MASSACHUSETTS INSTITUTE OF TECHNOLOGY

MIT JOINT PROGRAM ON THE SCIENCE AND POLICY of GLOBAL CHANGE

Global Changes

Spring 2013 | In this Issue

MISSION AND OBJECTIVES

Integrating natural and social science to further the international dialogue toward a global response to climate change

- Discover new interactions between natural and human climate system components
- Objectively assess uncertainty in economic and climate projections
- Critically and quantitatively analyze environmental management and policy proposals
- Improve methods to model, monitor and verify greenhouse gas emissions and climate impacts
- Understand the complex connections among the many forces that will shape our future

IN THIS ISSUE:

The Climate Impacts of Emerging Energy Technologies

In the 1930s, chlorofluorocarbons (CFCs) were invented and began to be used in household and commercial refrigerators. At the time, these very inert non-toxic chemicals appeared to be ideal for their purpose. With further time, their use expanded to household and mobile air conditioning, aerosol spray cans, industrial solvents and plastic foams. By the 1970s a global multibillion-dollar industry had formed with over 20 chemical companies producing and selling them worldwide. It was only then that scientists discovered that the levels of CFCs were growing rapidly in the atmosphere, and subsequent laboratory experiments, theoretical studies and atmospheric measurements would confirm that these chemicals were ultimately destroyed in the upper atmosphere depleting the Earth's protective ozone layer. The Montreal Protocol phasing out these chemicals quickly followed.

This history underscores an important lesson for efforts to transform the global energy industry toward lower or zero emission technologies: namely the need to consider energy alternatives not just at the scales of the laboratory and early deployment, but also at very large scales. Drawing on our integrated global system modeling capabilities, we do a lot of this type of thinking in the Joint Program. In recent years, we've been taking a critical look at a number of emerging new energy sources to evaluate their climate and other environmental impacts.

Read More:

Reprint 2012-23: Characterization of wind power resource in the United States, *Atmospheric Chemistry and Physics*.

Reprint 2012-11: Using Land to Mitigate Climate Change: Hitting the Target, Recognizing the Trade-offs, *Environmental Science and Technology*.

Reprint 2011-7: Potential climatic impacts and reliability of large-scale offshore wind farms, *Environmental Research Letters*.

Reprint 2010-3: Potential Climatic Impacts and Reliability of Very Large-Scale Wind Farms, *Atmospheric Chemistry and Physics*.

Reprint 2009-20: Indirect Emissions from Biofuels: How Important? *Science*.

Report 227: Impacts of Land Use and Biofuels Policy on Climate: Temperature and Localized Impacts, Joint Program Report Series (August 2012).

http://globalchange.mit.edu/research/publications

Natural gas is one of the sources we are focusing on because the expansion of hydraulic fracturing of shale has opened up a potentially major source of fossil energy for the future. However, the environmental implications of the use of natural shale gas are being heavily debated around the world. (Francis O'Sullivan and Sergey Paltsev studied the release of greenhouse gases during fracturing itself, see page 6).

In principal, replacing coal with gas could cut in half the amount of carbon dioxide emitted per unit of electrical energy produced by power plants. This conversion is already beginning to happen in the U.S. because of the low price of gas. So, we then asked the question: what if all coal-fired power plants were converted to natural gas? Would this be enough to induce a significant near- and long-term slowing of global warming? Not quite, as work I presented, along with my colleagues Sergey Paltsev and Andrei Sokolov, at the recent MIT Global Change Forum in Banff shows. If the conversion occurred, and leaks in natural gas pipes are fixed, global warming would decrease by as much as 1.8 °C. But, if that's the only step taken to confront climate change, the world would still warm by about 3.5 °C by 2100. Thus, converting coal to gas leads us in the right direction, but by itself is insufficient; it should be considered as a useful step toward alternative lower emitting forms of energy.

One potential low-emitting alternative is biofuels. Chemical engineers here at MIT are using cellulosic processes to make it cheaper to convert sugars and starches into fuels. Presuming this technology will develop over the next decade, what would the consequences be if biofuels went to large scale? One of our studies shows the use of biofuels could lead to significant deforestation, causing large emissions of greenhouse gases. If the biofuels industry were held responsible for paying for those emissions, it could take up to 40 years for them to see a net return on their investment. The alternative is more intensive use of arable land by using fertilizers and irrigation, and Africa, where arable land is cheap, would become a big player. Done right, and with these environmental challenges considered, a transformation to biofuel energy could be a significant part of our energy future. Food prices would increase, but not as much as some predict.

Much attention has also been paid to wind and solar. While both sources are too expensive to go to large scale right now and require subsidies to encourage their use, other significant challenges also exist. One obvious challenge is intermittency. Both technologies only work when the wind is blowing or the sun is shining. For the continental U.S., we've found that when the wind stops blowing in one area, it stops blowing in a very large surrounding region. This unfortunate coherence is lessened, but not removed, for off-shore wind farms. Because of this, the wind energy would either need be stored or back-up sources would need to be available—adding to the cost of this already expensive technology. Our preliminary research finds the available sunlight acts similarly.

The environmental challenges, however, go beyond availability. We have looked at the effect that very large wind farms generating terawatts globally could have on both regional and global climate. Our predictions —apparently confirmed by a study in Texas comparing satellite data before and after a wind farm was installed—show large-scale wind farms could cause a local warming of up to 1 to 2 °C and affect the global atmospheric circulation.

Solar energy has a similar effect at multiterawatt scales globally. Deserts, where most solar panels would be installed, reflect about half the incident solar energy back to space. Current solar panels absorb some 90 percent of this sunlight and convert about 10 percent of that into electric power. That means 80 percent of the solar energy is absorbed with the panels, instead of about 50 percent without them. This change in the reflectivity of deserts would warm the local region and affect the global circulation similar to the above wind effects. However, in this case a fix is available, admittedly with some cost; namely, adding reflecting white panels to the arrays to yield the same reflectivity as the underlying land surface.

This type of forward-looking thinking is required before significant investments are made, and before significant damage is done to our environment; not to remove new technologies from consideration, but to stimulate their improvement. With your continued support, we plan to continue integrating the economic and environmental impacts of key energy developments into our understanding of the evolving energy and climate landscape.

— Ron Prinn

XXXV MIT Global Change Forum
Cambridge, MA, USA, June 4-6, 2013
Theme: Food, Water, & Energy in a Changing World

New Tool Helps Forecast Water Woes, Provides Insights for Adapting

Researchers enhance model to assess the risks of water stress.

A conflict over water management has intensified along the Mississippi and Missouri rivers. Downstream states argue water should be released from the Missouri's upstream reservoirs into the Mississippi to allow shipping to continue in the record low-level waters. Upstream states are fighting to keep the water to irrigate their crops and prevent the drought from getting even worse next year. To add to the tension, still others want to move a portion of the Missouri River Basin's water to the Colorado Basin—which will see demand outstrip supply in the coming decades, according to a federal study released at the beginning of December.

These are the stakes in the conflict over water, and the impacts could be profound and widespread. Agriculture, river navigation, energy and other industries all stand to lose as populations increase and the possible side effects of climate change emerge.

To measure future changes on water resources, researchers at the Massachusetts Institute of Technology have enhanced their IGSM model to include a new tool that assesses the risks of water stress.

"As fresh water sources throughout the world experience considerable stress becauses of an increasing population, economic growth, droughts, floods and other climate effects, this tool will provide valuable insights to industries and communities competing for water," says Ken Strzepek, research scientist at the MIT Joint Program on the Science and Policy of Global Change, who helped design the tool.

Strzepek and his colleagues Adam Schlosser and Élodie Blanc take population, GDP and other socioeconomic factors and combine them with hydro-climatic information such as precipitation and runoff from their earth system model.

They then combine this information to estimate changes in demand across sectors such as public and private water use, agricultural use and thermoelectric cooling used in energy production.

The result is an expanded model that can forecast if and where there could be stresses within water basins, along with the risks surrounding those changes.

"Globally, the tool is helping us see where the hot spots for water stress are and where might that stress increase in the future due to human population growth and climate change—two factors that are coming together and exacerbating the problem of water management," says Schlosser, the assistant director for science research at the Joint Program on Global Change.

While the new model paints the picture globally, it can also be applied at a regional and even local scale to help communities make important decisions about their future energy investments, infrastructure plans and adaptation strategies. Uniquely, by incorporating risk and uncertainty, the model helps policymakers evaluate the question: What investments do we need to make to be better prepared?

