Implications of a Nuclear Renaissance

By David L. Chandler

A major expansion of nuclear power is essential as a measure against climate change, John Rowe told a Harvard audience in 2008. But the chairman and CEO of Exelon, the nation's largest utility company, and owner and operator of the largest fleet of nuclear plants in the United States (who was delivering a Future of Energy lecture sponsored by the Harvard University Center for the Environment), also said that an investment in new plants simply doesn't make financial sense for a company like his, even after the promise of federal loan guarantees—a position he reiterated earlier this year.

Surprising or seemingly paradoxical positions on nuclear power are not unusual these days. And the complexity of Rowe's perspective on the subject illustrates the way, all across the spectrum of political opinion, analysts are now looking at the potential benefits and risks of nuclear power with fresh eyes, weighing anew a range of issues, including the need for regulatory and technological safeguards and the political, social, and economic questions surrounding the prospects for what many see as a need for a resurgence of the industry—a hoped-for major expansion that is often described as a "nuclear renaissance."

The new impetus is driven overwhelmingly by one factor: the push for ways of meeting ever-growing needs for energy without using more fossil fuels, which add to the already risky levels of greenhouse gases going into the atmosphere and which are vulnerable to disruptions in foreign supplies.

The consequence is that after a quarter-century hiatus nationally in orders for new nuclear plants—a period during which globally the number of functioning reactors also leveled off—the first new licensing requests by American companies have been made this year, in the wake of President Obama's call for loan guarantees for the new plants. But despite that slight bounce, essentially nobody thinks the road ahead for nuclear power will be an easy one.

For a nuclear resurgence to have any significant impact on those concerns, the global industry "really has to grow a lot," says Matthew Bunn, associate professor of public policy at the Harvard Kennedy School (HKS) and co-principal investigator at the school's Project on Managing the Atom. At present, about 4 new plants are being built per year around the world, but to make a significant dent in greenhouse gas emissions—at best, this would be something on the order of just a tenth of the new energy supplies that will be needed—"we would need about 25 new plants a year from now until 2050," he says. And relying on that level of new construction as a key component of a strategy to avert dangerous climate change is fraught with its own risks, he adds: a major disaster at a nuclear plant anywhere in the world, whether by accident or terrorism, "would doom any realistic prospect for a major nuclear contribution to the climate problem."

Bunn thinks a resurgence of nuclear power could indeed play a significant role in reducing anticipated emissions, mostly in the second half of this century, and is worth pursuing for that reason. But he and many others also point to a list of concerns that would need to be addressed to make that possible without creating undue new risks.

Matthew Bunn, associate professor of public policy at the Harvard Kennedy School and co-principal investigator of the Belfer Center's Project on Managing the Atom.

The Economic Picture

When Rowe said it would be too risky for a utility to order a new nuclear power plant today, his conclusion was based on the present economic realities—even in light of the administration's offer of loan guarantees. But why should it be so hard for a self-professed advocate of nuclear power, and for a company that has extensive experience in the area, to justify such an investment?

"Capital costs are huge, and have gone up by about a factor of two in the last few years," says Bunn. "There are a variety of proposals that could ultimately lead to lowered costs—including a standardization of designs—but for the time being, the choices available tend to be large, nonstandardized, and expensive."

Butler professor of environmental studies Michael McElroy explains: "The basic problem with nuclear [power] is that it's a high-risk activity, economically. People remember what happened at Shoreham: It was a major nuclear plant, and it never produced a single watt because of public opposition and public concerns about not being able to evacuate Long Island. A lot of money was spent, and the ratepayers had to pay."

"At present, about 4 new plants are being built per year around the world, but to make a significant dent in greenhouse gas emissions we would need about 25 new plants a year from now until 2050."

In light of that experience, he says, "imagine a utility making a decision to build a gigawatt plant, which costs about $4 billion. Once you have it, the fuel is cheap. But it's the capital cost that's a heavy factor. Given the risk, if you're going to finance it, what interest rate are you going to demand? Twelve, thirteen, fourteen percent? That makes nuclear power very expensive." And that investment is vulnerable in a way that investments in other sources are not, he adds: "it takes ten years to build, and you have to pay for it now, and if there's an accident that changes public perception, you lose your money. For a CEO [of a utility company], you risk going out in disgrace." A combined-cycle natural gas plant or a new wind farm are seen as much financially safer and less expensive alternatives, both domestically and in many other parts of the world.

