

# Work in Energy Efficiency



SA+P MIT SCHOOL OF ARCHITECTURE + PLANNING



## MIT Energy Initiative

*The MIT Energy Initiative was established in 2006 to help transform the global energy system to meet the needs of the future and to help build a bridge to that future.*

*The Institute-wide initiative includes research, education, campus energy management and outreach activities that cover all areas of energy supply and demand, security and environmental impact.*

*This booklet details some of the current contributions to that effort by the School of Architecture + Planning, in the following areas:*

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## At the Scale of Individual Buildings

*More than half the world's energy production is consumed in the construction and operation of buildings and urban transportation, and the manufacture of materials related to the building industry. In the US alone, buildings use about 40% of all energy – and 70% of all electricity – and about one third of all investment goes for construction of commercial and residential buildings. Because of these facts, researchers at SA+P are working on an array of efforts to address issues of energy efficiency at the scale of the individual building.*

**Energy Conservation.** Researchers in the Building Technology Program have developed an online tool with which anyone planning a building can readily see how much energy can be saved by orienting the building in a certain way, by making it bigger or smaller or taller, or by selecting various types of windows and insulation.

**Materials Conservation.** Another new computer tool has been developed to find more efficient structural forms during the preliminary design stage. For example, if it had been available in 1955, it could have reduced by half the amount of concrete used in the roof of MIT's Kresge Auditorium.

**Natural Ventilation.** Researchers in the program have also developed a computer tool that enables architects to predict how specific design choices will affect ventilation and occupant comfort, helping to ensure that naturally ventilated buildings can minimize or eliminate the need for conventional air-conditioning, saving both energy and money.

**Natural Light.** Another series of studies is exploring how better to incorporate natural light into building design. Substituting daylight for artificial light holds the potential to

reduce the need for electric lighting by as much as 80% while improving visual comfort and increasing wellbeing. Ongoing research aims at providing interactive and goal-driven methods for daylighting design, investigating technological solutions that could optimize the control of daylight and solar radiation, and generating new metrics for light and comfort that include climate and health considerations.

**Intelligent Buildings.** The Center for Bits and Atoms has launched a large-scale test-bed project to develop intelligent infrastructure. Early trials have found that as much as a third of the energy used for the lighting, heating and cooling of buildings can be recovered if building components collaborate – so that, for example, air handlers don't push conditioned air through open windows, lamps can adjust their brightness in response to natural light, and heating and cooling can vary with the occupancy of a space.

**Responsive Environments.** Researchers at the Media Lab are developing a novel sensor network system designed to detect the comfort level of building occupants, both in terms of temperature and lighting, and use this information to minimize energy con-

sumption by the building, while maintaining a reasonable level of comfort for the occupants. Research into current standards of environmental comfort will influence the creation of these 'reasonable' comfort zones, and will direct feedback and training of the system by the users.

**Highly Responsive Homes.** The Open Source Building Alliance in architecture has embarked upon a collaboration with a New Hampshire builder to develop and test a process for creating highly responsive homes. A goal of the initiative is to engage industry in the development of scalable solutions for creating mass-customized, zero-energy homes, bringing together advanced academic research with sophisticated commercial design and production processes.

**Environment Management.** The PlaceLab, a residential condominium designed to study how people interact with new technologies and home environments, is developing innovative user interfaces to help people easily control their environment and save resources.

**Prefabrication.** A research and design project of SA+P's Design Lab, yourHOUSE is a prefab version of New Orleans style 'Shotgun' housing using recycled plywood as the primary structural material. Fabricated entirely of friction-fit components with tabs or slots for easy assembly, yourHOUSE uses mass-customized as well as mass-standardized components to achieve low energy housing delivery, low cost construction, minimization of waste on construction sites, design cost controls and disaster response. yourHOUSE was developed in response to increasing concern about issues such as sustainability and the swelling global population, issues that have once again put prefabrication in the spotlight as a potential solution to a host of pressing problems.

**Masonry Vaulting.** Research on masonry vaulting is being implemented to create new low-energy buildings made from local materials. Researchers designed and constructed vaulting for a sustainable conference center near Dover, England that was awarded prizes for originality and sustainability from the Institution of Structural Engineers in London. A project now under construction in South Africa uses local materials to construct masonry vaulting for a low-energy museum at a World Heritage Site.