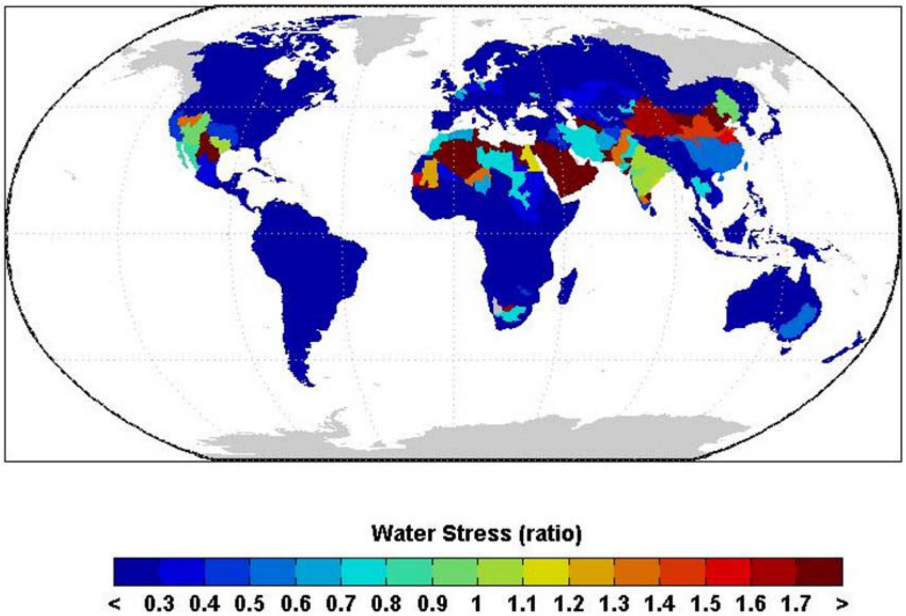
"When looking at different climate models, not only do they show different results, they show different directions—one shows a positive change where another might show a negative change," Schlosser says. "However, our technique allows us to quantify this uncertainty as risk to help decision makers formulate more robust investment plans."

The researchers have already begun to apply their model to the U.S. While their findings are still being written, the researchers agree that critical water management issues will arise—and in some areas are already emerging. They are finding that the areas that will see the greatest stress going forward are the same places where very rigid water management laws already exist, such as around the Missouri, Mississippi and Colorado rivers.

"Our model framework is able to account for water management and allocation policies," Schlosser says. "This allows us to take a situation like transferring water from the Missouri to the Colorado Basin and assess the impacts to both basins going forward."

Drawing from this measure of risk, the researchers warn that decision makers in developing countries should make their adaptation plans both flexible and efficient.

"If we don't know how much water will come down the river, we should design dams to be constructed in stages. For example, we should make provisions to add hydropower generation capacity easily and accordingly. " Strzepek says. "We need to have flexible designs, and also efficient designs, so we're building in a way that the structure will perform well under a variety of climates." ■



Results for Water Stress Index (WSI) from the IGSM-WRS averaged over 1981 to 2000 presented as a map of the 282 Assessment Sub-regions annual values (unitless).

Strzepek, K., C.A. Schlosser, A. Gueneau, X. Gao, É. Blanc, C. Fant, B. Rasheed and H.D. Jacoby, *JP Report 236*.

SPONSOR EXCLUSIVE

Listen to Niven Winchester's archived webinar "Biofuels in Commerical Transportion" on the sponsors-only website: http://globalchange.mit.edu/sponsors-only/webinar

"Fugitive" Methane from Shale Gas Production Less than Previously Thought

MIT researchers, using field practices, find emissions from shale gas production to be significantly lower than previous estimates.

While the U.S. lags in developing a broad-based climate policy, the nation's carbon emissions reached a 20-year low this year. Many have attributed some of that drop to a booming supply of low-carbon natural gas, of which the U.S. is the world's largest producer. But does natural gas—and specifically the quickly-developing production of shale gas—create other emissions, such as methane, that could be just as harmful? A new study by MIT researchers shows the amount of methane emissions caused by shale gas production has been largely exaggerated.

"While increased efforts need to be made to reduce emissions from the gas industry overall, the production of shale gas has not significantly increased total emissions from the sector," says Francis O'Sullivan, a researcher at the MIT Energy Initiative and the lead author of the study released on November 26th in *Environmental Research Letters*.

The research comes amidst several other reports on the impact of "fugitive" methane emissions—gas leaked or purposefully vented during and immediately after the stage of shale gas production known as hydraulic fracturing. While many of these reports studied the amount of potential emissions associated with the hydraulic fracturing process, the MIT researchers stress that this is only part of the puzzle. Consideration must also be given to how this gas is handled at the drilling sites, the study shows.

"It's unrealistic to assume all potential emissions are vented," O'Sullivan says, "not least because some states have regulations requiring flaring as a minimum gas handling method."

Sergey Paltsev, the study's co-author and the assistant director for economic research at the MIT Joint Program on the Science and Policy of Global Change, says companies also have an economic reason for wanting to capture this "fugitive" gas.

In talking with industry representatives and officials at the U.S. Environmental Protection Agency (EPA), O'Sullivan and Paltsev found that companies are already capturing about 70 percent of potential "fugitive" emissions. In factoring that into their analysis, the researchers find emissions from shale gas production to be strikingly lower than previous estimates of potential emissions.

Their analysis was based on data from each of the approximately 4,000 wells drilled in the five main U.S. shale drilling sites during 2010. Wells in two of those sites, Texas' Barnett shale and the Haynesville shale on the Texas-Louisiana border, had been studied by Robert Howarth from Cornell University last year when he looked at potential emissions released by the industry. His study garnered much attention because it claimed the greenhouse gas footprint of shale gas was larger than that of conventional gas, oil and, over a 20-year time frame, coal. That study, however, used very limited well data sets.

In studying potential emissions, Howarth found 252 Mg of methane emissions per well in the Barnett site and 4,638 Mg per well in the Haynesville site. The MIT researchers, using their comprehensive well data set, found that the potential emissions per well in the Barnett and Haynesville sites were in fact 147 Mg of methane (273 thousand cubic meters of natural gas) and 633 Mg (1,177 thousand cublic meters of gas), respectively. When accounting for actual gas handling field practices, these emissions estimates were reduced to about 35 Mg per well of methane from an average Barnett well and 151 Mg from an average Haynesville well.

According to Adam Brandt, an assistant professor at Stanford University, this analysis "provides an important contribution to the literature by greatly improving our understanding of potential shale gas emissions using a very large data set."

Brandt says, "Previous studies used much smaller and more uncertain datasets, while O'Sullivan and Paltsev have gathered a much larger and more comprehensive industry data set. This significantly reduces the uncertainty associated with potential emissions from shale gas development."

A U.S. Department of Energy study released in August confirmed that while electricity generated by gas produces half the emissions of coal generation, natural gas production does make up 3 percent of the nation's total emissions. While the overall benefits far outweigh the small increases during production, Paltsev believes the EPA's efforts to reduce those emissions through new air quality standards are a "step in the right direction." ■

O'Sullivan, F. and S. Paltsev, Shale gas production: potential versus actual greenhouse gas emissions, *Environmental Research Letters*, 2012.

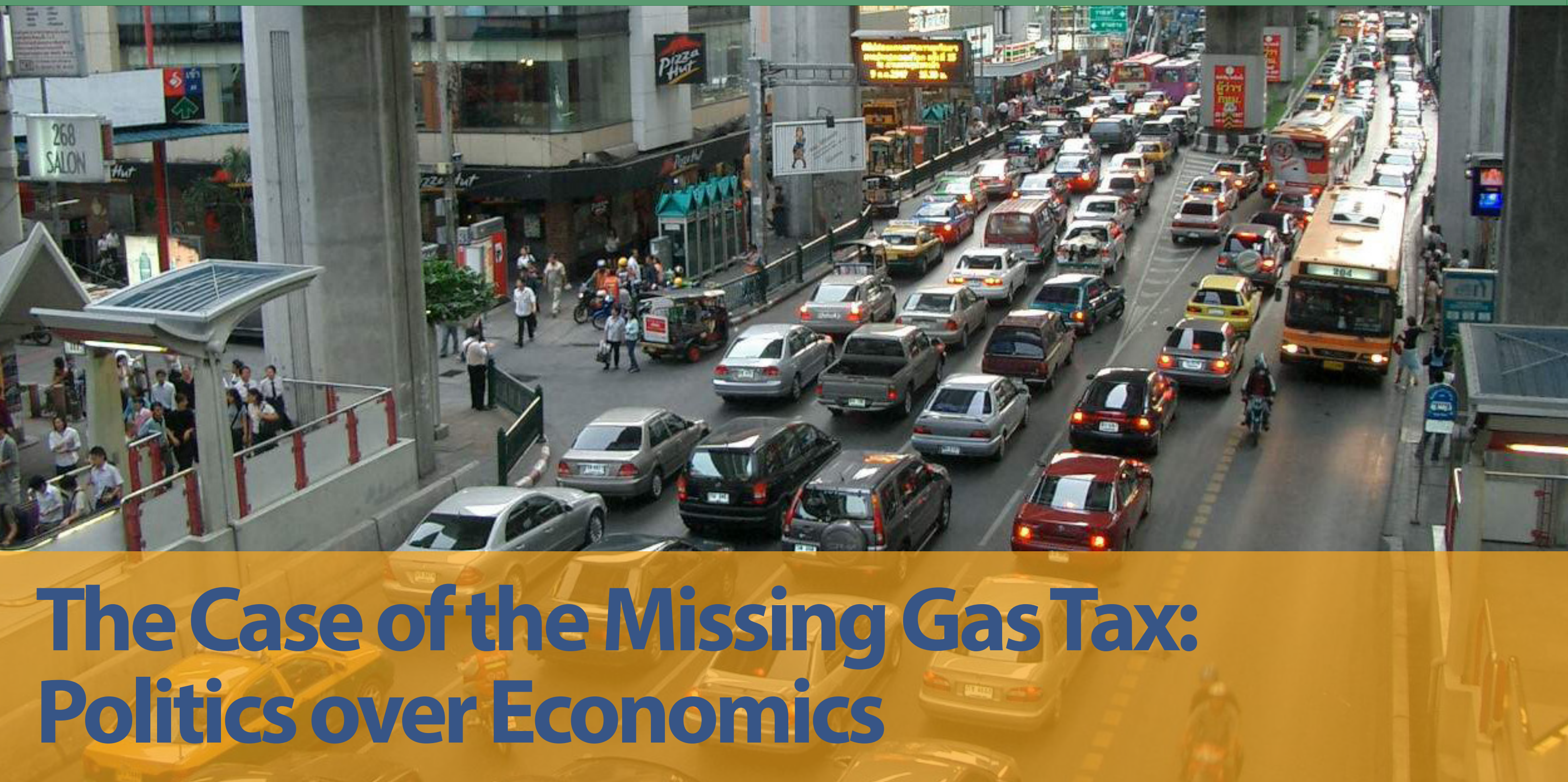
	Barnett	Fayetteville	Haynesville	Marcellus	Woodford
Per-GHG emissions: Mg CH_4/well (related CO_2 emissions are added based on 100 yr CH_4 GWP)					
All vented	146.7	159.1	632.7	217.7	261.8
Current field practice	35.1	38.0	151.3	52.1	62.6

