michel Haller, Sabine Perch-Nielsen, Daniel Eherer, Patrick Jeannarat, Irene Steimen, Nicole Meyer, and Carlo Centonze.*

activities and possible ways of contributing to this organization's work. The president of Green Cross Russia described recent developments and illustrated the everyday difficulties this organization faces in today's Russia.

From Moscow, the train followed the 6000-mile-long track of the Trans-Siberian Railway, the construction of which had been initiated more than a century ago by Czar Alexander III. For days the students travelled in carriages accommodating four people each, crossing vast Siberian winter landscapes. The daily stops the train made where the passengers could get off to get some fresh air and enjoy the surroundings were eventful. Reported ETH-Z student Sabine Perch-Nielsen, "Instead of having an aloof stewardess serve us chilled white wine at 6,000 meters above sea level, here in Russia a crowd of babushkas, old Russian women, simultaneously greeted us with a flood of Russian words and offered us fresh home-made food."

On the way, the students experienced countless impressions in rapid succession. Near Irkutsk, colorful winter festivities were being held on the frozen surface of Lake Baikal, which they watched while eating freshly smoked Omul fish, one of numerous local species. In the capital of Mongolia many people live in their "gers" (the traditional round nomad tents) right next door to three-story concrete houses. In Beijing, splendid palaces of past dynasties are set amidst shiny skyscrapers and narrow alleyways where the students ate grilled beetles from tiny stalls. The exceptional hospitality and friendliness of the people they met was a very special part of their voyage: Mongolians invited them to a special tea in their gers, and six old, traditionally-dressed women invited them to sing and eat with them in their carriage.

*"We put a lot of effort into finding strategies to further strengthen the international student network, it being such a unique organization, not only multi-disciplinary but also cross-cultural. Arriving at the students' conference without jetlag and having thoroughly prepared ourselves, we could focus on this understanding across boundaries. Considering this exchange crucial for tackling complex and world-wide problems, we discussed our ideas and strategies with our friends from abroad and with our wonderful hosts."*

Sabine Perch-Nielsen, ETHZ

The long train rides (up to three days without getting off) gave the students time to work and prepare for the conference. Without distractions, they were creative and productive in discussing sustainable mobility issues and also in setting up three workshops that they held at the student conference in Tokyo.

At the AGS annual meeting the Zürich students were able to thank the AGS for enabling the "sustain train" and with it an impressive experience and a constructive contribution to the international student community. "The conference enabled us to approach many different researchers without difficulties and also to gain an insight into many of the international research projects—tasks not often so easily attained at home," said Ms. Perch-Nielsen.

In Zürich the students documented their voyage and spread their enthusiasm. After publishing five articles in their online university newspaper along the way, they organized an event at ETH-Z where they showed slides as well as the short film they had made on the train trip. Recounting their trip, the students encouraged people to join the student community and start thinking about new ways of mobility.

For more information: www.sustaintrain.ch; for more on climate protection in air traffic: www.myclimate.org.

# *Mario Molina Is 9th Annual Heinz Award Co-Recipient*

A groundbreaking pioneer in the way air pollution impacts human health, MIT Institute Professor and Nobel Laureate Mario Molina is one of the scientists to receive this year's Heinz Award for outstanding achievement. Prof. Molina is well known for his pursuit of scientific solutions to global warming and air pollution. He also works with colleagues across disciplines to explore policy issues related to urban and regional air pollution and global climate change. Prof. Molina shares this year's award with Dr. John Spengler, Director of the Environmental Science and Engineering Program at Harvard University's School of Public Health.

The Heinz Awards were established in 1993 by Teresa Heinz to honor the memory of her late husband, US Senator John Heinz, and to honor outstanding leaders in the areas of greatest importance to the Senator. The awardees' "selflessness and perseverance, imagination and passion promise a healthier, more manageable and more hopeful way of life for all of us," said foundation chair Teresa Heinz. The awards were created to provide a message of inspiration regarding the power of the individual in American society.