**Landlord Investment in Energy Efficient Building.** This research examines the impact of the standard lease structure in the Boston office market on landlord investment in energy efficient building systems. Research includes interviews with landlords, tenants, property managers, brokers, attorneys, engineers and contractors to try to determine that effect, and to gauge their willingness and/or desire to make changes to the existing lease structure.

**Green Architecture.** The development of prototype housing for rebuilding in the hurricane-affected coastal bayous is focused on 'green' attributes of energy and environmentally sensitive design and material elements. The prototypes are intended to serve as examples for contractors and the many informal builders.

**Green Architecture Guide.** A recent theory and materials course on sustainability questioned the trendy rhetoric of today's developers and confronted the design profession's deep desires to proceed untrammelled with aesthetic questions over functional ones. The course produced a critical booklet, the Green Architecture Guide, pointing to the 'paper-thin discourse' that allows business as usual to proceed.

**Sustainable Urban Housing.** Research into the design of community housing that integrates sustainability, urban density, community need and material and technological development aims for a new form of urban housing that is energy self-sufficient and carbon negative. Focused primarily on 'next generation' innovations for pre-manufactured urban housing, the researchers hope to build a prototype cluster of houses near MIT, followed by a larger developer-funded project in the Boston area; studies are underway to test potential design strategies on MIT-owned sites in Cambridge.

**Sustainable Connected Homes.** Researchers in the Mobile Experience Lab are exploring sustainable connected homes, including subtopics of renewable energy systems, sustainable architecture, social sustainability and connected information systems to optimize home behavior. A goal is to build a full-scale prototype of a sustainable home with new technologies, materials and applications.



## At the Scale of the City

*While cities cover only 2% of the world's surface, they accommodate half the world's population and consume three-quarters of its resources. Within the next twenty years, they will also account for more than half the growth in global energy consumption. But in their density and compactness, cities also present a substantial opportunity for easing the causes and effects of global warming. To meet the global energy challenge, it will be crucial to help cities to formulate, test and implement strategies to reduce demand. The school is playing a key role in creating new understanding of urban energy policy choices at the city scale.*

**Sustainable Cities.** Researchers in architecture are working on establishing an agenda for Boston, informed by current best practices, that will help it become an example-to-follow as a 21st century sustainable city. It is already well on its way: Boston is the first city in the nation to adopt LEED Gold as an equivalent standard in its zoning ordinance for all major new construction efforts.

**Forecasting Tools.** Researchers in urban studies and planning are developing new forecasting tools to analyze the costs and benefits of energy strategies, exploring ways of building broad-gauged consensus regarding our reliance on renewable energy supplies.

**The RoboScooter.** In response to growing congestion in cities, and to booming auto sales that threaten to jam streets and pollute the air still further, the Smart Cities group at the Media Lab has developed a clean, green, silent scooter that can be folded in half and towed like a rolling suitcase – easy to take on trains, or indoors – or stacked in a rack for storage and battery charging.

**The City Car.** The Smart Cities group has also developed a stackable electric car that promotes a more efficient means of urban mobility. Designed to be used in dense urban markets, the vehicles can be stacked at key points of convergence throughout the city to create a transportation network that takes advantage of existing infrastructure such as subway and bus lines.

**Green Hub.** In conjunction with many other partners, the Community Innovators Lab is forming a 'green hub' at MIT to serve as a resource for governments, communities, institutions and investors pursuing the transformation of the world's cities from wasteful centers of resource consumption to generators of green industry, renewable energy and environmental stewardship. The Hub brings together experts on technology, methods, business models, financial models, social technologies and relationships for social inclusion to help create opportunities for innovation in green transformation. Central to the initiative is the proposition that successful carbon reduction/environmental sustainability is not possible without also paying attention to social equity.

**Sustainable Residential Neighborhoods.** Efforts in the Longhua District of Shenzhen, China, are dedicated to the development of housing and neighborhoods that are sustainable in economic, environmental and social dimensions. In energy use specifically, students have explored the ways in which housing density, the location of community facilities and walking/cycling paths can create a vital neighborhood in which automobile use is not needed.

**Transportation Innovations and Land Development.** Developed as part of the MIT Portugal Program, in collaboration with three Portuguese universities, this research aims to define innovative transportation solutions that may also contribute to more sustainable urban development patterns. A particular focus of the work is on the revitalization of urban districts in areas with low availability of street space.

**Real-Time Transportation Data.** Also developed as part of the MIT Portugal Program, this research focuses on the development of a knowledge infrastructure, computational models and user applications that allow access to real-time information about the state of transportation-related resources, as well as predictions regarding their future conditions. A pilot service will be provided to citizens – for making transportation services more efficient to use – and to policy-makers as a decision-support tool.