Per-well actual fugitive GHG emissions from shale gas-related hydraulic fracturing in 2010. (Source; authors' calculations based on HPDI 2012).

AWARD WINNER!

Sergey Paltsev and Valerie Karplus won the 2012 Pyke Johnson Award from the National Research Council's Transportation Research Board. The Pyke Johnson Award recognizes the best paper in the area of planning and the environment.

Learn more here: http://globalchange.mit.edu/news-events/news/news_id/236



The Case of the Missing Gas Tax: Politics over Economics

MIT researchers find vehicle efficiency standards are at least six times more costly than a tax on fuel.

Vehicle efficiency standards have long been considered vital to cutting U.S. oil imports. Strengthened last year with the added hope of reducing greenhouse gas emissions, the standards have been advanced as a way to cut vehicle emissions in half and save consumers more than $1.7 trillion at the pump. But researchers at MIT find that, compared to a gasoline tax, vehicle efficiency standards come with a steep price tag.

"Tighter vehicle efficiency standards through 2025 were seen as an important political victory. However, the standards are a clear example of how economic considerations are at odds with political considerations," says Valerie Karplus, the lead author of the study and a researcher with the MIT Joint Program on the Science and Policy of Global Change. "If policymakers had made their decision based on the broader costs to the economy, they would have gone with the option that was least expensive—and that's the gasoline tax."

The study, published in the March edition of *Energy Economics*, compares vehicle efficiency standards to a tax on fuel as a tool for reducing gasoline use in vehicles. The researchers found that regardless of how quickly vehicle efficiency standards are introduced, and whether or not biofuels are available, the efficiency standards are at least six times more expensive than a gasoline tax as a way to achieve a cumulative reduction in gasoline use of 20 percent through 2050. That's because a gasoline tax provides immediate, direct incentives for reducing gasoline use, both by driving less and investing in more efficient vehicles. Perhaps a central reason why politics has trumped economic reasoning, Karplus says, is the visibility of the costs.

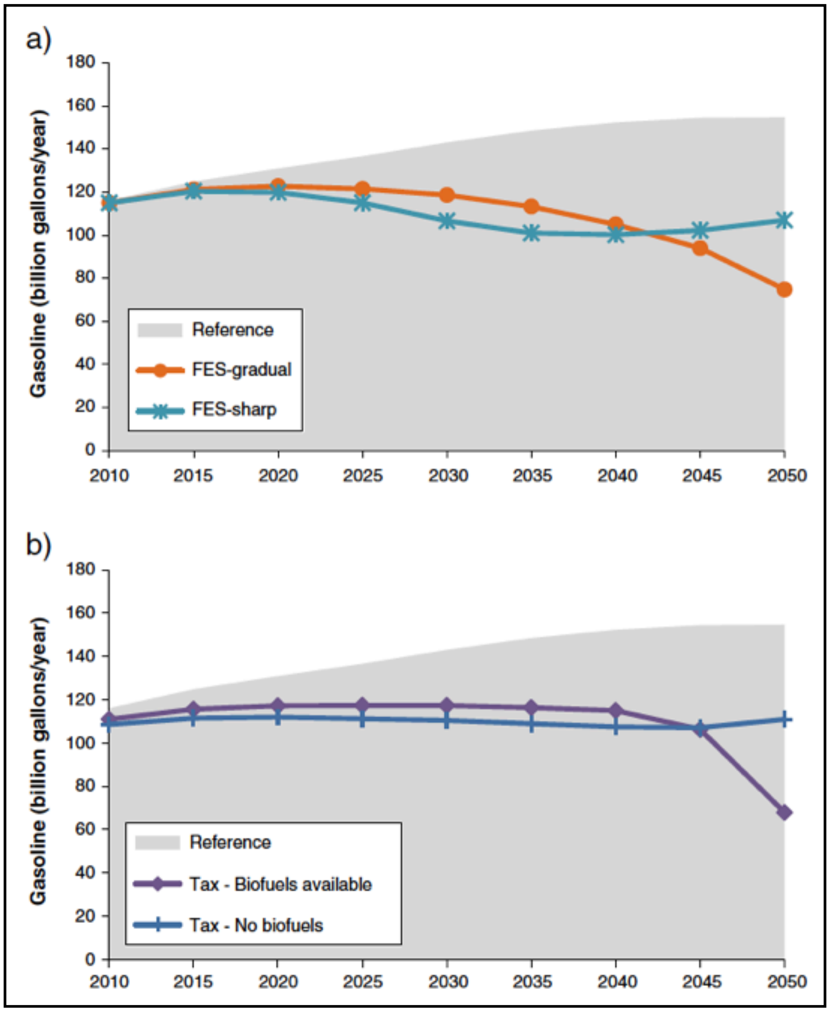
"A tax on gasoline has proven to be a nonstarter for many decades in the U.S., and I think one of the reasons is that it would be very visible to consumers every time they go to fill up their cars," Karplus says. "With a vehicle efficiency standard, your costs won't increase unless you buy a new car, and even better than that, policymakers will tell you you're actually saving money."

"As my colleague likes to say, you may see more money in your front pocket, but you're actually financing the policy out of your back pocket through your tax dollars and at the point of your vehicle purchase."

Along with being more costly, Karplus and her colleagues find that it takes longer to reduce emissions under the vehicle efficiency standards. That's because, with more efficient vehicles, it costs less to drive, so Americans tend to drive more. Meanwhile, the standards have no direct impact on fuel used in the 230 million vehicles currently on the road. Karplus also points out that how quickly the standards are phased in can make a big difference. The sooner efficient vehicles are introduced into the fleet, the sooner fuel use decreases and the larger the cumulative decrease would be over the period considered, but the timing of the standards will also affect their cost.

The researchers also find that the effectiveness of the efficiency standards depends in part on the availability of other clean-energy technologies, such as biofuels, that offer an alternative to gasoline.

"We see the steepest jump in economic cost between efficiency standards and the gasoline tax if we assume low-cost biofuels are available," Karplus says. "In this case, if biofuels are available, a lower gasoline tax is needed to displace the same level of fuel use over the 2010 to 2050 time frame, as biofuels provide a cost-effective way to displace gasoline above a certain price point. As a result, a lower gas tax is needed to achieve the 20 percent cumulative reduction."



Gasoline reduction trajectories for: a (the fuel economy standard, and b (the gasoline tax (with and without biofuels) that achieves a total cumulative reduction in gasoline use of 20 percent relative to the reference (No Policy) case.

To project the impact of vehicle efficiency standards, Karplus and her colleagues improved the MIT Emissions Predictions and Policy Analysis Model (EPPA) that is used to help understand how different scenarios to constrain energy use affect our environment and economy. For example, they represent in the model alternatives to the internal combustion engine based on the expected availability and cost of alternative fuels and technologies, as well as the dynamics of sales and scrappage that affect the composition of the vehicle fleet. Their improvements to the model were recently published in the January 2013 issue of *Economic Modelling*. ■

Karplus, V.J., S. Paltsev, M. Babiker, J.M. Reilly, *Energy Economics*, 36 (March 2013): 322–333, 2013.