Professor of government Stephen Ansolabehere says that even to those working in the field of nuclear power, "it's a little confusing as to what the price [of nuclear generated electricity] really is. There are a lot of factors that come in," and there is much heated disagreement as to the most accurate ways of estimating the true costs. In general, actual prices based on operating experience are substantially higher than the numbers that are often quoted, even by experts in the field, he says.

"It's often argued," Ansolabehere continues, that it's "because of regulation" that the costs of nuclear power often exceed those of most other sources, he says. But detailed analyses, such as a 2003 study from MIT, showed "the real driver of cost was the capital costs" of building the plants, because of the long lead times and high degree of perceived financial risk. Similar factors also drastically drive up the price of other large, complex installations, including proposed new combined-cycle coal plants with carbon capture systems, he adds.

For the present, at least, nuclear power remains the most politicized of all potential power sources, and the one with the highest negative public perceptions. In a recent survey, Ansolabehere found that 55 percent of Americans were strongly opposed to having a nuclear plant built within 25 miles of their homes, compared to 45 percent for a coal plant, 26 percent for a natural gas plant, and just 11 percent for a wind power facility.

On the other hand, people are generally much more likely to accept new nuclear plants at sites where they already operate, Ansolabehere found. "If you ask people about expanding at existing sites, the responses are much more positive," he says. Bearing that in mind, "companies should be much more attentive to the local communities, where there is usually a lot of support," especially when they represent stable jobs in an uncertain economy. "But you've got to maintain that."

During the short-term, the promised

"It's crazy that we've come to a point 60 years after the start of commercial nuclear power with no plan for how nuclear waste will be disposed of."

Federal loan guarantees should help, and have tipped some U.S. companies to file applications for new nuclear plants. But those guarantees will only apply to the first few plants ordered. The Nuclear Energy Institute, the industry's trade association, estimates that without the guarantees, the lifetime cost of a new U.S. nuclear plant would be about $98 per megawatt-hour produced (compared to about $79 for a conventional coal plant), and with the loan guarantees that would drop to about $64 per megawatt-hour. "It's not at all obvious that we will have nuclear power that's competitive after loan guarantees end," Bunn says.

But that depends partly on how things go for the first few new plants that get built—and on what new alternatives come along, in the United States and elsewhere. For one thing, standardization of plant designs could go a long way toward lowering costs while increasing safety, many analysts believe.

Peter Galison, Pellegrino University Professor and the director of the University's Collection of Historical Scientific Instruments, points out that this is one of the keys to France's success with nuclear power, which provides more than three-quarters of that nation's electricity. "One thing they've done that I admire is they've standardized their design, which means you learn." One reason that's important, he explains, is for safety: "Imagine if every airplane was different—different engines and different instruments and so on—we'd have nothing like the safety record we have." Yet in most of the world, that's essentially the way nuclear plants have been built. Standardization would make it possible to take advantage of the learning curve offered by monitoring large numbers of identical plants.

Bunn is not entirely persuaded, however. "I think standardization is important, but it's difficult in a world with several competing vendors. There are seven different designs being built now in China, for example, even though China is talking openly about wanting to standardize. Similarly, in license applications in the U.S., there are quite a variety of different designs utilities are pursuing."

For the next few decades, Bunn suggests, the vast majority of new reactors built are going to be fairly conventional light-water reactors (LWRs), the kind with which the world industry has the most experience. There are a few advanced designs that promise to be more economical and safer to operate, such as pebble-bed reactors that never need to be shut down for refueling and have no risk of meltdown. But because such approaches are unproven, "It's going to be very hard to get these things designed, tested, and deployed," Bunn says. But if such designs prove themselves, they could become major players in a nuclear revival in coming decades.

Among the new ideas, one that many find especially promising is the concept of much smaller, self-contained, and modular, factory-built reactors that could be shipped to a site fully fueled and ready to go. "Small modular reactors, at the moment, are not competitive," Bunn says. But that could change quickly if and when they start to be built and deployed in large numbers. Because of their smaller size, they could eliminate one of the biggest risks for utilities, the need to invest in huge plants all at once in order to make any use of nuclear electricity production. While traditional nuclear plants have significant economies of scale—they need to be at least a gigawatt in capacity to have any chance of being economically competitive—the idea is that the smaller plants could counteract the inefficiencies of smaller size with the greater efficiency of mass-production methods.