**Transport System Sustainability and Efficiency.** Developed as part of the MIT Portugal Program, this research aims to conceive, organize and simulate the implementation of new smart transport modes and services to optimize their integration with existing forms of transport.

**Travel Behavior of Older Adults.** SA+P researchers are seeking to better understand the residential and travel preferences of older adults in the Boston Metro Area. The research has included focus groups and a mail-

back survey, an attitudinal travel survey and a one-day travel diary disseminated to 7000 boomer households in suburban Boston. The aim is to inform community development efforts to ensure that current and future communities can meet the needs of older adults and the broader community.

**Healthy Neighborhood Design.** A joint project with the Harvard School of Public Health, this research seeks to assess the factors which induce walking, cycling and walks-to-transit to produce more healthy lifestyles and reduce dependence on the automobile for day to day travel. The project is evaluating patterns of neighborhood design, organization and land use to develop optimal models for healthy, low-impact development that can be implemented by the private sector.

**Clean Energy City.** Research funded by British Petroleum is reviewing 25 years of development practices in Beijing to determine their impact on development patterns and energy consumption. The study is using data developed through the Beijing Urban Design studio which has proposed development projects across the city since 1985. The project will result in a refocusing of the studio in the future to create new design and development models that consume less energy with cleaner results.

**Sustainability Indicators.** In collaboration with the Swiss Federal Institute of Technology, Chalmers University of Technology, the University of Botswana, the Catholic University of Chile and the University of Witwatersrand, SA+P researchers are developing sustainable urban development indicators based on three case cities – Santiago de Chile (Chile), Johannesburg (South Africa) and Gaborone (Botswana).

**Responsive Urban Systems.** Research sponsored by cities in Spain, Korea and Italy is developing new urban systems that are more responsive to weather, climate and human use, creating more efficient environ-

ments. The energy savings could be substantial: as one example, the SmartPark project allocates street and private parking spaces to individual cars as they approach the city, depending on willingness to pay; reserving spaces in this way will drastically reduce the time and gas used in the search for parking, which is estimated to consume up to one third of the energy used by cars in cities.

#### **Training a New Generation in Thailand.**

SA+P faculty are advising the City of Bangkok on the creation of a new university charged with training a new generation of city planners and public administrators to convert Bangkok into a model of sustainable development. Students will engage in real-time efforts to redesign the city's infrastructure, development patterns, water usage, transport and other elements to create a more efficient and healthy city, reducing energy consumption and pollution by redirecting growth and reforming development patterns.

**Sustainability in Action.** In a course focused on improving sustainability and lower resource utilization in Boston, a group of students developed a project encouraging retrofits to foreclosed real estate in the city that would be energy efficient and contribute to neighborhood stabilization.

**Sustainable Housing in China.** Research funded by the Vanke Corporation, China's largest home builder, is developing more energy efficient, sustainable models of high density housing that could feasibly be developed in Shanghai and Shenzhen. The project began by assessing the range of existing housing types being built in major cities of China for their energy consumption and livability. Approaches to retrofitting these older projects to improve their efficiency have been proposed, as well as models for new housing development that will save energy, water and other resources.

**MIT@Lawrence.** Faculty and students are working on a variety of projects aimed at solving energy related problems in Lawrence MA. The Green Commons Project focuses on local initiatives in the energy and environmental arena, from youth education to efficient housing design and construction. Future projects aim to bring these efforts to scale by building on MIT's expertise and the Merrimack Valley's plan to develop a sustainable technology industry cluster to ensure Lawrence residents and businesses participate in the region's 'green revival'.

**Urban Metabolism.** SA+P researchers are developing an urban metabolism tool that tracks the flow of resources through cities; the tool will help planners gauge the environmental impact of different urban development strategies.

**The Platform for a Permanent Modernity.** Researchers are seeking to reduce the energy footprint of new urban developments by focusing on the long-term ordering potential of infrastructure and infrastructural architecture. The aim is to reduce the capital energy investments in new infrastructure by developing simple, effective, multi-usable and multi-interpretable orders. The focus is on the establishment of ordering principles that can outlive a first generation of investment and continue to benefit future users, long after current fashion and technology have become outlived.

**Urban Sustainability Evaluation.** This research aims to ascertain whether cities' efforts to become more sustainable are actually yielding environmental and social benefits. It focuses on energy consumption, as well as water use, habitat conservation, waste production and disposal, food production and consumption, and other environmental impacts of cities. The first phase looks at 100 US cities; later phases will involve international comparisons.