IN THE NEWS

Read the *Washington Post's* coverage of this study and research by Chris Knittel in the Wonk Blog on February 22nd: http://globalchange.mit.edu/news-events/news/news_id/256

Protection of Coastal Infrastructure Under Rising Flood Risk

Three Questions with Megan Lickley

What risks do climate change pose to coastal infrastructure?

Climate change brings increasing sea surface temperature, which is the engine of tropical storms, allowing them to grow in intensity and destructive power. At the same time, sea levels are predicted to rise. Further adding to the risk, some areas are sinking as the result of natural processes, or because of removal of subsurface water or fossil fuels. (This geological sinking is known as subsidence). The combination of increased hurricane risk, rising sea levels and sinking coastal areas greatly increases the risk of significant damages to coastal infrastructure from flooding.

How is your analysis structured?

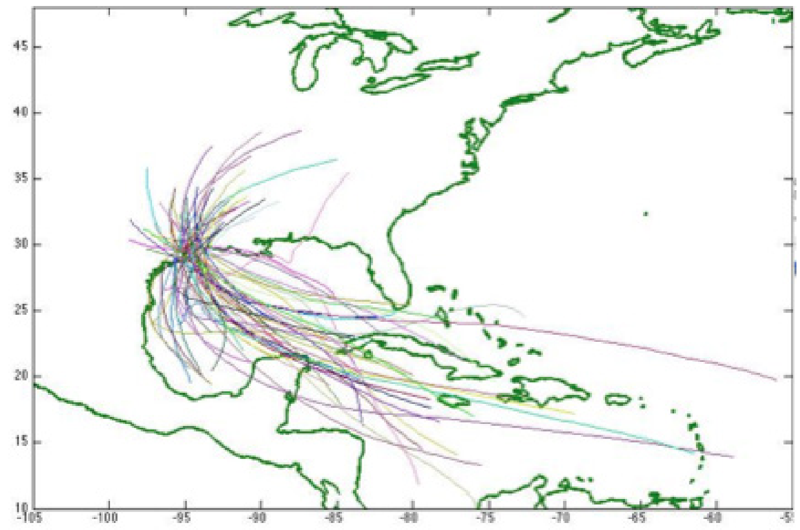
We evaluate the annual risk of inundation through the year 2100 for a sample site—Galveston Bay, TX. Using results from multiple climate models, we modeled the change in hurricane activity and applied the results to a surge model in order to project the change in frequency and magnitude of storm surge heights. We couple these projections with uncertainty surrounding the magnitude of sea level rise and subsidence and the result is a detailed projection of flood risk in 2100. We then use decadal flood risk projections to develop a dynamic decision-making framework to help inform adaptation decisions.

Remember Megan Lickley from the Summer newsletter? Read her profile here:

http://globalchange.mit.edu/sponsors-only/Newsletter_Summer2012/StudentSpotlights/Megan.

How can this framework be used?

The extensive damage caused by hurricanes in the last decade foreshadows a risk that will continue, and likely increase, with a changing climate. As the risk of flooding increases, we will need to decide to abandon or adapt high-risk facilities. The information produced by our framework can be used to inform when these decisions should be made. For example, in our analysis we consider a facility in Galveston Bay sitting at 5 feet above sea level. We determine that the optimal long-term adaptation path is to protect the facility through the construction of a sea wall, but that the sea wall should be constructed in phases, i.e. not all at once, since the cost of construction and maintenance increases with sea wall height. Our dynamic decision-making process finds the cost-benefit path that minimizes the costs of adaptation by considering the risks of not adapting through all time periods in the coming century. This type of analysis informs city, state and regional authorities facing issues of zoning and building standards, as well as efforts to anticipate future investments in protection and adaptation.



50 of the storm tracks used in the analysis, passing through filter centered at Galveston.

Lickley, M., N. Lin and H.D. Jacoby, Protection of Coastal Infrastructure under Rising Flood Risk, in review.

Ernie Moniz Nominated Secretary of Energy

On March 4th, President Barack Obama nominated MIT's Ernest J. Moniz to head the U.S. Department of Energy (DOE).

Moniz is the Cecil and Ida Green Professor of Physics and Engineering Systems, as well as the director of the MIT Energy Initiative (MITEI) and the Laboratory for Energy and the Environment. His principal research contributions have been in theoretical nuclear physics and in energy technology and policy studies. Moniz has been on the MIT faculty since 1973, and was the head of the Physics Department in the 1990s. He has also served on President Obama's Council of Advisors for Science and Technology (PCAST).

"Ernie knows that we can produce more energy and grow our economy while still taking care of our air, our water and our climate," President Obama said in his nomination speech.

"President Obama has made an excellent choice in his selection of Professor Moniz as Energy Secretary," said MIT President L. Rafael Reif. "We have been fortunate that Professor Moniz has put his enthusiasm, deep understanding of energy, and commitment to a clean energy future to work for MIT and the Energy Initiative—and we are certain he will do the same for the American people."

Moniz is the founding director of MITEI, which was created in 2006 by then–MIT President Susan Hockfield. Under Moniz's stewardship, MITEI has supported almost 800 research projects at the Institute, has 23 industry and public partners supporting research and analysis, and has engaged 25 percent of the MIT faculty in its projects and programs.

Moniz served as DOE undersecretary of energy from 1997 to 2001. In that role, he had oversight responsibility for all of DOE's science and energy programs and the DOE national laboratory system. He also led a comprehensive review of the nuclear weapons stockpile stewardship program, advanced the science and technology of environmental cleanup, and served as DOE's special negotiator for Russia initiatives.

From 1995 to 1997, he served as the associate director for science in the White House Office of Science and Technology Policy. There, his responsibilities spanned the physical, life, and social and behavioral sciences; science education; and university-government partnerships.

Moniz received a B.S. in physics from Boston College and a Ph.D. in theoretical physics from Stanford University. He was then a National Science Foundation postdoctoral fellow at Saclay, France, and at the University of Pennsylvania. ■

Climate Change Series: Mitigating the Damage

90.9 wbur Boston's npr news station

On January 30th, Henry Jacoby spoke as part of Northeastern University's Climate Change Series. This is an op-ed featured in WBUR that reflects his presentation.

By: Henry "Jake" Jacoby

Talking about mitigating climate change risk is a bit like the story of the man arrested for murder whose lawyer said to him, "I've got good news and bad news. The bad news is the blood found at the crime scene matches your DNA. The good news is your cholesterol level is down to 160."

First, the bad news about climate change: The quantity of greenhouse gases humans have pumped into the atmosphere since the dawn of the industrial age is already changing the earth's climate and raising global temperatures. What's not widely recognized is that simply stabilizing global greenhouse gas emissions at today's levels will not stabilize their atmospheric concentrations and effects on climate. Much deeper cuts will be required. Moreover, even if we succeed in reducing future emissions drastically, our children and grandchildren will have to live with the consequences of global warming—not just higher temperatures, but more severe storms, sea level rise, fire, drought and other environmental changes.

Whatever we and the other nations do, climate change will adversely affect future generations. By steadily pressing ahead to create a non-carbon-based economy by whatever means available, we can limit the damage.

With no additional mitigation policy, we estimate there's about a 50/50 chance that global temperatures will rise by as much as 5 °C by the end of this century. There's almost a one in four chance global temperatures will rise by 6 °C or more.

Over the past two decades, diplomats have tried to negotiate a deal to limit atmospheric concentrations of "Kyoto gases" (carbon dioxide, methane, nitrous oxide and other industrial gases). Their ultimate goal: to curb global temperature increases to 2 °C by the year 2100. However, after analyzing the data, the objective looks daunting.

Whatever we and the other nations do, climate change will adversely affect future generations. By steadily pressing ahead to create a non-carbon-based economy by whatever means available, we can limit the damage.

For example, one specific target is to limit atmospheric concentrations to about 450 parts per million (ppm). But given that the concentration of these gases has already risen from 275 ppm in the late 18th century to around 440 ppm today, and is climbing steadily, it's doubtful we can achieve that goal.

But all is not lost. According to our calculations at MIT's Joint Program on the Science and Policy of Global Change, even if we limit atmospheric concentrations of the Kyoto gases to a more modest 650 ppm, the high-end risks of climate change—temperature increases of 5 to 7 °C—disappear. In other words, our grandchildren would still have to live with the disruptive effects of climate change,

but they wouldn't have to face the most catastrophic scenarios. That's the good news about climate change: almost anything we do to limit greenhouse gas emissions has its biggest effect on the worst possible outcomes. That's why it's worth keeping up the fight to reduce greenhouse gas emissions even though some targets will be hard to meet.

Here in the U.S., despite the national gridlock on climate change policy, energy-related carbon dioxide emissions have dropped in recent years—in part because of the recession but also due to a shift from coal to natural gas as a power source. The fact that President Obama talked about climate change in his inaugural address, plus the effect of recent storms and drought on public understanding of the risk, may help shift the debate toward a more aggressive policy response.

