2009 MITEI Summer UROPs and Interns

Yieu Chyan

Grafton Daniels

Julia Day

Ian Fischer

Daniel Kelly

Haitao Mao

Kwadwo Nyarko

Nikhil Pradhan

Christos Samolis

Anya Shafiro

Anna Shcherbina

Josh Siegel

Elizabeth Turner

Juliana Velez

Joshua Velson

Patrick Yamane

The MIT Energy Initiative (MITEI) was formally launched by President Susan Hockfield in November 2006 to mobilize the capabilities and experience of the Institute to "foster new research in science and technology to increase energy supplies ... bringing scientists, engineers and social scientists together to envision the best energy policies for the future." MITEI is now a broad, Institute-wide initiative designed both to 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.

MITEI works with the MIT **Undergraduate Research Opportunities Program** (UROP) to support the participation of undergraduates in energy research and to encourage undergraduate interest in the energy field. MITEI UROPs can be conducted in any academic department or interdisciplinary laboratory.

MITEI UROP funding is provided by individual donors and by members of the MIT Energy Initiative, including individual Affiliate Members with a particular interest in supporting undergraduate research (http://web.mit.edu/mitei/about/members.html).

MITEI's **Affiliate Member Program** contributes to a critical link in the energy innovation chain — the pairing of MIT's world-class research teams with innovators in industry who will be responsible for moving many of the products of this collaboration into the energy marketplace. Most importantly, it provides key focus, research opportunities and critical funding for the next generation of energy technologists.

Website: http://mit.edu/mitei/education/urop.html

Summer 2009 Energy UROPs and Internships
Brief Project Descriptions (excerpted from student proposals)

Student: **Yieu Chyan** (’11)
Faculty: Timothy Swager (Chemistry)
Project: Dibenzocyclooctatetraene Based Electronic Polymers
Sponsor: GreengEnergy (MITEI Affiliate Member)

As growth in global energy demands rapidly increases dependence on limited supplies of nonrenewable resources, and as greenhouse gas emissions from fossil fuels are generating environmental concerns, methods of directly harvesting solar energy are receiving increased attention. A promising method of harvesting energy from sunlight is to utilize photovoltaic devices. As one of the greatest barriers to the practical implementation of solar cells as an energy source has been the cost of crystalline silicon for traditional cells, organic photovoltaic devices may represent a solution, offering advantages over existing silicon-based devices in both cost and ease of processing. Another advantage is that organic materials are lighter and more flexible, properties that allow for a wider scope of application. However, the main disadvantage of organic materials is that their efficiencies of energy conversion and device lifetimes are not yet as high as existing silicon cells. As such, this UROP is focused on developing new organic materials that may offer improvements in these areas, specifically novel n-type conjugated polymers, with pendant fluoroalkyl chains, that display unique physical and chemical properties.

Student: **Grafton Daniels** (’11) (collaborating with **Christos Samolis** ’12)
Faculty: Christopher Zegras (Urban Studies and Planning)
Project: Computer Programming for OPUS/UrbanSim Enhancements
Sponsor: Nth Power (MITEI Affiliate Member)

Open Platform for Urban Simulation (OPUS) is an open source software platform for simulating land use and transportation models. A main goal of OPUS is to test public policy regarding urban planning. For this UROP, I am working with Christos Samolis, a rising sophomore majoring in Electrical Engineering and Computer Science. We will be working in the “Backyard” of the Department of Urban Studies and Planning, which is located on the fifth floor of Building 9 on MIT's campus. Christos and I began the UROP by exploring the software architecture of the platform in order to get a better understanding of how OPUS works. The tasks we plan to complete this summer include: examining new ways to model travel, documenting the internal structure of OPUS through a wiki, and investigating other ways that OPUS can be improved.

Student: **Julia Day** (’10)
Faculty: Kripa Varanasi (Mechanical Engineering)
Project: Application of Micro and Nano-Engineered Surfaces to Increase Power Plant Efficiency
Sponsor: MITEI

Much of the current research into energy conservation deals with finding new sources of energy: solar, wind, bio-diesel. But implementing these new technologies, once they are developed, could prove difficult in developing countries because creating new power plants requires a lot of capital. Because energy needs in developing countries are the source of most of the world's increased energy needs in the future, technologies that improve efficiencies in preexisting power plants will become increasingly important. The focus of this project will be to use nano- and micro-engineered surfaces to vastly improve power-plant efficiencies. The focus of the lab is to develop materials and manufacture processes that will allow superhydrophobic and super-hydrophilic technologies, which can be tailored to the improve the function of different parts of steam turbines, condensers and boilers, to enter power plant industries.