**The Sustainable Green Village.** Researchers at the Design Lab and Mobile Experience Lab are partnering with Italy's Provincia di Trento and the Fondazione Bruno Kessler to investigate how to transform the village of Zambana into a Sustainable Green Village. The goal is to redesign the village from an urban planning perspective, as well as from architectural and new media design perspectives, to explore a variety of ideas, scenarios and concepts.

**New Century Cities.** A joint research effort by the Center for Real Estate, the City Design and Development Group and the Media Lab is exploring the potential of New Century Cities such as Seoul's Digital Media City and other projects in Belfast, Helsinki, Copenhagen, Singapore and elsewhere. The technologies these cities deploy include such things as programmable street furniture and remote utility maintenance, as well as digital signage that can be updated by the minute. Global positioning technology makes it possible to pinpoint people and activities at any time, while miniature sensors enable even more location intelligence by tracking data such as

the amount of natural light and people movement in an individual room, automatically adjusting the environment. Not all of these characteristics are unique to New Century Cities but NCCs combine these characteristics to support new kinds of places, activities and lifestyles, making them living laboratories in which people can experience and test the future today.

**Adapting to Climate Change.** Faculty and students in the Department of Urban Studies and Planning are working on the development of an online tool to help municipal governments around the world adapt to climate change. The need for the effort arises from the fact that local governments around the world are faced with the challenge of integrating complex climate change issues into their local planning processes but few tools have been developed to help them meet that challenge. This project was the first step toward developing such a tool. Among other things, it will help cities learn what others in similar situations have already tried, especially simple steps that can be implemented in the course of their normal activities.

## At the Regional Scale

*By 2030, the share of the world's population living in developing regions could reach 81 percent, according to United Nations projections, and those countries will account for 62% of the rise in energy demand. Developing countries are also forecast to account for two-thirds of the projected increase in carbon dioxide emissions. Four major countries alone -- Indonesia, China, India and Brazil -- will emit two billion tons of carbon annually by 2010. Because of that, SA+P is paying a great deal of attention to energy issues in China and India.*

**Energy Efficiency in China.** Research efforts in China are focused on Beijing as the first city-scale example of energy efficiency in the context of a developing economy. Design studios, energy seminars and planning practicum courses provide important opportunities for student and faculty interchanges. At the regional level, researchers continue to study the networks and processes that feed into a city-scale energy efficiency framework that looks 50 years into the future.

**Energy Intensity in China.** Researchers in urban studies and planning are exploring energy intensity in China in hopes of helping develop policies for technological change and for reducing the generation of pollutants. In one study, they focused on measuring the energy intensity in the manufacture of coke; in another, they measured pollution levels in cokemaking plants and coke-workers' homes to assess the potential health risks of the entire cokemaking process. Currently, they are studying the regional distribution of coal-generators in China for the production of electricity and the coal transportation required to supply the Chinese power plants.

**Land Recycling in China.** As many energy-intensive plants – such as iron and steel, chemicals and cokemaking – are being closed and/or relocated from the center of urban areas in China to the periphery or to other regions, researchers are studying the implications of this regional restructuring on the land and on the physical infrastructure, housing, financial structure and socioeconomy of the region.

**Efficiency in Chinese Building.** It is projected that by 2094, housing will account for a third of total energy use in China – meaning that for every nine units of energy consumed in the world, one will be used for Chinese housing. An international research program is underway at SA+P – a collaboration with six other schools in China, Switzerland and Japan – to identify new technologies, and applications of current technologies, that will increase the environmental efficiency of Chinese building. In addition to designing, building and evaluating a number of buildings, the program features a series of seminars and workshops conducted by MIT to educate developers and architects in China on the technologies and design approaches utilized during this project.

**Housing in China.** Another effort in the building technology program, the China Housing Project, is a collaboration of architects and engineers aimed at designing low-energy sustainable buildings with developers' needs in mind. Those researchers are also involved in the Norway Project, making buildings more energy efficient in Scandinavia.

**Rapid Urbanization.** Current efforts in China seek to expand the range of real estate products offered in the marketplace and to develop models for a more sustainable architecture and lower-impact development. In India, efforts are focused on combining financial research with spatial and institutional analysis in the evolution of planning strategies and development policies to sustain economic growth. Work in Mexico City is focused on such key factors as downtown development, land use, sustainability and urban insecurity.