Right now, the U.S. has a cobbled together quilt of state, regional and national policies—automobile mileage standards, appliance efficiency ratings, renewable energy subsidies—that indirectly limit greenhouse gas emissions. From an economic perspective, the cheapest and best way to reduce emissions would be with a carbon tax, or a cap-and-trade system that places a price on carbon emissions. It's a win/win/win solution. It would 1) lower greenhouse gases emissions and oil imports, 2) increase revenue which could be used to cut other taxes, and 3) have a neutral-to-positive effect on economic growth. If a price penalty for emitting greenhouse gases is not politically feasible, then more expensive regulatory measures are going to be the way forward.

Whatever we and the other nations do, climate change will adversely affect future generations. By steadily pressing ahead to create a non-carbon-based economy by whatever means available, we can limit the damage. ■

Henry "Jake" Jacoby is William F. Pounds Professor Emeritus in the MIT Sloan School of Management, and former co-director of the MIT Joint Program on the Science and Policy of Global Change.

Adjusting China's CO_2 Emissions-Intensity Targets to Account for Interprovincial Trade

China's Twelfth Five-Year Plan (2011–2015) aims to reduce national carbon intensity by 17percent through provincial emissions targets, but an uneven distribution of production and consumption activities across China's provinces makes these targets difficult to set. Broadly speaking, China's western and central provinces emit carbon during the production of goods for export to China's more developed eastern provinces. The CO_2 footprint of goods consumed in the eastern provinces thus includes a large share of emissions associated with production in the central and western provinces. Recognizing this, some have called for assigning provincial intensity targets based on the emissions associated with consumption.

Objective

This study develops a method for adjusting provincial emissions-intensity targets that account for emissions transfers that occur between China's provinces as a result of uneven production and consumption activities. It then evaluates the economic effects of this target allocation.

Approach

The study simulates the effects of a provincial target allocation using a computable general equilibrium model (CGE) model of the Chinese economy, which provides a comprehensive representation of regional market interactions through price and income-responsive supply and demand responses.

Impact

We find that adjusting CO_2 intensity targets on a consumption basis increases the reduction burden of the eastern provinces significantly, and is predicted to double the total national welfare loss, relative to the current politically-negotiated targets. An alternative approach to emissions-intensity targets that divides emissions responsibilities so that they are shared between producers and consumers leads to a more equal distribution of economic burden among China's provinces. ■

Springmann, M., D. Zhang, and V.J. Karplus, Consumption-Based Adjustment of China's Emissions-Intensity Targets: An Analysis of its Potential Economic Effects, *JP Report 241*.

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The Energy and CO_2 Emissions Impact of Renewable Energy Development in China

Objective

China's recently-adopted targets for developing renewable electricity—wind, solar and biomass—would require expansion on an unprecedented scale. What effect will these targets have on both renewable and fossil energy use, as well as CO_2 emissions?

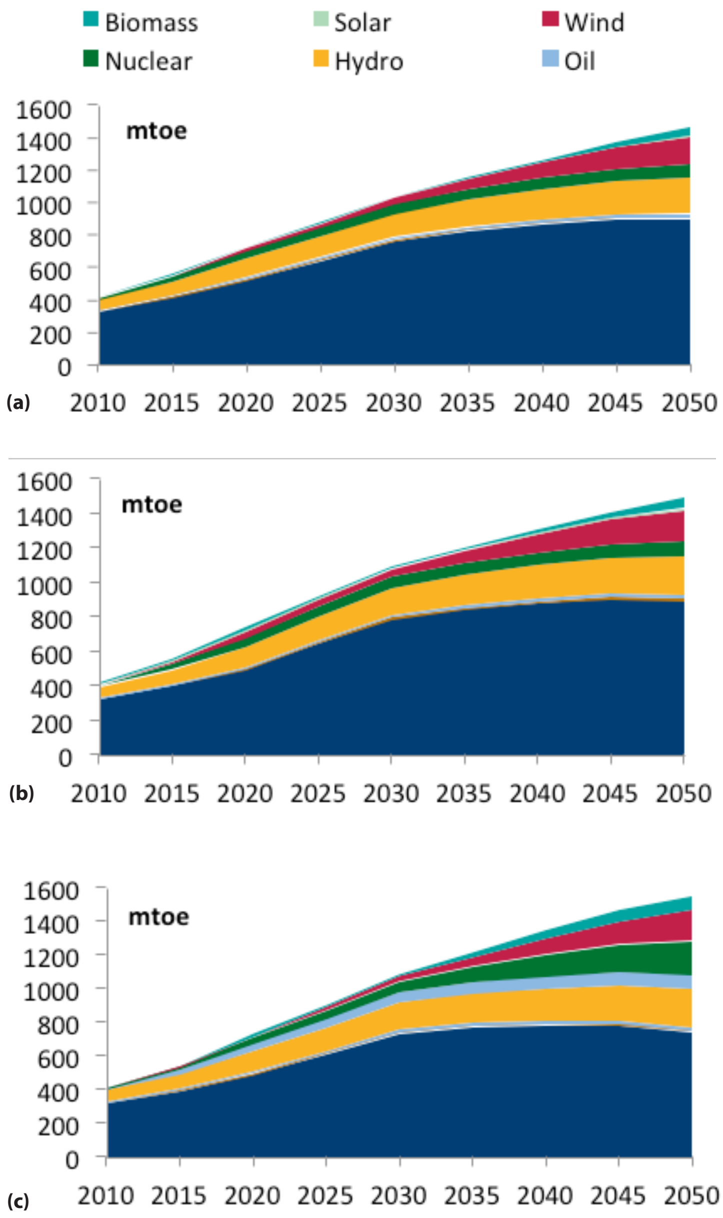
Approach

The researchers apply their China-in-Global Energy Model (C-GEM) to evaluate the effect of China's renewable electricity targets on energy and CO_2 emissions. They consider how outcomes differ under high, medium, and low growth scenarios. The study simulates current renewable targets through 2020 and considers the effects over the period 2020 to 2050.

Impact

China's renewable electricity targets result in significant growth in wind and solar electricity generation and reduce CO_2 emissions through 2020 under all three growth scenarios, relative to if there was no policy. However, over the long term, the emissions reduced by the targets are offset by increased emissions from sectors not constrained by the targets. This occurs as renewables displace coal in the power sector, causing the price of coal to fall and leading to increased coal use in other sectors. After 2020, as subsidies are phased out, the role of renewable electricity depends on its cost competitiveness relative to other energy sources. If the cost of renewable electricity falls as a result of early experience with the technology, renewable energy plays a much larger role over the period 2020 to 2050, compared to a scenario where cost remains unchanged. ■

Xiliang Zhang, Tianyu Qi and Valerie Karplus, The Energy and CO_2 Emissions Impact of Renewable Energy Development in China, in review.



The evolution of the electricity generation mix through 2050 in the (a) No Policy reference case, (b) Current Policy case, and (c) Current Policy + Low Cost scenario.

Experts Meet for Landmark Study on the Impact of China's Vehicle Emissions Policies

The MIT-Tsinghua China Energy and Climate Project held a workshop on Tuesday, March 12 to kick off a landmark study on the impact of China's vehicle emissions and fuel standards on the economy, energy, emissions, air quality and health. The study is supported by a grant from the Energy Foundation, which provides resources to institutions that most effectively leverage change in transitioning to a sustainable energy future. The workshop, held at Tsinghua University, was hosted by collaborators at the university's Institute for Energy, Environment, and Economy.

"Understanding the role fuel quality standards could play in cutting China's emissions and air pollution is crucial to the health of the communities, as well as to addressing growing urban sustainability challenges," says Valerie Karplus, director of the MIT-Tsinghua China Project and a co-researcher for the study. "This study will provide that insight. We're grateful to have the support of the Energy Foundation, as well as feedback from a varied stakeholder base."

The researchers will perform a comparison of policy options for reducing transportation emissions in China. This process will begin with an analysis of China's transport sector and an updated inventory of emissions by sector. Researchers will also identify regional air quality impacts using a regional chemical transport model and analyze the impact of various policy options on energy use, emissions, the economy and human health.

"This study will be the first to use an integrated model—simulating travel demand, fuel use, vehicle emissions and air quality—to determine health and economic impacts of fuel policies in China," says Eri Saikawa, a professor at Emory University and the lead researcher for the study. "The model will be a powerful tool for assessing transport policy options currently under discussion in China."

Throughout the project, researchers will communicate their results to policymakers through an ongoing and interactive process. The March 12th workshop was the first of several of these meetings. It brought together stakeholders from China's Ministry of Environmental Protection and the Beijing Environmental Protection Bureau, as well as experts from Tsinghua University, Beijing University, Nanjing University, Clean Air Initiative—Asia, the International Council on Clean Transportation, the Energy Foundation, and the Health Effects Institute.