Prof. Molina is one of the world's leading authorities on air pollution and the effects of chemical pollution on the environment. In 1995, he shared the Nobel Prize in Chemistry for joint research on the effects of chlorofluorocarbons (CFCs) on the earth's atmosphere, showing that CFCs widely used in refrigeration and household aerosol can propellants, such as hair spray, were destroying the ozone layer.

The ozone layer protects the earth from the most damaging rays of the sun. In areas where the ozone layer is thinner, a higher incidence of skin cancer has been observed. Ultraviolet rays from the sun have other negative environmental impacts on sensitive ecosystems. When scientists discovered a huge hole in the ozone layer over Antarctica in 1984, some skeptics still questioned whether CFCs were causing the damage. Prof. Molina demonstrated how chlorine-activation reactions were taking place in the presence of ice under polar stratospheric conditions and eating away the ozone layer.

In 1995, based on these research findings and through the Montreal Protocol on Substances that Deplete the Ozone Layer, the production of CFCs was banned in developed countries. The Montreal Protocol is an international agreement convened by the United Nations Environment Programme. After a series of rigorous meetings and negotiations, the Protocol was finally agreed upon in September, 1987 at the Headquarters of the International Civil Aviation Organization in Montreal.

Prof. Molina continues teaching and research at MIT. In recent years, he has directed the Mexico City Project between MIT and the local government of Mexico City, with the purpose of improving the dangerous air quality situation in that great mega-city.

In 2002, Kluwer Academic Publishers launched the Alliance for Global Sustainability (AGS) Book Series, "Science and Technology: Tools for Sustainable Development." Second in the series is *Air Quality in Mexico: An Integrated Assessment*, edited by Prof. Molina and his wife, Dr. Luisa Molina. In this book, which is an outcome of the Mexico City Project, 35 American and Mexican experts in atmospheric sciences, human health, economics, and social and political sciences contributed to an integrated assessment of the complex elements needed to structure air quality policy in the 21st century through a case study of the Mexico City Metropolitan Area, one of the world's largest mega-cities where air pollution grew unchecked for decades. (For a review of the book, see newsletter, Volume 4, no. 2.)

Dr. John Spengler, co-recipient of this year's Heinz Award, has devoted his career to studying and understanding the effects of indoor and outdoor air pollution on human health. He pioneered the development of personal monitors to measure how air pollution affects individuals as they go about their daily activities. This breakthrough helped

researchers gather data critical to understanding the link between pollution and human health.

The combined work of Prof. Molina and Dr. Spengler covers a broad range of human health issues related to air pollution, from indoor and ambient air pollution to the global problems of stratospheric ozone depletion and the consequences of fossil fuel combustion. These scientists have heightened public awareness of the risks of air pollution and have helped to dramatize the impact of anthropogenic stresses on the environment as well as championing new thinking about mankind's stewardship of the earth's resources.

Web site: http://eaps.mit.edu/molina

# *LFEE Co-Sponsors Seminar on Metals Recycling*

On February 28, in a seminar co-sponsored by MIT's Laboratory for Energy and the Environment (LFEE) and the MIT Materials Systems Lab, Prof. Markus A. Reuter and Dr. Antoinette Van Schaik of the Department of Applied Earth Sciences, Delft University of Technology, spoke on the subject, "Developments in Metals Recycling at Delft University of Technology, The Netherlands."

Delft University of Technology has a number of interfaculty research programs focused on applied scientific research aimed at solving urgent problems. Their central objective is to pursue multidisciplinary research, which crosses the borders between the traditional technical disciplines. One of these interfaculty programs is Smart Products Systems managed by Prof. Reuter, which consists of four sub-projects. Prof. Reuter and Dr. Van Schaik work in one of these sub-projects, which deals with optimization for the recycling of materials out of obsolete products by adapting the design of a product concurrently with developing recycling technology, while taking into account the entire life cycle to obtain the lowest environmental impact and use of resources.

Goods and products, such as passenger vehicles, are manufactured by using a wide spectrum of different raw materials to meet highest consumer requirements during use. At the end of their useful lives these products return, as complex multi-component materials that cannot directly be converted into products once more due to their complex mineralogy. However, society requires that a maximum of the materials and energy coming from end-of-life products find their way back into the resource cycle, while minimizing the impact to the environment and taking into consideration the economics of recycling.