**Sustainable Sanitation in India.** A practicum on human rights and sustainable sanitation in the Indian state of Gujarat resulted in a potential solution to the human rights issue of manual scavenging, the act of removing excreta from dry pit latrines. The MIT team designed a latrine that makes sanitation safe from both the users' and cleaners' perspectives, requiring neither water nor the laying of expensive sewer piping. Over time, if correctly operated, such Ecosan latrines are more sustainable and less resource-intensive than pour-flush toilets.

**Sustainable Entrepreneurship.** The Legatum Center for Development and Entrepreneurship provides a launching pad for entrepreneurs who want to develop the skills and technologies necessary to operate innovative businesses in the developing world. Its initial cadre of students comes from around the world – including Rwanda, Nigeria and Pakistan – and includes students working on ways to harvest rainwater in eastern Africa; to incubate mobile phone technologies in Pakistan;

to use mobile technologies for health diagnosis in Nigeria; and, to address deforestation rates approaching 98% in Haiti, to produce low-cost charcoal using sugar cane waste instead of timber.

**Green Infrastructure.** Researchers are working on the implementation of low-tech ecologically driven design solutions that address development impacts while maximizing the benefit of natural systems. Specific work includes stormwater management, road ecology, urban streams and constructed wetlands, flood zones and waste water solutions. Recent work in East Biloxi MS addressed strategies for hazard mitigation along the Gulf Coast where new residential neighborhoods and tidal bayous must co-exist.

**Reclaiming Wastelands.** The Project for Reclamation Excellence (PREX) studies ways to reclaim vast waste landscapes created by outmoded industry, mining and abandoned development on a regional level. The aim of the project is to develop strategies to bring these areas back into productive use, saving enormous amounts of energy and resources now consumed by developing on virgin land and leaving wasted landscapes untouched. The project also aims to develop strategies that will build the capacity for regeneration and recycling into the design of major new development, to reduce waste in the future.

**Production of Biofuels.** SA+P researchers are studying the differences in labor, capital and land used in alternative production technologies to produce ethanol in the North and South of Brazil.

**Islamic Architecture and the Environment.** A recurring architecture course explores how Islamic architecture and urban planning coped with environmental constraints in different areas and climates, turning them into constructive design tools. It examines the strategies behind the design of selected

examples ranging in scale from the region to the city, the house, the garden and the single architectural element; it also explores the social, cultural, symbolic and psychological dimensions of environmental design as they developed over time.

**Water-Conserving Design in Comparative Perspective.** A new architecture course explores water-conserving design in the Islamic realm – which varies from arid to humid, and from coastal to mountainous landscapes – compared with the US and Europe, which share common points of contact and significant differences along with a highly contested literature on the role of water in cultural history.

**Landscapes of Islamic Environmental Design.** This seminar-workshop explores contemporary Islamic environmental design. The course combines systematic study of Islamic landscape history and theory, with reanalysis and redesign of award-winning projects in the Aga Khan Award for Architecture.

**Water and Wisdom in Islamic Environmental Design.** This research seminar develops and tests theories of water in environmental design with an emphasis on one or more urban environments in the Islamic realm. Participants explore how water knowledge, creativity and wisdom have historically, and might theoretically, be synthesized in the design process.



## At the Global Scale

*According to the US Department of Energy, global energy consumption will grow by more than 50% during the first quarter of the 21st century. But the global supply of energy is not growing fast enough to keep up with demand, especially from the United States and the developing nations of Asia. Unless there is a shift in world energy policies, global energy demand will continue to strain the world economy and the environment. Researchers at SA+P are approaching the issue from a number of angles.*

**Environmental Decision Making.** A program in urban studies and planning is focused on finding better ways to incorporate science into environmental decision-making. Students are trained as intermediaries who can facilitate effective interaction between government science agencies and a wide range of stakeholder groups and elected public officials. Graduates of the program are currently working for the US Environmental Protection Agency, CERES, National Oceanic and Atmospheric Administration, US Forest Service and the Rockefeller Foundation.

**Green Development.** The Center for Real Estate maintains an ongoing commitment to encouraging a culture of social responsibility in the global real estate industry, regularly visiting the issue of sustainability in all of its courses and fieldwork; new educational offerings that pointedly explore green development are also being developed.

**Global Treaty Negotiations.** In conjunction with the Program on Negotiation at Harvard Law School, SA+P faculty have been leaders in the study of global climate change negotiations, assessing the prospects for reforms

in the global treaty making system that will resolve long-standing conflicts between the developed and developing world, increase the direct role of civil society in treaty formulation and implementation, and enhance the role of scientific advisory panels.