"They're hoping you'll get economies of production scale, but it's a chicken and egg problem," Bunn says. "You don't get economies until you have large-scale production, and companies are unlikely to order large numbers until the economies are there." So the real potential of such reactors lies in the longer term: "I'm a fan of the small modular reactors, but from now until 2050, they'll only displace a smidgeon of carbon," he says.

Graham Allison, Dillon professor of government and director of the Belfer Center for Science and International Affairs at the Harvard Kennedy School. Allison is an expert on U.S. national security with respect to nuclear proliferation.

The Waste Issue

Regardless of whether, and how fast, a nuclear renaissance takes hold, dealing with the nuclear waste already discarded by commercial nuclear power operators during the previous half century remains a problem. At the moment, there are few encouraging models. The United States has spent more than two decades, and perhaps $10 billion, developing plans for a single repository to hold all the nation's high-level nuclear waste at a site called Yucca Mountain in Nevada, but after years of lawsuits by the state, that option has now been taken off the table once and for all—with no replacement in sight.

"It's crazy," says Galison, "that we've come to a point 60 years after the start of commercial nuclear power with no plan for how nuclear waste will be disposed of." But the issue may be more political than technological.

"There's a lot of debate," he says. "Should we put it into granite mines, which are stable, but have a risk of water infiltration? Or in salt mines, where there's a prima facie case for no water infiltration" since any water would have dissolved the salt? There, the issue is "they close up, so it's not recoverable," if a future generation wanted to dig up the radioactive material for use in new plants or for some new purpose we haven't thought of yet. And there are a variety of other feasible options for underground storage.

"This is a debate we really need to have as a country," Galison says. "We have this waste already, it's not theoretical. The waste we have is not well secured at the moment, so we have to figure out what to do with that stuff." And the quantities of waste will be increasing: "There are so many plants already slated for production. It's not just inevitable, it's already happening." Apart from new plants in the United States, China and India are gearing up for major increases, and many other nations are eager to use nuclear energy for the first time.

There are three main concerns about the waste, Galison says: water, theft, and longevity. Water, he says, is the most significant worry. "The biggest issue, it seems to me, which is both incredibly simple and incredibly complex, is water. If water gets into a site," he explains, this "will cause the waste to migrate; and if it gets into aquifers, that's a real danger. To me, that is the number one issue."

The second concern, he says, is the risk of people trying to dig into the repository to get hold of the waste for the purposes of making weapons: whether in the form of simple "dirty bombs," or for reprocessing to provide the material for nuclear weapons; and the third is simply the need to keep highly radioactive material sequestered for the thousands of years that it takes for the radioactivity to decline to safe levels—"periods of time comparable to the history of civilization itself," as Galison puts it.

All of those issues, however, might be moot if the material were stored underground in large salt formations. Because the salt would seal itself up around the buried waste, the radioactive material would be virtually impossible to recover —either intentionally or by accident. And such formations are not subject to water infiltration. Other kinds of geological storage may also offer similar levels of protection.

"It's a problem, but it's not a big safety issue," says Bunn. "You want to put it deep underground, where there are only moderate risks." And it's important to keep the risks in perspective, he says: "Compared to the tens of thousands of people who die every year from the emissions from coal plants, it's minor."

The big question is how to get a site chosen and accepted. On this, the track record has not been encouraging. The U.S. is not the only country without a plan. France, often touted as a shining example of an effective nuclear power program, doesn't have one either. There, most of the waste goes to a single reprocessing plant, which produces large quantities of plutonium. Some of that is re-used in power plants, but the majority is just piling up at the reprocessing facility. No long-term storage facility has been identified.

But there is at least one encouraging exemplar out there, Bunn points out: in Finland, a final long-term repository for that country's nuclear waste has been decided on, essentially without controversy. In fact, when the decision was announced as to which of two possible sites would be chosen, there was an immediate lawsuit over the choice—by the community that *didn't* get picked.

What did Finland do right? One tack that helped, Bunn explains, is that right at the outset the government made it clear that no community would be forced to accept a storage facility. That made it easy for communities to investigate the possibility, without fear that a permanent repository would be sited there against their will. In addition, planners decided early on to locate the site near an operating nuclear plant, where there is already an

Peter Galison, Pellegrino University professor and director of the Harvard University Collection of Historical Scientific Instruments.

on-site spent fuel pool. So the choices facing that community were to keep the waste stored on the surface, or have it buried deep underground. "That's a no-brainer," Bunn says.