Recycling complex, multi-component products (of which passenger vehicles are a clear example) is complicated and involves a network of interconnected processes of dismantling, mechanical separation and metallurgy (each with their own recoveries, products, residues, etc.) and material and energy streams. The recovery of the materials present in the car is strongly influenced by various aspects such as the design of the product and the efficiency of the different unit operations and processes within the interconnected resource cycle system, as well as the optimal interconnection between the different processes in the recycling system.

Recycling of products can, however, lead to certain problems. The products obtained by the recycling processes must fulfill certain requirements of grade (purity), the level of which is dictated by the competing raw materials. As a result, in almost all cases, the recovery, with respect to the materials entering the process, is never 100%, and some components and materials cannot be recovered at all due to poor separation precipitated by product design that did not consider material recovery.

Although technical developments in processing and the economics of recycling are primary factors, design also plays a significant role in recycling. For the environmental and economic optimization of product recycling systems it is necessary to adapt the design of products to reflect their entire life cycles. The adjustments in product design must be developed with respect to the restrictions to the design imposed by the product requirements, including functionality, quality, safety, and economics.

During the seminar, Prof. Reuter and Dr. Van Schaik discussed the influence of design and constructive choices on the composition of recycling streams and on the efficiency of the resource cycles. They have developed optimization models for the recycling of materials from end-of-life vehicles.

The two researchers also talked about their experience with melting experiments for the recovery of advanced light metals and with optimization modeling for resource cycles by the use of the developed optimization models. They emphasized a strong link to industry to ensure that physical separation and liberation data as well as metallurgical data is of a quality sufficient to enable good calibration of the models that have been developed.

# *John Deutch Talks about Fuel Cells at MIT*

Professor John Deutch, Institute Professor at the Massachusetts Institute of Technology, gave an Environment and Sustainability Seminar at the Laboratory for Energy and the Environment (LFEE) on March 12 on the subject of fuel cell system assessment. Nearly 100 students, faculty, and practitioners attended the highly technical and informative talk.

In previewing his talk, Professor Deutch said, "My talk will address fuel cell systems and their applications with attention to the technical characteristics that limit performance of proton exchange membrane (PEM) fuel cells. I will assess the prospects for fuel cell system use in transportation and stationary power relative to alternatives."

A fuel cell is an electrochemical system consisting of several sub-systems, providing power to a particular application such the automobile. In a fuel cell, hydrogen and oxygen are combined to produce energy and water. Among some fuel cells are the solid oxide, alkaline, and polymer electrolyte/membrane types, the latter of which operates at temperatures of 60-100° F.

According to Deutch, the thermodynamic efficiency of fuels cells is determined by the ratio of electrical energy out to chemical energy in. He said a very high efficiency can be achieved, although he admitted that much is needed to optimize and improve fuel cells at their present level of development.

The advantages of fuel cells are no moving parts (simplicity and lower cost), higher efficiency, no emissions, quiet operation, and no smell. However there are challenges to overcome in fuel cells. These include startup, acceleration, corrosion, reliability, lifetime, catalytic poisoning, pressurized operation, water balance, cost, reformer complexity, reformer startup, testing, and freezing.

Since the fuel cell requires hydrogen, the sources of hydrogen are important. Possible sources of hydrogen are electrolysis, using electricity from nuclear power; photolysis or thermal cracking of water; and reforming hydrocarbons such as methane, the latter of which is not a clean operation.

Deutch mentioned the Toyota Prius hybrid car which operates with a parallel direct drive power train and whose cost is in the $25K range. He also mentioned Daimler-Chrysler's fuel-efficient diesel hybrid. With the use of hybrids, the US could double the efficiency of engines in urban driving, Deutch said, and the petroleum consumption could be reduced from 14 million barrels a day down to three million barrels. But fuel cells present a potential alternative to both technologies, he added.