**Green Technology Innovation.** Through the MIT Alliance for Global Sustainability, SA+P faculty along with their international colleagues, have developed the Public Entrepreneurship Networks (PENs) model now being used to examine green technology innovation in six countries. The PENs model offers a fresh approach to meeting goals for greenhouse gas reduction.

**US Energy and Food Security.** Researchers are testing the hypothesis that conventional measures of direct and indirect energy requirements for food Gross Domestic Product (GDP) – as measured by the energy-cost share of food GDP – may lead to a substantial measurement bias that understates this energy requirement. They also plan to develop a decision-support system to assist decision-makers in managing agriculture/food emergencies.

## Work Outside of MIT

**Portable Light.** Sheila Kennedy's MATx team initiated the paradigm-changing Portable Light Project, a non-profit global initiative to develop portable energy harvesting technology in a textile form that can be adapted by local people; the project has expanded to serve five countries and is currently working with the Massachusetts General Hospital and the iTEACH Program to provide renewable power and light to people with HIV and TB in South Africa. Kennedy and her colleagues have also developed the SOFT HOUSE, which transforms household curtains into simple 'plug and play' solar textiles that can be moved along a track to harvest energy.

**One Laptop Per Child.** Several of SA+P's faculty have been involved with the One Laptop Per Child project, a now-independent effort to reduce the amount of energy needed by laptops and servers to make them suitable for off-the-grid deployments, and to come up with alternative power solutions for educational computing and communications resources.

**Clean Development Mechanism and Transportation.** For the past 7 years, Chris Zegras has been examining the potential use of the Kyoto Protocol's Clean Development Mechanism (CDM) to induce changes in urban mobility patterns in developing countries – through changes in vehicle technolo-

gies, shifts to lower carbon intensity mobility options, and modifications to urban growth patterns in Santiago de Chile. Currently he is developing a methodology to qualify urban development projects for the CDM, by the changes in travel behaviors produced, examining the specific case of urban China.

**Student and Faculty Efforts in New Orleans.** PhD candidate Will Bradshaw (MCP'06) is the founder of Green Coast Enterprises, a sustainable building firm located in New Orleans; to help them achieve their vision, Bradshaw and his business partner Reuben Teague were awarded Echoing Green Fellowships for 2008-09. Bradshaw and Jeffrey Schwartz (MCP '08), amongst others, also helped the City of New Orleans write its successful DOE Solar Cities grant, and Schwartz joined with David Quinn (Building Technologies '08) to help write the City of New Orleans' sustainability/green road map, awarded \$1.5M in funding from the Ford Foundation.

**Consensus Building.** Lawrence Susskind received the Global Environment Award from the International Association for Impact Assessment for his 'outstanding, sustained and unique contribution to the field of environmental assessment, especially in regard to the founding of the Consensus Building Institute -- an organization which has been involved

in resolving hundreds of intractable environmental disputes'. It is currently involved with a wide range of resource management disputes including the mediation of Bedouin land claims in Israel, air quality management in Mexico City and strategies for resolving facility siting disputes in Korea.

**LEED Building.** Michael Dennis' dormitory at Princeton attained a 'silver' LEED sustainability rating by using techniques such as bamboo floors, deep-set triple-glazed windows with built-in louvers and extra layers of gypsum to increase internal thermal mass. Within ten years, the extra costs incurred by including those features will be paid off in energy savings.

**LEED Gold Certified Building.** A pivotal part of urban revitalization in South Boston, Nader Tehrani's Macallen Condominium Building is the first LEED Gold certified building of its type in Boston. It is fully integrated – in structure, MEP and sustainability – replete with sustainable features such as a sloped green roof that controls storm water drainage and reduces heat island effect; the use of local, recycled, rapidly renewable and low VOC materials; and a fresh air ventilation system with energy recovery units that capture energy from exhaust sources.

**First LEED Certified Gas Station.** Nader Tehrani's Helios House in LA transforms an existing gas station in an environmentally conscious manner by 'upcycling' old materials and installing new materials that are sustainable and recyclable, making it the first LEED certified gas station. Features include 90 solar panels that cover the canopy's roof; energy-efficient lights and sensors throughout; a green roof of native plants over the back building; a water collection system that contains the run-off of contaminated water in an underground cistern, filters and distributes to irrigate plants on-site; 100% recycled glass aggregate in the concrete mixture; and prefabricated stainless steel panels to conserve labor costs and reduce material waste.