Student: **Ian Fischer** (’12)
Faculty: Alex Slocum (Mechanical Engineering)
Project: Concentrated Solar Power Research
Sponsor: William Chao ‘78

The Concentrated Solar Power Experimental Study Group (CSPESG) is a Freshman Advising Seminar in which students will implement a new type of concentrated solar power on the roof of building 24. The CSPESG do the initial prototyping of the solar array to evaluate its feasibility as a Freshman Advising Seminar. The group will design and test the program for the seminar, optimizing the structure and organization of the class. If all goes as planned, the seminar will be ready to implement by the fall semester of 2009. This UROP will focus on the initial prototyping of the solar array and the testing part of the program and will encompass management, electrical and mechanical engineering.

Student: **Daniel Kelly** (’12) (collaborating with **Kwadwo Nyarko** ’12)
Faculty: John Heywood (Mechanical Engineering)
Yang Shao-Horn (Mechanical Engineering)
Wai Cheng (Mechanical Engineering)
Yet-Ming Chiang (Materials Science & Engineering)
Project: MIT Electric Vehicle Team Porsche Work
Sponsor: Natalie Givans ’84 (MITEI Affiliate Member)

The MIT Electric Vehicle Team (EVT) is dedicated to the research, design, and operation of electric vehicles (EV). EVT has converted a 1976 Porsche 914 into a battery electric vehicle (BEV). EVT has estimated the gasoline-equivalent fuel economy, performance, and range for the Porsche based on a model of the vehicle which is then simulated over the EPA drive cycles and acceleration tests. Having recently implemented a complete data acquisition system for this vehicle, it is now possible to both 1) test these results on the road and 2) use more accurate, real-world data to validate the model. This project will involve testing, modeling, and validating the Porsche. Modeling will be done using ADVISOR (for which the Sloan Lab has a license that is available to EVT). Specific tasks include learning how to use the ADVISOR vehicle modeling software, modeling and analyzing a range of vehicles (both conventional and electric), modeling the Porsche 914 BEV, developing a test plan to validate the Porsche model and test range and performance, add additional instrumentation and data logging capabilities to the Porsche (e.g. vehicle speed and additional temperature measurements), and implementing test plan and updating the vehicle model as appropriate.

Student: **Haitao Mao** (’12) (collaborating with **Patrick Yamane** ’11 and **Nikhil Pradhan** ‘09)
Faculty: Thomas Malone (Sloan)
Robert Laubacher (MIT Center for Collective Intelligence)
Project: Climate Collaboratorium
Sponsor: William Chao ‘78

The Climate Collaboratorium, a project of MIT-Sloan’s Center for Collective Intelligence, is a website being built to support large scale collective intelligence to develop plans to address climate change. The idea is to have an online interface that will allow many people to offer their own opinions about various environmental questions as well as comment on the opinions of others. With this information, we should be able to develop plans that address climate issues in a manner that will be better supported by the general public and thus more effective once implemented.

Student: **Kwadwo Nyarko** (’12) (collaborating with **Daniel Kelly** ’12)
Faculty: John Heywood (Mechanical Engineering)
Yang Shao-Horn (Mechanical Engineering)
Wai Cheng (Mechanical Engineering)
Yet-Ming Chiang (Materials Science & Engineering)
Project: **Electric Vehicle Modeling and Testing**
Sponsor: Natalie Givans ’84 (MITEI Affiliate Member)

The MIT Electric Vehicle Team (EVT) is dedicated to the research, design, and operation of electric vehicles (EV). EVT has converted a 1976 Porsche 914 into a battery electric vehicle (BEV). EVT has estimated the gasoline-equivalent fuel economy, performance, and range for the Porsche based on a model of the vehicle which is then simulated over the EPA drive cycles and acceleration tests. Having recently implemented a complete data acquisition system for this vehicle, it is now possible to both 1) test these results on the road and 2) use more accurate, real-world data to validate the model. This project will involve testing, modeling, and validating the Porsche. Modeling will be done using ADVISOR (for which the Sloan Lab has a license that is available to EVT). Specific tasks include learning how to use the ADVISOR vehicle modeling software, modeling and analyzing a range of vehicles (both conventional and electric), modeling the Porsche 914 BEV, developing a test plan to validate the Porsche model and test range and performance, add additional instrumentation and data logging capabilities to the Porsche (e.g. vehicle speed and additional temperature measurements), and implementing test plan and updating the vehicle model as appropriate.