Galison says "the attempt to find a rational and well-engineered disposal site is essential." And those who oppose such a facility on environmental grounds need to be realistic about what the alternatives are. "It's not robins in an untouched meadow versus a nuclear disposal site. It's a current unregulated mess versus something protected against leaks." Getting it right is mostly a matter of how it gets decided at this point, he says. "You have to have an open enough, clear enough process, not secretive decisions. I don't think this is impossible. It's complicated, but it's necessary."

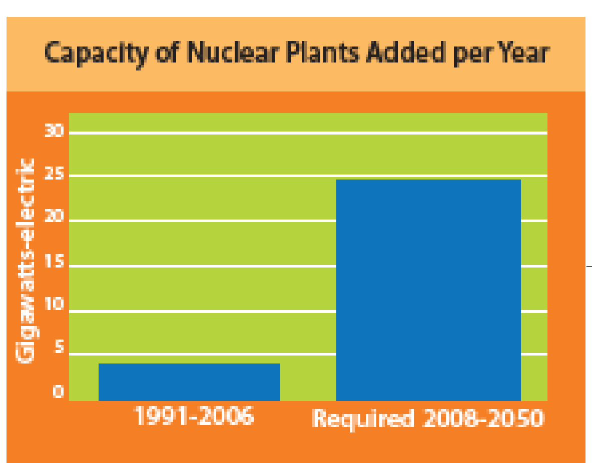
James K. Hammitt, professor of economics and decision sciences at the Harvard School of Public Health. "We as a people express more fear about technologies that seem unfamiliar, exotic, or that we don't understand," Hammitt says in reference to public attitudes about nuclear power.

Accidents and Attacks

When it comes to thinking about the potential risks associated with nuclear power, most of the public's attention—from the release of the movie "The China Syndrome" through the accidents at Three Mile Island in 1979 and Chernobyl in 1986—focused on the possibility of a major accident such as a meltdown of the reactor core.

Most people probably overestimate that risk, Bunn suggests. The risk was always low, and nuclear plants "are safer today than in the past," he says. But what of the push for greatly increased numbers? "At the current risk rates, if we have three or four times as many plants, that's still a significant amount of risk," he says. On the other hand, newer designs, including passive cooling systems and other advanced safety measures, may help to drive risks down.

"It seems to be true that we as a people express more fear about technologies that seem to be unfamiliar, exotic, or that we don't understand," says James Hammitt, professor of economics and decision sciences at the Harvard School of Public Health. This seems to be the case with nuclear power, he points out, even though it represents some 20 percent of the nation's generating capacity and has been around longer than the lifetime of the average person.



Source: Matthew Bunn/Harvard Kennedy School of Government

Between 1991 and 2006, only four Gigawatts-electric of nuclear generating capacity was added anually. Six times that amount would need to be added each year between now and 2050 to make a significant impact on greenhouse gas emissions.

People also react differently to a single large event than to a large number of smaller ones, as with the inverted impressions people tend to have about the risks of airplanes versus cars. "To the extent we're fearful of low-probability serious outcomes," Hammitt says, "if you compare nuclear with coal and other fossil fuels, I'm quite certain that burning coal is having serious health effects on people; but it's very hard to estimate the low chance of some really catastrophic event at a nuclear plant." So people are weighing "the certainty of lots of deaths and illnesses, against the uncertainty of a probably small, but probably very serious outcome."

If the risk of accidents is overestimated, the opposite may be true for the risk of attack. Even in the post-9/11 era, it's a possibility that gets relatively little serious attention. But Graham Allison, Dillon professor of government and Director of the Belfer Center for Science and International Affairs at HKS, has been studying the issue for years. He says the risk of terrorist exploitation of nuclear power and its byproducts, though real, also needs to be put into proper perspective. First, he explains, it's important to realize that even an all-out attack on a nuclear plant poses no danger of a nuclear bomb-like explosion. Still, "if an aircraft were to crash into it, especially into the most vulnerable components, then that's like a 'dirty bomb' on steroids. You'd have dispersal of a lot of radioactive material, including quite nasty materials. That would spook people for a long time, and have local health effects." Because of that possibility it's essential for all nuclear plants to have "reasonable precautions against any reasonable threats," he says.