**Green Theater.** Matthew Mazzotta, a graduate of the visual arts program, is developing a Green Theatre that runs 100% from the energy of the natural environment and the physical actions of the audience – a performance driven habitat that, like nature, is self-sustaining, regenerative, energy harnessing and self-cleaning. It asks the audience to be an active participant in the performance by fueling the sounds, lights and temperature of the space.

## Alternative Approaches

**Water Wall Technology.** Researchers at the SENSEable City Lab have developed a building made of water, its liquid curtain walls achieving maximum effect with a minimum of resources. Named one of the best inventions of the year by Time, the Digital Water Pavilion uses very thin streams of water so the throughput needed to create large surfaces is remarkably small and the cooling effect of the vapor eliminates the need for air conditioning.

**Harnessing Human Power.** Two graduate students from the Department of Architecture won an international competition for thinking outside the box by proposing to harness human power as a source of sustainable energy. The Crowd Farm would harness the energy generated by human footsteps through a responsive flooring system that absorbs vibrations of movement that would otherwise be wasted.

**Solar Power.** Researchers in architecture are working on incorporating alternative energy sources into interactive light and sound installations for public spaces. Meejin Yoon's Hover is a solar powered canopy that harvests energy by day and illuminates at night – an off-grid lighting system that creates shelter, shade and light for public use.

**Rammed Earth.** A group of MIT students engaged in a long-term test of rammed earth – a construction technique used in the Great Wall of China 2000 years ago – to see how relevant it might be to the modern industrialized world and, in particular, to the New England climate. By conservative estimate, the production of cement accounts for 7% of the world's CO2 emissions, while the preparation of a rammed earth mixture produces very little CO2 and uses no toxic chemicals at all. A building made of rammed earth also creates no disposal hazard when it is demolished.

**Off-Shore Wind.** Researchers in the Environmental Policy and Planning Group in the Department of Urban Studies and Planning are monitoring the changing federal and state regulatory context for reviewing the environmental impacts of proposed off-shore wind energy facilities. The group has been asked to assess experiments just getting underway with floating facilities far off-shore.

**Regulation.** Recognizing that the solution to our energy problems will be cultural as much as technical, researchers in the history, theory and criticism program are working on the concept of regulation as it emerged around questions of energy systems in the environment and building trades. Understanding the history of what gets left out and put into the system is a crucial step in formulating future approaches.

**Camera for the Invisible.** Researchers at the Media Lab are developing a camera for exploring and experimenting with the urban environment; the camera doesn't sense light, but rather things that the eye can't see like CO<sub>2</sub>, temperature or wind.

**Urban Utopias, Heterotopia and Dystopia.** In the fall of 2008, the Monday Night Lecture Series @ the Visual Arts Program will examine alternative communities, societies to come and scenarios if we do not change our use of resources.

**The FEMA Trailer Project.** A researcher in the Visual Arts Program has arranged to host a FEMA Trailer at MIT as part of a course to develop proposals for its eventual transformation. The project will identify and work with a community partner to convert the trailer into a sustainable vehicle that addresses the frequency and complexity of emergencies in contemporary society. The project will serve as a model of environmental sustainable building practices.

**Chameleonic China.** An art project by a graduate student in the visual arts program seeks to illustrate the public's evolving perceptions of China and issues of sustainability in a physical way, educating online visitors by portraying and exposing the complexity of the issues through a visual display of the network system of relevant actors. The final participatory element of the piece poses a query to visitors regarding the issue of sustainability in China.

**Automatic Polling of Wildlife Creatures.** Researchers are exploring the use of cell phones to extract environmental information from recordings of bird vocalization through cell-phone networks. The idea has strong repercussions in conservation projects, born out of the need to automate and facilitate bird population surveys.

**Electricity from Cow Dung.** Research at the Legatum Center is developing technology that will enable rural Bangladeshi to generate electricity from cow dung, an innovation that won a silver at the 2008 Asian Innovation Awards. The cow dung, converted to methane gas through a bio-digester, could drive a Stirling engine to light a small cluster of houses for six hours every evening. A core feature of the innovation is that it makes the most use of every part of the process, both minimizing waste and improving efficiency. The manure itself is recycled; the biogas-production process pushes out a slurry that can be used for fertilization and composting, boosting productivity on the land; the methane gas, instead of being released into the atmosphere, is fed into the electricity production, improving health and hygiene as well as the environment; and the heat generated as a byproduct can be used to heat homes and water and/or dehydrate vegetables and fruit.