Student: **Nikhil Pradhan** (’09 – summer intern) (collaborating with **Haitao Mao** ’12 and **Patrick Yamane** ’11)
Faculty: Thomas Malone (Sloan)
Robert Laubacher (MIT Center for Collective Intelligence)
Project: Climate Collaboratorium
Sponsor: MITEI

The goal of the Climate Collaboratorium project is to revolutionize the discussion on climate change, by creating an online community where users can effectively discuss climate change issues through uniquely structured arguments on robust, transparent models. I specifically will be working to integrate quantitative models of the different parts of climate change--from economic development to carbon dioxide emissions to sea level change--into the Collaboratorium.

Student: **Christos Samolis** (’12) (collaborating with **Grafton Daniels** ’11)
Faculty: Christopher Zegras (Urban Studies and Planning)
Project: OPUS/ UrbanSim Enhancements
Sponsor: Nth Power (MITEI Affiliate Member)

OPUS is an open source platform for simulating transportation and land use models related to urban development. UrbanSim is an application that uses the OPUS platform for this purpose. The source code for this software constitutes of 100,000 lines of code approximately written in the Python language. The work for this UROP will take place for the most part in the Backyard of the department of urban studies and planning in building 9, fifth floor. I am working in collaboration with undergrad Grafton Daniels. For the initial part of the UROP we set out to understand the software components that have already been developed. The tasks we plan to complete this summer include: investigating ways to model travel, creating a website that will present the class hierarchy of OPUS and documentation of the interface, and further exploring new ways to ameliorate the OPUS platform.

Student: **Anya Shafiro** (’10)
Faculty: Ernest Moniz (Physics, MITEI)
Daniel Cohn (Plasma Science and Fusion Center)
Tony Meggs (MITEI)
Project: MIT Natural Gas Study
Sponsor: MIT Natural Gas Study

The goal of this research project is to understand the availability of natural gas and its effects on the US economy. What is the role of natural gas in a carbon constrained world? We intend to estimate the resources, both in the present and projections into the future, taking into account diminishing remains and improving extraction technology. Furthermore, the demand for these materials is important to gauge, hence we must look at future trends of various energy fuels. My work specifically will be focused on construction of costs of discovery of new gas wells or unconventional gas sources and estimating production curves from these resources. I will be doing data analysis for construction of cost curves for US oil and gas basins via modeling and statistical inference.

Student: **Anna Shcherbina** (’11)
Faculty: Roman Stocker (Civil and Environmental Engineering)
Project: Biofilms and Carbon Sequestration
Sponsor: William Chao ‘78

Carbon dioxide sequestration is a promising strategy to reduce greenhouse gas emissions generated from the combustion of fossil fuels. This technique involves injecting supercritical CO2 into deep saline aquifers, coal seams, oil-bearing structures, and other underground formations. “Blow out”- the leakage of CO2 back into the atmosphere through pores in the cap-rock or through fractures, poses a major problem for successful carbon dioxide sequestration. Biofilms -- conglomerations of microorganisms that attach firmly to a surface -- may be used as a tool to combat CO2 leakage from underground aquifers. This UROP project investigates the behavior of biofilms under the harsh conditions required for carbon dioxide sequestration, including analysis of experimental videos of biofilm formation and the development of a numerical model that represents the flow of biofilms through a porous medium as an electric circuit.

Student: **Josh Siegel** (’11)
Faculty: Sanjay Sarma (Mechanical Engineering)
Project: Fuel Efficiency Monitoring in Modern Vehicles
Sponsor: William Chao ‘78

The goal of this UROP is to develop a means of metering energy use where it has the most widespread impact: in vehicles and in buildings. Focusing first on metering energy usage inside buildings, we plan to develop a wireless, mesh-networking sensor for determining how much energy is supplied by each outlet. Each sensor will then update a master node connected to a computer, which logs the data for analysis. The second task is to measure the energy use and path-efficiency of a vehicle. Industry-standard OBDII (on-board diagnostics II) protocol in all vehicles manufactured from the 1996 model year to present provides a readily available source of realtime data. Integrating a Bluetooth wireless OBDII scanner and GPS chipset for localization, we may log critical parameters as a vehicle moves, including engine speed, vehicle speed, fuel consumption, and emissions data. The wired version of this hardware is in development, and the wireless version is to be a modified version of the original.