But as deadly as such an attack may sound, he says, "To put it in perspective, if I compare the threat of an attack on a spent-fuel pool with the threats to chlorine tankers that are on the rails, or the chemical facilities that are in many cities, the chemical risks are greater. In an advanced industrial society we live with lots of very dangerous stuff."

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A much more serious concern regarding nuclear material, Allison says, is proliferation. There are many risks associated with the production and disposal of nuclear fuel—in particular with the facilities that produce the fuel for the reactor, and the facilities that extract plutonium from nuclear waste. Nuclear weapons can be made from either enriched uranium, or plutonium. "Enriched uranium is made by putting it through an industrial process, including centrifuges, like vast washing machines that spin at the speed of sound to concentrate Uranium 235 (U-235)," he explains. For use in a nuclear power plant, the uranium is enriched to a level of 4 or 5 percent U-235. To make a bomb, U-235 is typically enriched to about 90 percent, but in both cases the enrichment takes place in a similar facility. "With a little re-piping, you can produce 90 percent. So if any state that decides to build nuclear plants also decides to build a fuel-production facility" explains Allison, "it's a straight step to a nuclear bomb." Likewise, reprocessing spent nuclear fuel to separate out plutonium, as France does, produces material that can be used to run nuclear power plants, but also to make bombs.

Allison notes that while a facility designed to produce reactor fuel could, in principle, be diverted to make weapons material, that's not the likeliest scenario. Instead, the expertise and technology developed for such production may be used to build a similar, hidden, much smaller facility for producing bomb-grade uranium or plutonium.

Bunn says that "every country that has launched a nuclear weapons program since nuclear power became available has acquired some crucial elements from commercial nuclear power, either as a fig leaf, or as a way to build up infrastructure and expertise. So, for example, Pakistan sought to buy a big reprocessing plant from France. In later interviews, they said 'we never intended to use the French plant to produce weapons material, but rather to use that knowledge and expertise to build a smaller facility'" to make the material for bombs. In short, he says, "The proliferation concerns are broader and more complex than is often portrayed."

Nuclear fuel security in nations that have not previously had nuclear power could also present inviting targets for nations or terrorist organizations bent on obtaining weapons material. "There, the issue is whether the required infrastructure will be in place" to assure control of the fuel and waste, Ansolabehere says.

But efforts are underway to address the range of proliferation scenarios, by bringing existing weapons-grade material under strict international control, and providing a system so that countries that want to build nuclear power plants can get their fuel, and get rid of their waste, through internationally monitored supply chains.

In a Future of Energy lecture in 2008, Anne Lauvergeon, head of Areva, France's largest nuclear power company, said that her company is already building completely self-contained reactors that companies or countries can order without having to get involved in fuel production or disposal. The reactors would remain sealed for their operating lifetimes and the fueling and disposal would be handled by the company. "The fact that we can deliver the whole plant, with the fuel cycle, without any possibility of proliferation, and take back the waste and recycle it, is absolutely key," she said. "It's a precondition for us to sell new reactors."

Professor of government Stephen Ansolabehere says that of all energy sources, nuclear power has the one of the highest negative public perceptions.

Similarly, Abu Dhabi recently entered into an agreement to buy four nuclear plants from a South Korean company. But in the process, Allison says they signed a contract "saying that for the lifetime of those plants, they will buy their fuel from an outside supplier, and ship their spent fuel back to them." That not only provides security, but it also just makes sense, he explains. "In terms of economics, the potential of enriching your own uranium makes no sense unless you're operating

50 reactors." So the International Atomic Energy Agency (IAEA) is developing a system of guarantees for any country that wants nuclear power: to provide them with a fuel supplier, along with a backup supplier, and as a further backup the IAEA itself, which plans to maintain its own supply of fuel.

That would address the biggest concerns, both of the U.S. and other industrialized nations and of the countries seeking nuclear power. "The Iranians have used [the lack of a reliable source of fuel] as an excuse," for their centrifuge program, Allison notes. Under the planned system, which was kick-started with a $50 million donation from Warren Buffet and matched by pledges for another $100 million by from various national governments, the IAEA will provide the fuel of last resort, as a way to "make sure it's nuts for a nation, that it economically makes no sense," he says, to make or reprocess their own nuclear fuel.