*The lifetime of the fuel cell has increased from 5,000 to 10,000 hours, but this falls considerably short of a turbine engine and even further from an internal combustion engine, which has the longest life of the three types of engine.*

A conventional ICE has an efficiency of about seven per cent while an advanced ICE that relies on a parallel direct drive power train like the Prius has double that efficiency. Fuel cells have 13 per cent efficiency, near that of the advanced ICE. But lifetime and reliability of fuel cells are key, and the capital cost will depend strongly on productive run.

The lifetime of the fuel cell has increased from 5,000 to 10,000 hours, but this falls considerably short of a turbine engine and even further from an ICE, which has the longest life of the three types of engine. "There is a lot of room for creative solutions to fuel cells," said Prof. Deutch, and "fuel cell systems are an ideal subject for research and teaching at MIT."

Deutch believes that fuel cell systems will become an important energy technology, but the practical application will be a technical challenge. But fuel cells, he said, are a superb platform for teaching many aspects of science and engineering problems focused on an important problem. Fuel cell applications are an excellent example of the need for a system approach and integrating scientific, engineering, and economic considerations in research, but they will require a major effort through considerable modeling on the part of chemists, mechanical engineers, economists, and systems people, among others.

Prof. Deutch said that the fuel cell is a very important technology for the future, and hydrogen is going to be a superb fuel even though it is not economical at present. But the lifetime of the fuel cell is a big problem to overcome, as it cannot now compete with turbine or ICE systems.

# *UN Envoy Links Development, Sustainability, Leadership*

*Environmental protection must be linked to development. Negotiations will fail if this overriding concern is not met.*

At a session sponsored February 20 by the MIT Laboratory for Energy and the Environment (LFEE), Jan Pronk, Chair of the International Institute for Environment and Development, shared his 30 years of experience in the struggle for effective global agreement. His presentation, "Global Environmental Negotiations and the Need for Effective Leadership," drew an attentive audience of students and faculty members sharing an interest in the future of the principles first articulated as Agenda 21 in 1992 at a UN-sponsored meeting in Rio de Janeiro.

Jan Pronk was Special Envoy for the World Summit on Sustainable Development on behalf of the UN Secretary-General, Kofi Annan. The summit, held in Johannesburg, South Africa in the summer of 2002, addressed issues of implementation of the principles hammered out at the Rio convocation. Pronk also served as Minister of Development for the Netherlands from 1998 to 2002.

A principle of long standing in world trade, now adapted to the environment, is "common but differentiated responsibility" among nations. Pronk's remarks addressed critical importance of robust leadership among nations negotiating the equitable allocation of responsibility for a sustainable global future. He observed that effective negotiations will depend on four conditions.

First, the developed nations, able to afford the education and support of large numbers of environmental experts and negotiators, need to develop this capacity in the less developed nations. Some LDCs may lack the manpower to adequately represent themselves in the proliferating round of global forums while also developing and implementing policy at home. Agreements reached without robust participation from the South are unlikely to inspire commitment or compliance. Capacity-building for leadership requires financial aid in several forms, including university fellowships.

Second, environmental protection must be linked to development. Negotiations will fail if this overriding concern is not met. As spelled out by Kofi Anan, the international community should focus for the next five years on rehabilitation, water, energy, agriculture, and biodiversity. These concerns of the South must be addressed before LDCs can be expected to join the North in long-term environmental strategies.

A third *sine qua non* of international negotiation for sustainability is attitude. Negotiators must be able to see a problem through the eyes of other parties to a prospective agreement. They must also be able to view themselves as others might see them.

Fourth, in Pronk's view, ongoing negotiations to attain global sustainability are too important to be left to professional negotiators. His experience shows that all affected parties must be involved; these include women, youth, business, indigenous people, and government at all levels of jurisdiction. For many of these people, environmental sustainability is not an abstract concept, but a matter of life and death.

In his presentation, Pronk returned frequently to the theme of partnerships. International treaties tend to offer very conservative, lowest-common-denominator type solutions. Motivated partners, for example, an important local industry and the government overseeing it, can experiment with much more innovative environmental strategies and technologies. Such models can offer framers of future pacts more ambitious principles, practices, and targets and enable governments to legalize them.