Student: **Elizabeth Turner** (’10)
Faculty: Robert Jaffe (Physics)
Project: Rare Elements and Scalability of Energy Technology
Sponsors: William Chao ’78

In recent media articles and scientific papers potential problems have been noted regarding the availability of certain critical elements such as lithium (batteries) and tellurium (high efficiency photovoltaics). The purpose of this UROP is to look at the constraints on new energy technologies posed by possible limited supplies of critical elements. The study focuses especially on problems that arise when new technologies are scaled from laboratory experiments to widespread implementation.

Over the course of the summer I will do background research on the rare materials that play a critical role in energy technology. The goal of this project is to create a comprehensive list of materials that appear to be most critical to energy technologies. The critical elements will then be examined in depth and compared in terms of factors such as availability, mineralogy, extraction, reserves, potential for recycling, economics and scalability. Furthermore, I will develop a series of case studies that examine the elements deemed most critical. The final product of the investigation will organize the information that is already available on certain critical elements and analyze and pose questions concerning the future of these minerals with regards to their use in emerging energy technology.

Student: **Juliana Velez (**’11)
Faculty: Leon Glicksman (Architecture)
Project: Data center cooling
Sponsor: Millennial Net (MITEI Affiliate Member)

Data centers are facilities that hold many computer systems. These rooms contain many racks of servers in rows and are kept cold to maintain an optimum temperature for the servers to function properly. The issue of concern is that the methods of cooling these data centers are not very efficient. Currently, the air flows to the servers in such a way that not all the air goes through the servers to cool them. Some of the air from the out flow misses the servers completely and goes directly to the exhaust vent. This inefficient method wastes energy and money. The goal of this UROP is to develop more efficient methods of cooling the data centers, in order to benefit the environment and save on cooling costs.

Student: **Joshua Velson** (’10)
Faculty: Jean-François Hamel (Chemical Engineering)
Project: Conversion of Biodiesel-derived Raw Glycerin
Sponsor: MITEI

The advent of large-scale production of biodiesel brought with it a glut of raw glycerin, which can be contaminated with up to 50% soap, water, methanol and other detritus from biodiesel reactions. This glut has driven down prices to the point where many biodiesel manufacturers must dispose of their co-product at a loss, while pure glycerol prices remain relatively high because the energy-intensive separation process limits the fall in its price. One of the most simple ways in which biodiesel could be made competitive with conventional distillate fuels is to devise a simple way in which raw glycerin can be turned into a value-added product, ideally without separation beforehand. One such way is to ferment glycerin using microbes into a product that can be sold at a profit. The experimental design used in this study will center on medium and culture technique manipulation for the optimization of production of GLA from *Spirulina platensis*.

Student: **Patrick Yamane** (’11) (collaborating with **Haitao Mao** ’12 and **Nikhil Pradhan** ‘09)
Faculty: Thomas Malone (Sloan)
Robert Laubacher (MIT Center for Collective Intelligence)
Project: Climate Collaboratorium
Sponsor: William Chao ‘78

The Climate Collaboratorium, a project of MIT-Sloan’s Center for Collective Intelligence, is a website being built to support large scale collective intelligence to develop plans to address climate change. The idea is to have an online interface that will allow many people to both offer their own opinions about various environmental questions as well as comment on the opinions of others. By using this information, we should be able to develop plans that address climate issues in a manner that will be better supported by the general public and thus more effective once implemented.

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GREENgENERGY

MITEI Affiliate Member

GREENgENERGY's mission is to produce a cost-effective, renewable energy solution that is easily implemented, carbon neutral, aesthetically appealing and community scalable. To accomplish this goal, the company is combining bio-mimicry and nano technologies in a unique artificial-tree design called SolarBotanics which utilize cutting edge photovoltaics, thermovoltaics and piezovoltaics to maximize energy harvesting.