Will this plan work, and make possible a major worldwide expansion of commercial nuclear power without adding to the risk of nuclear terrorism? "There are optimists and pessimists," Allison says. "The optimists say we will revitalize the nuclear order. Pessimists say the trend lines are negative, and the amount of energy required to bend them is too large." In other words, political forces may, or may not, make it possible to implement international controls over the way nations initiate or expand their use of nuclear power.

The outcome is far from guaranteed, and it will take serious effort on the part of the United States and the international community to make the proposed system work, Allison says. Still, "I would say most days I get up as an optimist."

But the need for international agreement is growing fast, as the pressures for a rapid expansion of nuclear power continue to mount. Faced with the twin threats of climate change and the risk of shortages of the most readily available fossil fuels, most energy experts agree that foreclosing any option for energy production would not be prudent for the United States or the world as a whole. As Michael McElroy puts it, "I think we should be pursuing every reasonable, practical, economically feasible option."

Environmental Fellows Prepare to Take (and Make) Their Mark

The Center for the Environment warmly welcomes the incoming group of Environmental Fellows who will arrive at the center this fall. The new fellows will be joining a group of remarkable scholars starting the second year of their fellowships. Together, the Environmental Fellows at Harvard form a community of researchers with diverse backgrounds united by intellectual curiosity, top-quality scholarship, and a drive to understand some of the most important environmental challenges facing society. The Center also congratulates the outgoing Fellows (class of 2008-10) as they prepare to embark on the next stage of their careers. For more information on the Environmental Fellows program, including how to apply, visit http://www.environment.harvard.edu/grants/fellows.

Incoming Fellows: Class of 2010-12

Daniel A. Barber (Ph.D. Columbia University) is an architectural historian analyzing affinities between the history of architecture and the emergence of environmentalism in the 20th century. As a Ziff Environmental Fellow, Daniel will work with Charles Waldheim at the Graduate School of Design to pursue a research project that complements his dissertation. Tentatively titled "The Invention of Thermal Comfort: Climate Science and the Globalization of Modern Architecture, 1933-1963," the project explores the multifaceted proliferation of climatic architectural strategies at mid-century, and in particular research on "thermal comfort"—the internal climatic conditions of the built environment. The concept developed as part of an interest in the formal aspects of passive ventilation and heating strategies, and was quickly subsumed into the global proliferation of mechanical heating, ventilation, and air conditioning systems by the end of the decade. The project reveals empirical and conceptual relationships between architectural research, climate science, and the global emergence of political, economic, and cultural concern for environmental conditions.

Elizabeth Landis (Ph.D. University of Wisconsin) is a materials chemist who is interested in applying surface chemistry to solar energy collection and storage. At the University of Wisconsin, Beth developed methods for attaching molecules to vertically aligned carbon nanofibers and studied the electronic properties of the resulting interfaces. This work demonstrated the suitability of the nanofibers for use in fuel cells and for energy storage. As a Henson Environmental Fellow, Beth will work with Cynthia Friend in the Department of Chemistry and Chemical Biology to study how surface layers of titanium dioxide can be doped to change and control the optical properties of the material. This work will focus on tuning this abundant metal oxide to harvest solar energy.

Alexander (Zan) Stine (Ph.D. University of California-Berkeley) is a climate scientist interested in how to separate natural signals of climate variability from human-induced changes in the observational record. As a Kernan Brothers Environmental Fellow, Zan will work with former Environmental Fellow (now assistant professor) Peter Huybers in the Department of Earth and Planetary Sciences to understand changes in the response of tree growth to temperature during the last century. Because tree-ring growth is correlated with temperature at many locations, early tree-ring records have been used to infer the temperature history of the Earth before the advent of the thermometer. However, in the late 20th century many of these tree rings ceased to track temperature, suggesting a large-scale change in the way the terrestrial biosphere responds to climate, and calling into question tree-ring based reconstructions of past climates.

Rich Wildman (Ph.D. California Institute of Technology) is an environmental engineer whose interests also include chemistry and oceanography. As a French Environmental Fellow, Rich will work with James Shine in the Harvard School of Public Health to study the transport, degradation, and toxicology of chemical contaminants during water reuse. Since reservoirs are the centerpiece of many water reuse strategies, Rich will focus his research on trace organic pollutants in reservoirs that receive highly treated wastewater intended for future consumptive use.