# Comprehensive Programs

*The School is engaged in a number of cross-cutting efforts with significant efforts in energy efficiency.*

## **The Building Technology Program**

The Building Technology Program is an interdisciplinary program jointly sponsored by the Department of Architecture with the departments civil + environmental engineering and mechanical engineering. Their work applies recent advances in the fields of materials, manufacturing and thermo-fluid sciences to the construction of new buildings, to the retrofit or rehabilitation of existing buildings and to the efficient operation of buildings.

## **The Joint Program in City Design and Development**

The Joint Program in City Design and Development is a collaboration of all the divisions of the school that seeks to better understand the changing urban environment and to invent new architectural forms, public policies, development products and technologies that will improve the quality of urban life. The program addresses both cities and urban regions, examining ways they have been designed, planned and developed in the past, while proposing new visions for the future. It is also international in scope, with studios and research projects in the US and worldwide.

## **Environmental Policy and Planning**

Environmental Policy and Planning is a program in the Department of Urban Studies and Planning focused primarily on training people for careers in the public and not-for-profit sectors worldwide. Faculty have expertise in areas such as dispute resolution, environmental politics, and civil society mobilization. Faculty research and teaching focus on a range of substantive issues, including pollution prevention, habitat and natural-resource conservation, urban sustainability, adaptation to climate change, toxic and hazardous waste reduction, and the siting of public facilities. The faculty are also directly involved in environmental policymaking at the local, national and international levels, helping to formulate more sensible regulatory strategies, pursuing environmental justice and addressing the problems of enforcement in a global context.

## **UrbLab**

Established in 2006, the Urbanization Laboratory is a program of joint research and academic projects focused on design and development issues posed by rapid urbanization. UrbLab addresses the many challenges and opportunities posed by urbanization through policy, finance and design mechanisms,

working at scales that range from single buildings to entire regions. The program builds on twenty years of collaboration between the schools of architecture and planning at MIT and Tsinghua through the Beijing Urban Design Studio, one of the world's most enduring academic programs between the US and China. Since 1985, close to 400 students and faculty have taken part in the studio, working together on issues of urban design and development. Current efforts focus on China and India; future projects are in development for Brazil, Mexico and South Africa.

### **The Design Lab**

A new research lab in the School of Architecture + Planning engages people from all the school's divisions, and from elsewhere in the Institute, to come together to work on projects that cut across the traditional boundaries of design and engineering disciplines. Organized as a collection of multidisciplinary teams, the new lab works on projects that explore the interfaces of technology with complex human systems, addressing problems of social, economic and cultural importance. Unlike existing MIT labs, the new lab is primarily concerned not with individual products

and systems employing particular technologies, but with taking a comprehensive design approach to buildings and urban areas and the roles these play in larger systems and their long-term sustainability.

### **Transportation**

The approach to transportation issues in the Department of Urban Studies and Planning includes multi-modal coursework, practice and research that incorporates economic, social and environmental values and understands the fundamental relationship between transportation and the built environment. Working both domestically and across the world, efforts include planning, designing and developing interventions for neighborhoods, cities, regions and mega-regions.

### **Regional Planning Track**

Faculty and students in the regional planning track of the Department of Urban Studies and Planning are working on various energy and environmental issues in Brazil, China, India, Iran and the United States.

## Putting Our Own House in Order

**GreenSAP.** GreenSAP is a student group in the School of Architecture and Planning that works on sustainability and environmental issues. The group connects students interested in pursuing sustainability in their education, research, and careers to share knowledge and perspectives across different disciplines, and to connect these interactions with their educational experience. The group pursues projects to encourage sustainable operations within the school – including a carbon emissions audit, research into printing use, initiatives to reduce the impact of food at events, better recycling information, a postcard to encourage faculty and staff participation in a sustainable campus and a toolkit for audits of MIT departments' energy use. Future projects will include a pilot compost project and an audit of energy consumption from lighting and other infrastructure.

### **Campus Parking and Transportation.**

SA+P students helped initiate a class to look at campus transportation policy and made recommendations to the parking and transportation committee to influence more sustainable transportation behavior on campus. The class focused on ways to shift employees away from parking towards public transit, including commuter rail. Students explored the relative roles of MIT and the MBTA as transportation providers, as well as the efficiency and effectiveness of related subsidy policies currently in place for all modes of transportation.