MIT Natural Gas Study

The MIT Natural Gas Study is an 18 to 24 month interdisciplinary effort to understand the future of natural gas in a carbon-constrained world. The study effort is divided into four areas: natural gas supply; demand; natural gas infrastructure and geopolitics; and system studies analysis using the MIT EPPA (Emissions Predictions and Policy Analysis) model. The study examines gas supply and demand globally, with a special focus on North America. As with previous MIT energy studies, one of the primary audiences will be US policymakers.

Millennial Net

Wireless Sensor Networking...Anywhere

MITEI Affiliate Member

Millennial Net is a Massachusetts-based wireless network company that was founded in 2000 by two MIT researchers, Sokwoo Rhee '97 SM, '00 PhD and Sheng Liu '93 PhD, who both have their degrees in Mechanical Engineering. Millennial Net develops wireless sensor networking software, systems, and services that enable OEMs and systems integrators to quickly and cost-effectively implement wireless sensor networks.

Natalie Givans '74 *MITEI Affiliate Member*

Natalie received her bachelor's degree from MIT and master's degree from Johns Hopkins, both in electrical engineering. She is currently the Vice President of Booz Allen Hamilton, a leading strategy and technology consulting firm that is based in Herndon, VA. She leads the firm's Assurance & Resilience team, which delivers Information Assurance and IT Security capabilities and service offerings into the firm's U.S. government and commercial Cyber markets.

Nth POWER

Energy | Vision | Capital

MITEI Affiliate Member

Nth Power is a venture capital firm based in San Francisco. Nth Power funds promising startup companies in the growing sector of energy technology, materials and other related businesses. Nth Power prides itself on playing a visionary role in pushing forward the businesses that are addressing some of the worlds' most pressing energy challenges.

William Chao '78

Mr. Chao received his bachelor's degree from MIT in electrical engineering. He has made substantial accomplishments in the field of logic simulation for large-scale computing systems and digital IC designs, and is President of California-based Innovative Systems & Technologies. Mr. Chao is concerned about science and technology education, national energy policy and the capacity of US technology and engineering developments to meet rising energy demands in a fiscally, socially and environmentally responsible fashion.

Name	Project Title	Class Year	Student Department	Faculty Supervisor
Yieu Chyan	Dibenzocyclooctatetraene Based Electronic Polymers	2011	Chemistry	Swager
Grafton Daniels	Computer Programming for OPUS/UrbanSim Enhancements	2011	Electrical Eng & Computer Sci	Zegras
Julia Day	Application of Micro and Nano-Engineered Surfaces to Increase Power Plant Efficiency	2010	Mechanical Engineering	Varanasi
Ian Fischer	Concentrated Solar Power Experimental Study Group	2012	Aeronautics and Astronautics	Slocum
Daniel Kelly	MIT Electric Vehicle Team Porsche Work	2012	Mechanical Engineering	Shao-Horn, Heywood, Cheng, and Chiang
Haitao Mao	Climate Collaboratorium	2012	Electrical Eng & Computer Sci	Laubacher, Malone
Kwadwo Nyarko	Vehicle Modeling and Testing	2012	Mechanical Engineering	Shao-Horn, Heywood, Cheng, and Chiang
Nikhil Pradhan	Climate Collaboratorium	2009	Chemical Engineering	Laubacher, Malone
Christos Samolis	OPUS/ UrbanSim enhancements	2012	Electrical Eng & Computer Sci	Zegras
Anya Shafiro	Natural Gas Study	2010	Economics	Moniz, Cohn, Meggs
Anna Shcherbina	Biofilms and Carbon Sequestration	2011	Electrical Eng & Computer Sci	Stocker
Josh Siegel	Fuel Efficiency Monitoring in Modern Vehicles	2011	Mechanical Engineering	Sarma
Elizabeth Turner	Rare Elements and Scalability of Energy Technology	2010	Civil & Environmental Eng	Jaffe
Juliana Velez	Data center cooling	2011	Mechanical Engineering	Glicksman
Joshua Velson	Fermentation of Used Vegetable Oil Biodiesel-Derived Raw Glycerin to 1,3-Propanediol using Clostridium Butyricum	2010	Chemical Engineering	Hamel
Patrick Yamane	Climate Collaboratorium	2011	Electrical Eng & Computer Sci	Laubacher, Malone