# *Power without Pollution: MIT Teams up with Local Secondary School*

Where does energy come from? What is it used for? Does it pollute? What can be done to reduce energy-related pollution? These questions were posed to Cambridge, Massachusetts ninth graders to spark their interest in the large and complex realm of energy studies.

In a special event sponsored by the Massachusetts Institute of Technology (MIT) in collaboration with the Cambridge Public Schools and the US Environmental Protection Agency, on April 17 the Cambridge Rindge and Latin School (CRLS) hosted an "Alternative Energy Seminar: Power without Pollution!" throughout the school day.

The purpose of the April 17 event was to broaden students' awareness of the variety of energy sources available and to introduce them to fundamental scientific concepts associated with alternative forms of energy. The students' physics class work in the days following the event focused on the mechanics of energy, reinforcing the event's themes. This event was the launch, for most students, into an energy curriculum. This seminar was the second of two seminars on current environmental topics to be offered to the Cambridge community and organized by MIT during the spring term of 2003. On February 14, MIT hosted a water quality-focused seminar and workshop day, incorporating interactive opportunities between Cambridge middle school students and area energy experts.

The presentation began with introductory comments by CRLS Principal Dr. Sybil Knight, Cambridge City Councillor Brian Murphy, and Managing Director of MIT's Environmental Programs Office and Senior Counsel, Jamie Lewis Keith. Stephen Connors, Coordinator of Multidisciplinary Research and Director of the Analysis Group for Regional Electricity Alternatives at MIT's Laboratory for Energy and the Environment, gave a spirited talk to encourage students to think about energy and its many uses. He described how much of today's energy is generated by burning fossil fuels to power steam turbines and introduced students to renewable energy in the form of solar and wind power, showing them slides of large solar arrays and wind farms (large arrays of energy-generating windmills).

Connors noted that the challenges with renewables are arranging to have solar arrays in places where it is sunny most of the time and locating wind farms where it is windy most of the time, such as in Denmark, where there is a large offshore windmill array. The height of some modern windmills can be as much as half that of the Washington Monument in Washington, DC, and they are arranged by the dozens in large arrays either in the countryside or off the seacoast. In addition, Connors told students that energy has major uses outside personal consumption, including vehicles and industry, the latter of which comprises roughly half of all energy consumption in the US.

Energy conservation was also emphasized. In particular, the gasoline/electric hybrid car was described as being "smaller and smarter" than cars with gasoline-only internal combustion engines (ICEs). The students were told that hybrid cars are more efficient in city traffic, as the engine is actually turned off during a wait at a red light, thus conserving the energy that would otherwise be wasted as the ICE engine idles.

After the morning assembly at CRLS, energy experts from MIT and beyond visited individual physics classes to introduce students to specific topics related to renewable energy. Representatives from MIT included Stephen Connors and Prof. Jeff Tester of LFEE, and doctoral student Marcus Sarofirm of the Joint Program on the Science and Policy of Global Change. Local specialists (including Massachusetts Energy Consumers Alliance, Beverly [Massachusetts] High

*Richard Moran of NSTAR discusses the relative efficiency of compact fluorescent bulbs with Cambridge Public School teacher Barbara Dorritie and high school student James Fish.*

*Photo Credit: Melissa Kavlakli.*

School Solar Program, Northeastern University [Boston, Massachusetts], and NSTAR [Massachusetts' largest investor-owned electric and gas utility]) also visited individual physics classrooms and provided interactive sessions on specific aspects of renewable energy, energy efficiency, and related issues.

The seminars on April 17 and February 14 were part of Urban Focus, an ongoing collaboration between MIT and the Cambridge Public Schools. Urban Focus brings Cambridge teachers together with environmental researchers at MIT and is intended ultimately to promote increased sharing of current environmental information between MIT and the Cambridge community. In another related event, on May 17 public school teachers and other educators gathered at MIT for a conference on the future of sustainability education and environmental science.

This project has been undertaken by MIT in connection with the settlement of an enforcement action brought by the US Environmental Project Agency and the US Department of Justice for alleged violations of the Federal Clean Water Act, the Clean Air Act, and the Resource Conservation and Recovery Act. There was no actual finding of harm to the environment.