At the March 12th meeting, the stakeholders provided input on which policy questions would be of greatest interest for the study to consider and explored how the results of the study might be used within their organizations. It was decided that the research would focus on assessing the impacts of fuel quality standards and tailpipe emissions standards in China, with a focus on the potential benefits of implementing the China 6 standard, which is the toughest standard announced so far and targets deeper reductions in nitrous oxide emissions country-wide before 2020. ■

Meet the Researcher

Michael Davidson is a masters candidate and pre-doctoral student in the Technology and Policy Program of the Engineering Systems Division and CECP. In 2008, he was a Fulbright Fellowship recipient at Tsinghua University in Beijing, where his research highlighted the importance of distributed renewable energy systems to rural development. His current work focuses on the modeling framework for large-scale penetration of low-carbon electricty sources.

Forthcoming CECP Reports

A Global Energy-Economic Model for China: China in Global Energy Model (CGEM)

The Energy and Economic Impacts of Linking China, the EU, & Australia in an Emissions Trading System

A Distributional and Economic Analysis for a Chinese Emissions Trading System

New Peer-Review Study

Analysis on energy-water nexus by Sankey diagram: The case of Bejing, *Desalination and Water Treatment*

Driving Down Costs


Credit: Dominick Reuter

Energy Economist Christopher Knittel gives policymakers a better crystal ball.

Christopher Knittel had big dreams heading into college. Those dreams involved baseball.

"I entered undergraduate with the hopes of being a professional baseball player," says Knittel, who was good enough to make the team at California State University-Stanislaus as a second baseman. But during the season reality sank in. "My hopes were quickly extinguished."

It didn't take long for Knittel to step into a new field: economics.

"I took my first undergraduate econ class my freshman year and basically fell in love with it," says Knittel, the William Barton Rogers Professor of Energy Economics at the MIT Sloan School of Management and a co-director of the Center for Energy and Environmental Policy Research (CEEPR) at MIT.

Knittel has spent most of his career bouncing between the nation's two coasts. After receiving his masters and Ph.D. from the University of California at Davis and Berkeley, respectively, he left California to teach at Boston University's School of Management. He returned to California a few years later to teach at his alma mater, U.C.-Davis, only to return to Boston in 2011 when given the opportunity to work at MIT.

"It's hard to tell MIT 'No,'" says Knittel, who was named the Institute's first energy faculty chair last year. "I can't think of a better place to do the work I do because it draws heavily from the hard sciences and engineering. So it's great to be around world class scientists and engineers. They've already helped inform my work."

A "Car Guy" at Heart

Economics "teaches you how to think," says Knittel, explaining why he fell in love with the field.

Giving an example from his research, he explains how when doubling fuel economy most would recognize that gasoline consumption would fall. But as an economist, Knittel has learned to go one step further. He finds that as drivers save on gas, they start driving more, and gas consumption climbs back up.

Because policymakers don't always think through the entire chain of events, Knittel's work focuses on "informing policymakers to do the right thing."

This is especially true when it comes to climate policy.

"It's such a big and important issue," Knittel says. "Yet there's a lot of policies in place that are quite inefficient."

Because the transportation sector makes up a third of the nation's carbon emissions, Knittel has focused much of his most recent research on cars and trucks—though in a sense, he has been studying cars and trucks most of his life. Knittel's father was an engineer for Peterbilt, the truck manufacturer, and in high school Knittel rebuilt the engine of his '68 Ford Mustang Fastback to double its horsepower.

"I've always been a car guy," Knittel says. "It's kind of in my blood."

Some of Knittel's work looks at, not

just the impact of inefficient policies, but why we might have them. One recent study shows that policies like the Renewable Fuel Standard and ethanol subsidies—which most economists agree are inefficient ways to reduce gasoline consumption—create big winners, in particular corn growers and ethanol producers.

"There's a lot of people losing a little bit of money, and a few people gaining a lot of money," Knittel says. "So you have a natural group that's going to promote these policies, but no real natural group that has a strong incentive to fight them."

What effect do these "big winners" have on Congress? Controlling for party affiliation, Knittel found that congressmen tended to vote on the side of the winners.

"If you're representing a district that is going to gain from these ethanol subsidies or the Renewable Fuel Standard quite a bit, you're much more likely to vote against the efficient policies, like a cap-and-trade bill," Knittel says.

He found similar results when he looked into the gasoline tax—which economists by and large promote as an efficient way to reduce greenhouse gas emissions and local pollutants. Yet in the U.S., gasoline taxes are much lower than every other developed country in the world. Why is that?

Looking state-by-state at which income groups are most impacted by gasoline taxes, he found rural communities are affected more because people living in these areas tend to need to drive longer distances and own less fuel-efficient cars.

"So if you think about getting a high gas tax through the Senate, where rural states are disproportionately represented, you can see that it's going to be very difficult," Knittel says. "That's at least one explanation of why we don't have the gas taxes that other countries have."

The Economics of Efficiency

Knittel, along with his MIT colleague Michael Greenstone and two colleagues from the University of California-Berkeley, recently received a sizeable grant from the Sloan Foundation to study energy efficiency in both the electricity and transportation sectors.

With the funding, they started E2e, a center housed within CEEPR at MIT and the UC Energy Institute. Its name captures the spirit of the center's work: striving to go from using a large amount of energy ("E") to a small amount ("e") and to include experts that range from engineers (hard scientists - "E") to economists (soft scientists -"e").

Knittel's motivation for studying energy efficiency lies in the McKinsey Curve—named after the cost curve developed by the McKinsey consulting firm that depicts the abatement of greenhouse gas emissions. The striking feature of the curve is that almost half of it lies below zero. That is, not only do the costs to reduce emissions balance out, but abating emissions actually pays for itself and then some.

"It's very easy to understate what—not only the costs of investing in energy efficiency are—but also the benefits from investing," Knittel says. "Our goal is to better understand what the costs and benefits of energy-efficient investment are—where the low hanging fruit is in terms of energy efficiency, as well as how high that fruit is up the tree. The McKinsey curve would suggest the fruit's already on the ground. We want to prove that ourselves."

Knittel and his colleagues plan to prove the benefits of energy efficiency by running actual experiments. The first experiment is already underway. The team has research assistants at Ford dealerships educating consumers. Half of the consumers are told how much they would save if they switched from their current vehicle to a more fuel-efficient car, the other half are told about other reasons to buy (the control group). The students then track the consumers to see what vehicles they purchased, and if better information about fuel economy actually changes their purchasing habits.

This experiment builds off a study in *American Economic Review*, where Knittel proved the conventional wisdom about car-buyers is wrong. That wisdom, at least for policymakers, holds that consumers only focus on the first three years or so of the car's life. If there's a technology out there—for example, hybrid technology —that doesn't pay for itself in the first three years, they don't invest in it. Using transactional data on 80 million sales, Knittel found that consumers are investing the correct amount in fuel economy.

Knittel explains the importance of these results:

"A major reasoning behind a lot of policies is that consumers are making mistakes. So if we adopt the policy, the thought is they won't make as big of a mistake, and that's a benefit to society. But if consumers aren't making that mistake—as we find in this case—then there is no benefit."

Asked if his research proves that more economists should be politicians, Knittel jokes, "Yeah, maybe. Although, we're often not willing to say the right thing. We tell it as it is, and it's not always what people want to hear." ■

COMMENTARY

Read Knittel's *USA Today* op-ed, " Energy efficiency needs more research."
http://globalchange.mit.edu/news-events/news/news_id/255

Amanda Giang: Tackling Environmental Injustice by Reducing Mercury

Amanda Giang's path toward studying human health and the environment began in 7th grade when she realized biology was "really cool." When her high school civics teacher encouraged her to help on a documentary film on HIV/AIDS in Africa, Giang learned how she could apply her love of biology to study human health—and especially, health inequities.

"Biology was part of the first magic of science for me," Giang says. "Then I learned that I could use my love of biology to really engage with social justice issues."

Giang went on to study biomedical engineering at the University of Toronto. While interning at an environmental toxics lab after her first year, she realized the importance of addressing health problems before they start.

"I became interested in human health not so much at the cellular, molecular level, but from a systems perspective—preventing disease before it happens," Giang says. "If you focus on preventing illness it can be a cheaper way to address these health problems."

Looking to see the bigger picture, Giang decided to attend MIT's Technology and Policy Program. Working with Assistant Professor Noelle Selin, she has focused on assessing the benefits of pollution reduction policies—and specifically, mercury pollution. Assessing these benefits, Giang says, is critical to motivating policymakers both in the U.S. and globally.

"Pollutants like mercury tend to operate at different spatial and temporal scales, which makes accounting for benefits of pollution reduction policies very difficult," Giang says. "Mercury is a great case study for other pollutants because we know, relatively speaking, a lot about it and it shares many of the same cross-scale problems. But many of the methods we currently use to assess the benefits related to pollution reduction policies might not be totally adequate."

To more accurately assess the benefits of reducing mercury, Giang takes a more holistic perspective by using integrated economic and atmospheric models. She uses these models to look at the environmental and economic complexities and uncertainties that current methods don't take into account.