Outgoing Environmental Fellows: Class of 2008-10

Etienne Benson (Ziff Environmental Fellow) will join the Max Planck Institute for the History of Science in Berlin, where he will continue his work on the history of endangered species science. Etienne's first book, *Wired Wilderness: Technologies of Tracking and the Making of Modern Wildlife,* will be published this fall by Johns Hopkins University Press.

William Boos (French Environmental Fellow) will join the Department of Geology and Geophysics at Yale University as an assistant professor, where he will continue his work on tropical climate dynamics.

Susan Cameron (Kernan Brothers Environmental Fellow) will join the University of Florida as an assistant professor in the Department of Wildlife Ecology and Conservation.

Mauricio Santillana (Henson Environmental Fellow) will begin a new postdoctoral fellowship in the School of Engineering and Applied Sciences, where he will continue his research in atmospheric chemistry. Mauricio will also teach a graduate course in applied mathematics in the fall.

Alex Wissner-Gross (Ziff Environmental Fellow) will serve as chief scientist of Enernetics, Inc., a research and development company he co-founded in 2007 that is leading the convergence of physical and digital worlds.

Shengwei Zhu (Ziff Environmental Fellow) will return to China where he plans to join the faculty of the Architecture and Urban Planning School of Huazhong University of Science and Technology—one of the top ten schools in the country.

Ziff Environmental Fellow Rafael Jaramillo Receives Young Investigator Award

HUCE congratulates Rafael Jaramillo, a Ziff Environmental Fellow (2009-11), on receiving the 2010 Rosalind Franklin Young Investigator Award. The award, given by the Advanced Photon Source (an office of science within the U.S. Department of Energy), recognizes Jaramillo for furthering understanding of itinerant magnetism and for his contributions to the study of quantum matter at high pressure using synchrotron x-ray diffraction. As an environmental fellow, Jaramillo works with professor Shriram Ramanathan (School of Engineering and Applied Sciences) on the problem of controlling electron transport across thin oxide barriers—a problem with broad relevance to future generations of solar cell technologies.

Environment @ Harvard

A sampling of the spring semester's events

Conferences and Workshops

Promises and Challenges of Development and Conservation in the Amazon
March 10, 2010
Co-sponsored with the David Rockefeller Center for Latin American Studies, this event featured presentations and commentary by Arnóbio "Binho" Marques, Governor of the State of Acre, Brazil; Jorge Viana, Former Governor of the State of Acre, Brazil; Roberto Mangabeira Unger, Pound professor of law (HLS), and former Minister of Strategic Affairs for the Brazilian government; and HUCE faculty associate John Briscoe, (SEAS, HSPH) and former World Bank Country Director for Brazil.

The Environmental Turn in Literary and Cultural Studies
April 8, 2010
Co-sponsored with the Humanities Center at Harvard, this colloquium on the field of "ecocriticism" featured HUCE faculty associates Lawrence Buell (Dept. of English and American Literature and Language) and Karen Thornber (Dept. of Comparative Literature), along with Ursula Heise of Stanford University. Among other questions, participants in the dialogue considered the value of interdisciplinary collaboration between the arts and humanities and the social and natural sciences.

Ongoing Series

The Future of Energy
The Future of Energy is an ongoing lecture series focused on finding secure, safe, and reliable sources of energy to power world economic growth. The spring series opened with **Aubrey McClendon,** chairman and CEO of Chesapeake Energy. McClendon championed the potential of natural gas as a major source of clean energy for the U.S., arguing that the combination of abundant reserves and improved extraction techniques puts the domestic supply of natural gas on par with Saudi Arabian oil reserves. The Center also hosted **David MacKay,** chief scientific advisor to the Department of Energy and Climate Change in the UK. MacKay addressed the limitations of solar and wind power, and suggested that renewable energy sources alone cannot adequately replace conventional fossil fuels in meeting the world's energy demands. Returning the focus to domestic energy consumption, **Kristina Johnson,** U.S. Under Secretary of Energy, detailed the steps needed to accomplish the ambitious goal of reducing fossil fuel use from 80 percent to 20 percent of U.S. energy use by the year 2050. The final lecture was delivered by **Marvin Odum,** President of Shell Oil. Odum echoed MacKay's view that it will take a mix of sources to meet future energy demands, emphasizing that renewable sources will