## *Christine Ng Receives TPP Best Thesis Award*

This spring, MIT graduate student, Christine Ng, was given an award of Best Thesis by the Technology and Policy Program (TPP). Each year TPP awards a Best Thesis Award to a graduating master's student. The award recognizes a TPP thesis which represents strong policy work based upon substantial technological analyses and draws upon key aspects of the TPP curriculum.

Ms. Ng's research considers the influence that public-private clean diesel R&D partnerships have on emission regulations in the US. While there is substantial literature on the contribution of public-private R&D partnerships to facilitating organizational learning, innovation, and national competitiveness, there has been little research on its influence on environmental policy- and rule-making. Understanding whether partnerships are influential in the regulatory process, and the conditions under which they are influential, will increase awareness of the potential regulatory impacts of future partnerships. Ms. Ng's research focuses on the effects of such partnerships on US Environmental Protection Agency (EPA) rule-making with respect to diesel fuel quality in heavy-duty vehicles.

Diesel exhaust contains air pollutants such as particulate matter and nitrogen oxides (NOx), which have adverse human health and environmental impacts. For this reason, the heavy-duty diesel industry in the US has been subject to increasingly stringent federal emission regulations. The EPA sets technology-forcing standards in order to drive industry progress in emissions reduction. Since the EPA bases its rule-making largely on its appraisal of technological development in industry, technologists in companies and research organizations play an important role in providing the EPA with timely technical information.

A comparative analysis of three public-private partnerships, all of them including several industry and government partners, formed the basis for a comparative case study. The partnerships investigated the effects of diesel fuel quality, particularly sulfur levels, on emissions reduction. Publicly available documents, interviews, and questionnaires provided insights on the three partnerships and public-private partnerships in general.

The comparative analysis revealed that public-private partnerships do play a role in influencing policy, but that role is limited by the circumstances of each partnership and regulators' preference to rely more on other sources of knowledge for technical input. A clear understanding of upcoming regulations, broad stakeholder involvement, and the generation of publicly accessible results are all critical to a partnership's potential regulatory influence. Partnership results can directly provide input to a regulatory decision, but its effects on technological progress, knowledge networks, and further research collaboration are also relevant to the regulatory process.

Ms. Ng received dual master's degrees in Technology and

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*June 2003, Volume 5, No. 2*

*Initiatives in Energy and the Environment* is published by MIT's Laboratory For Energy and the Environment. For more information about the Lab, please see the Lab's website: http://lfee.mit.edu/ or contact the Lab staff at:

Laboratory For Energy and the Environment
Massachusetts Institute of Technology
1 Amherst Street
Building E40-455
Cambridge, MA 02139
Tel.: 617-258-8891
Web: http://lfee.mit.edu/

To be placed on the mailing list, contact:
Ms. Karen Gibson
MIT, Building E40-469
Cambridge, MA 02139
Tel.: 617-258-6368
email: kgibson@mit.edu

Policy and Civil and Environmental Engineering in June, but she will be continuing in the PhD program in Technology, Management, and Policy in MIT's Engineering Systems Division.

From her master's research, Ms. Ng found that regulators rely on a range of sources for knowledge on the latest clean diesel vehicle technologies. Partnership research represents only one input, and the cooperative and public nature of partnerships discourage the sharing of competitive and proprietary information. When regulators seek to assess the status and progress of technology, they routinely rely on private information from various companies and on their own laboratory research.

The research that Ms. Ng plans to pursue for her PhD also considers a type of partnership, but it is one that is substantially different from those investigated in her master's research. Instead of broad-based industry-government partnerships that lift the position of all firms within an industry, this alternative type of partnership creates an alliance among "environmental first-mover" firms, regulators, and environmental groups. It works alongside the naturally competitive nature of firms, and yet it does so in the interest of improving human health and the environment. Ms. Ng will be working with Professor Kenneth Oye in the Center for International Studies as well as faculty in MIT's Laboratory for Energy and the Environment.

**Laboratory For Energy and the Environment**
Massachusetts Institute of Technology
1 Amherst Street, Room E40-455
Cambridge, MA 02139

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