"When trying to design policy, you have to think about health problems from a linked perspective. If you don't take into account interacting factors you might get perverse effects," Giang says. "Integrated assessment is a great way to show how things are linked. It allows us to look at all of the systems, and institutions, both natural and human, that are affected by our environmental policies."

Through Giang's thesis, she has been working to improve assessment methods by adding factors such as the cardiovascular impacts of mercury emissions. Other studies have not included this health effect because there is still uncertainty around mercury's impact on heart health as opposed to cognitive effects, which have been documented much longer.

"The cardiovascular evidence is less strong, but the impacts may be much larger," Giang says. "A small increase in the rate of heart attacks from a welfare perspective is quite large because heart attacks cost a lot, both in terms of medical expenses and broader societal costs like lost productivity from sick days, and pain and suffering. Including this impact can have a large effect on the potential benefits of mercury policies."

Giang's research concludes that the recent gains the U.S. has seen thanks to new Mercury and Air Toxics Standards, will likely be outweighed by global mercury emissions growth—despite a new global treaty.

Having attended the international mercury negotiations in January, Giang says, "It's still unclear, based on the new treaty, what the future emissions trajectory will be."

But without taking local action, would we have global policies at all?

"The fact that the U.S. has some of the most stringent mercury regulations may have given the U.S. the right to push for stronger global regulations," Giang says.

Giang will continue on at MIT next year and pursue her Ph.D. in the Engineering Systems Division. She plans to use the knowledge she gained in the Joint Program to study how different governance systems deal with uncertainty in their policymaking. ■

IN THE NEWS

PBS News Hour wrote about the MIT Mercury blog written by Noelle Selin and MIT graduate students during their visit to Geneva for the Minamata Convention. Learn more: http://globalchange.mit.edu/news-events/news/news_id/239

Anita Ganesan: Reducing Uncertainties in South Asia

In November 2011, Anita Ganesan travelled to the foothills of the Himalayas to the small, remote village of Darjeeling, India. Her goal: to fill the hole of missing greenhouse gas data.

"People can say they are for or against something, but because of uncertainties in climate science, it is more nuanced," says Ganesan, who recently completed her Ph.D. "But the more measurements there are, the more data we have, the better we'll be able to reduce uncertainties. That's what I wanted to achieve as I set out to fill in some of the gaps in this important region of the world."

With the support and encouragement of her thesis advisor and Joint Program Co-Director, Ron Prinn, Ganesan built and set up an air monitoring instrument in Darjeeling that has been feeding her valuable information about the composition of the atmosphere every 10 minutes for now over a year.

Specifically, Ganesan designed the device to report the concentrations of some of the most potent greenhouse gases —methane, nitrous oxide and sulfur hexafluoride.

Ganesan's location was strategic. A strong monsoonal flow allows her to detect the pollution from across India. At the same time, Darjeeling borders Nepal, Bhutan and Bangladesh, so Ganesan can gather data from parts of South Asia.

The hope, Ganesan says, is that her station will become fully integrated into a greater network created and overseen by Prinn—the Advanced Global Atmospheric Gases Experiment (AGAGE). Through AGAGE, Prinn and a team of researchers from around the world have been measuring the composition of the global atmosphere since 1978. This observational data has helped to refine and improve climate change research for the past three decades.

"There are very few measurements being made in the developing world," Ganesan says. "I see this station in Darjeeling as a starting point. Given India's role as a significant player in the global economy, it's important that we continue this effort."

Like other researchers collecting atmospheric measurements, Ganesan is using the data and backtracking to figure out where the emissions originate. This inverse method allows her and her colleagues to determine how emissions are changing over time—reducing uncertainty in each region where measurements are being made.

Ganesan's inverse modeling finds, not surprisingly, that methane and nitrous oxide are coming largely from India's agricultural industry— namely rice paddies, cattle and fertilizers.

"Now that we have a better idea of the level of emissions and where they're coming from, the next step is obviously what are we going to do about it?" Ganesan says. "That's a much more difficult question to answer in some ways because it's really integrated with the human factor, and specifically India's food system. This is something that a lot of scientists are working on—finding ways to improve farming practices to minimize emissions of methane and nitrous oxide, while preserving crop yields."


Darjeeling, India

Thinking about the bigger picture is something Ganesan has been trained to do, having worked closely with Prinn and the Joint Program.

"This ability to integrate the science and the policy is something that I don't think exists everywhere," Ganesan says. "Having not known much about the economic side before coming to MIT, I've been able to learn from others and that's been really important because it affects everything I study. It was an opportunity I don't think I would have gotten anywhere else."

She also credits Prinn for giving her the freedom to take the project in the direction she chose, and her colleagues in the Department of Earth, Atmospheric and Planetary Sciences for their support.

"Because everyone is really hard working, it's a good environment to do an ambitious project because everyone around you is also so motivated that it gives you a little bit of fuel," says Ganesan, "It will be difficult to leave."

She won't have to leave just yet. Ganesan has started postdoctoral research with Prinn and will continue her work with the Indian government and collaborators to make the monitoring station an official part of the AGAGE network. ■

The Environment @ MIT

Massachusetts Confronts Climate Change

MIT researchers and Massachusetts officials highlight strategies to adapt to climate change.

Just days after President Obama called for action on climate change in his second inaugural address, members of Massachusetts Governor Deval Patrick's administration joined MIT professors Kerry Emanuel and Michael Greenstone to discuss strategies for adapting to climate change. The panel discussion fostered a continued partnership between MIT and the Commonwealth to advance energy and environmental innovation. "We are so pleased to have the opportunity to utilize one of the Commonwealth's greatest intellectual resources—MIT—to tackle this global challenge," said Massachusetts Undersecretary for Energy Barbara Kates-Garnick, the moderator of the panel.

Two years ago, the Commonwealth released the Massachusetts Climate Change Adaptation Report, which lays out strategies to help prepare for and respond to the impacts of climate change. Stephen Estes-Smargiassi, director of planning for the Massachusetts Water Resources Authority (MWRA), and the Department of Agricultural Resources Commissioner Gregory Watson spoke about some of their efforts. Panelists agreed that despite the substantial efforts underway in Massachusetts, there is a need for continued work.

MIT hosted a series of events during the Independent Activities Period (IAP) to highlight what is being done —and what needs to be done—to face the realities of a post-Sandy world.

Watch the full event and learn more: http://globalchange.mit.edu/news-events/news/news_id/241

Student Showcase on Climate Research

As Massachusetts and communities throughout the country face the realities of a world where severe weather events like Super Storm Sandy could become more common, smart adaptation strategies are needed. MIT students and researchers presented their latest ideas and findings at the January event. The interdisciplinary group of researchers presented to officials from the Massachusetts' Executive Office of Energy and the Environment, in hopes that the state would be able to leverage the information for future planning and implementation.

Going forward we will need to be thinking out-of-the-box, creatively for future planning," Massachusetts Energy Undersecretary Barbara Kates-Garnick said at the event. "So much of what you're doing is totally relevant to what we're working on…I'm sure that we will be back in touch."

Learn more about the students' presentations: http://globalchange.mit.edu/news-events/news/news_id/248

Inside Tour of MassDOT

During the January IAP session, students took a tour of several Mass Department of Transportation facilities, including an underground ventilation tunnel system, bus operator training school, and the organizational headquarters for the T. MBTA staff discussed how America's oldest subway system is preparing for climate and weather emergencies in the post-Sandy world. More: http://globalchange.mit.edu/news-events/news/news_id/247

Science and Policy in Action

In January, the United Nations Environment Programme agreed on the first major environmental treaty in over a decade. Its focus was reducing mercury pollution. There to participate in the events were ten MIT students and their instructor Noelle Selin. Selin and the students hosted a panel discussion on Wednesday, February 6 to share their experiences and lessons learned from witnessing international environmental policymaking in action.

Selin kicked off the event by describing the problem of mercury in our environment and why an international treaty was essential to curbing the environmental and public health effects. She explained that mercury levels in the Earth have increased greatly due to the burning of fossil fuels, cement production, and more. Mercury then rains down into oceans, where it contaminates fish as toxic methylmercury. "The health risks to consumers of fish include neurological effects, particularly in the offspring of exposed pregnant women," Selin explained.

MIT MERCURY BLOG:
http://mercurypolicy.scripts.mit.edu/blog/

Mercury is an element that cycles in the environment, meaning that once it's released into the atmosphere it can take decades to centuries for mercury to make its way back to ocean sediments. "This becomes a global issue, this becomes a long term issue, and thus an issue for international cooperation," Selin said.

There were five student teams on the trip that covered topics including: governing institutions, products and processes, emissions, waste/trade/mining, and finance. A member from each team presented on their area of interest at the panel and shared their thoughts and observations on the international negotiation process.

The students attended the conference as part of a National Science Foundation grant, with the idea being to train a cohort of graduate students for science policy leadership through a semester-long course and an intensive policy engagement exercise. The group had UN observer status and was able to observe all of the negotiations, breakout sessions and meetings. The students also presented their latest scientific information about mercury through a poster presentation, and shared their experiences and observations through a blog and twitter feed.

More: http://globalchange.mit.edu/news-events/news/news_id/249

Sponsored by the Joint Program and the Harvard University Center for the Environment

Constesting Geoengineering Governance: On February 12th, Alan Robock from Rutgers University, visited Harvard University, and shared his GeoMIP project and discussed how his climate model experiments with standard stratospheric aerosol injection scenarios already show that temperature and precipitation responses would be uneven globally.

Smoke and Mirrors: Is Geoengineering a Solution to Global Warming: On April 2nd, Steve Rayner, Professor of Science and Civilization and Director of the Institute for Science at Oxford University, visited MIT. He shared various alternative framings of geoengineering and explored the "definitional politics" of including or excluding various kinds of technology under the "Geoengineering" heading, and its relationship to mitigation and adaptation.

An Integrated Assessment of Emissions, Air Quality, Economic and Health Impacts of Transport Policies in China

Project Leaders: Eri Saikawa (Emory University), Valerie Karplus (MIT)

The goal of this project is to perform a comparison of policy options for reducing transportation emissions in China and to communicate our results to policymakers through an ongoing and interactive process over the course of the project. The policy comparison will be accomplished in four research tasks: (1 to introduce a detailed description of China's transport sector in a national energy model of China; (2 to develop a new emissions inventory for China focused on the transport sector detail and project possible future emissions of NO_x, CO, VOCs, BC, and OC under reference and policy scenarios; (3 to identify regional air quality impacts for a subset of scenarios using a state-of-the-art regional chemical transport model; and (4 to analyze the impact of various policy designs on transport emissions, the economy, and human health. The portion of the research conducted at MIT will involve (1 developing a detailed representation of vehicle transportation activities (both passenger and freight vehicle use) in an energy-economic model of the Chinese economy; (2 simulating in the model policy constraints on vehicle ownership, fuel quality, and emissions using this model; and (3 implementing a module in the model to quantify the health effects of air pollution exposure.

Source: Energy Foundation

LEARN MORE
Visit our website for information on all our projects:
http://globalchange.mit.edu/research/projects

What are Sustainable Climate-Risk Management Strategies?

Project Leaders: Klaus Keller (Penn State University), Mort Webster (MIT)

Current analyses of climate-risk management strategies have typically used integrated assessment models that link knowledge and tools from fields such as earth system science, engineering, economics, decision analysis, operations research and statistics. These integrated assessments have broken important new ground, but they face severe limitations with respect to four interrelated research questions: (i) How large are the uncertainties? (ii) What might be actionable early warning signals? (iii) What are the trade-offs between the diverse set of current and potential future objectives? (iv) What are the relevant value decisions and how do they affect the conclusions? Analyzing these questions requires fundamental advances in the relevant disciplines, an effective, large-scale, and sustained network to link them together, a research-training program to educate the next generation of scientists and engineers, and an integration of stakeholders and decisionmakers within a process of shared discovery. This research network on sustainable climate-risk management strategies will provide these advances and address these research questions.

Researchers will catalyze fundamental, mission-oriented, and transdisciplinary research to characterize the trade-offs associated with choosing among climate-risk management strategies and analyze how different sustainability criteria interact across a broad range of temporal and spatial scales.

Source: U.S. National Science Foundation

Coming and Going

Alli Gold joined as communications assistant.

Bhaskar Gunturu completed his postdoctoral appointment and returned to India.

Shubhada Kambli resigned as the assistant to co-directors, project management.

Da Zhang and Tianyu Qi completed their visiting student terms and have returned to Tsinghua University (CECP).

Eri Saikawa left to join Emory University as an assistant professor.

Nidhi Santen completed her studies and accepted a postdoc position at Harvard University

Tammy Thompson completed her postdoctoral appointment and joined Colorado State University Cooperative Institute as a

Newly-Released Joint Program Reports

Report 242: The Energy and CO_2 Emissions Impact of Renewable Energy Development in China

Report 241: Consumption-Based Adjustment of China's Emissions-Intensity Targets: An Analysis of its Potential Economic Effects

Report 240: Protection of Coastal Infrastructure under Rising Flood Risk

Report 239: Analysis of U.S. Water Resources under Climate Change

Report 238: Market Cost of Renewable Jet Fuel Adoption in the United States

Report 237: Analyzing the Regional Impact of a Fossil Energy Cap in China

Report 236: Modeling Water Resource Systems under Climate Change: IGSM-WRS

Report 235: Non-Nuclear, Low-Carbon, or Both? The Case of Taiwan

Report 234: Shale Gas Production: Potential versus Actual GHG Emissions

Forthcoming Joint Program Reports

The Global Energy, CO_2 Emissions, and Economic Impact of Vehicle Fuel Economy Standards

Integrated Economic and Climate Projections for Impact Assessment

A Framework for Modeling Uncertainty in Regional Climate Change

Climate Change Impacts on Extreme Events in the United States: An Uncertainty Analysis

Climate Change and Crop Productivity in the United States: An Uncertainty Analysis

The Energy and Economic Impacts of Linking China, the EU and Australia in an Emissions Trading System

A Distribution and Economic Analysis for a Chinese Emissions Trading System

A Global Energy-Economic Model for China: China-in-Global Energy Model (C-GEM)

Peer-Review Studies/ Pending Reprints

Nuclear exit, the US energy mix, and carbon dioxide emissions, *Bulletin of the Atomic Scientists*

Future trends in environmental mercury concentrations: implications for prevention strategies, *Environmental Health*

Land-ocean warming contrast over a wide range of climates: Convective quasi- equilibrium theory and idealized simulations, *Journal of Climate*

Global emission estimates and radiative impact of C4F10, C5F12, C6F14, C7F16 and C8F18, *Atmospheric Chemistry and Physics*

Integrating Mercury Science and Policy in the Marine Context: Challenges and Opportunities, *Environmental Research*

Comparing two methods to estimate the sensitivity of regional climate simulations to tropical SST anomalies, *Journal of Geophysical Research*

Do Trading and Power Operations Mix? The Case of Constellation Energy Group 2008, *Journal of Energy Markets*

Newly-Released Joint Program Reprints

Reprint 2013-3: Applying engineering and fleet detail to represent passenger vehicle transport in a computable general equilibrium model, *Economic Modelling*

Reprint 2013-2: Impact of anthropogenic absorbing aerosols on clouds and precipitation: A review of recent progresses, *Atmospheric Research*

Reprint 2013-1: The Impact of Climate Policy on US Aviation, *Journal of Transport Economics and Policy*

Reprint 2012-33: Valuing climate impacts in integrated assessment models: the MIT IGSM, *Climatic Change*

Reprint 2012-32: The role of China in mitigating climate change, *Energy Economics*

Reprint 2012-31: Green growth and the efficient use of natural resources, *Energy Economics*

Reprint 2012-30: The Role of Stocks and Shocks Concepts in the Debate Over Price versus Quantity, *Environmental and Resource Economics*

Joint Program In the News

http://globalchange.mit.edu/news-events/news

March 14, *Washington Post,* What's the best way to design a carbon tax? Lawmakers ask for suggestions.

March 5, *USA Today,* Energy efficiency needs more research

February 22 & 23, *New York Times,* The Case for a Higher Gasoline Tax; *Washington Post,* Gas taxes are six times as effective as stricter fuel-economy standards

February 15, *Nature,* Natural hazards: New York vs the sea

February 8, *Washington Post,* An oil tax could be one of the least paniful ways to trim the deficit

February 5, *WBUR,* Climate Change Series: Mitigating the Damage

January 23, *PBS News Hour,* Paint Pigment, Violent Raccoons, and Other Surprising Mercury Trivia; *LA Times,* Big Deal, little fanfare over global pact on mercury controls

January 22, *Scientific American,* Mercury Emissions Threaten Aquatic Environments

January 17, *Washington Post,* Home air conditioning cut premature deaths on hot days 80 percent since 1960

January 15, *New York Times,* An Antidote for Climate Contrarianism

January 14, *Energy Biz,* Carbon Tax Revisited

December 12, *New York Times,* If Mercury Pollution Knows No Borders, Neither Can Its Solution

December 10, *The New Yorker,* Paying for It

December 3, *CNN,* A tax we could learn to love

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RWE Power (Germany)
Shell International Petroleum (Netherlands/UK)
Southern Company (USA)
Statoil (Norway)
Suncor Energy (Canada)
Tokyo Electric Power Company (Japan)
Total (France)
Toyota Motor North America (USA)
Vetlesen Foundation (USA)
U.S. Department of Agriculture [USDA]
U.S. Department of Energy [DOE]
U.S. Department of Transportation [DOT]
U.S. Environmental Protection Agency [EPA]
U.S. Federal Aviation Administration [FAA]
U.S. National Aeronautics and Space Administration [NASA]
U.S. National Science Foundation [NSF]

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