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SUMMARY OF THE 2014-15 CLIMATE LECTURE SERIES

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During the 2014-2015 academic year, the Center for Energy Studies (CES) at Rice University's Baker Institute for Public Policy hosted a series of lectures addressing various perspectives on matters at the intersection of public policy and climate change. Four speakers were invited to address various aspects of climate change and public policy. This summary begins by sharing those perspectives, which do not necessarily reflect the views of the researchers at the CES. Rather, the summary is presented here in order to highlight the discussions throughout the last year. The goal of the series is to shed some light on possible policy strategies that are capable of yielding multiple benefits while addressing the fundamental issue at hand. In closing, we offer some insights from CES researchers regarding climate change and the policy responses to the perceived challenges faced.

The Lectures

The lecture series was composed of four different talks and was designed to highlight several important themes germane to the public policy arena. To begin, it is important to highlight the apparent polarization of the discussion about climate change in policy circles. As such, Andrew Dessler, a professor in the Department of Atmospheric Sciences at Texas A&M University, presented his thoughts on the ideological drivers of what is often termed "climate skepticism."

Next, Megan Ceronsky, who was at the time the director of regulatory policy and a senior attorney at the Environmental Defense Fund but has since joined the White House Office of Energy and Climate Change as a senior policy advisor, outlined the current administration's efforts to curb carbon emissions in the United States through the Clean Power Plan (CPP). While the CPP as rolled out in August 2015 is slightly different from the version of the CPP discussed by Ceronsky, her talk nevertheless addressed the costs and benefits associated with a concerted policy action that may be a harbinger of the types of policies that will become more prevalent in various countries around the world.

The third lecture was given by Drew Shindell, professor of climate sciences at the Nicholas School of the Environment at Duke University. He explored environmental concerns that are broader than climate change, addressing the effects of pollutants other than carbon dioxide and advocating for the development of policies that reduce their emission—providing the benefit of both reducing emissions that contribute to climate change and lessening distinct, harmful, local impacts. While the lecture did not explicitly address it, a policy with multiple benefits that extend beyond a singular concern can tilt the scale in favor of policy adoption, as the cost-benefit analysis can move quite clearly in favor of the policy measure.

Finally, John Matthews, secretariat coordinator for the Alliance for Global Water Adaptation, delivered a lecture drawing the link between energy, water, and climate change and looking at water planning and governance as tools to mitigate the impacts of climate change and facilitate adaptation. Indeed, the energy-water nexus has been growing in terms of its perceived importance among commercial interests and policymakers alike, and highlighting the intersections with climate change provides useful insights in the complexity of the issues at hand.

Lecture 1: The Alternative Reality of Climate Skepticism—October 1, 2014
Andrew Dessler, professor in the Department of Atmospheric Sciences at Texas A&M University, presented his view of why debate over climate change persists despite widespread agreement among climate experts that the Earth is warming due to human activity. Most scientists believe that over the 21st century, Earth will warm by 2-4°C. Dessler argued that this seemingly small change becomes much more alarming when one realizes that the current climate is only 5-6°C warmer than the climate during the ice age that ended approximately 10,000 years ago. Despite a rather large body of scientific evidence, a vocal minority still questions the mainstream view of climate change. Dessler argued that this minority is able to adhere to this view by relating to an alternate reality that is carefully constructed by those who oppose introducing policies that would protect Earth's climate.

Dessler posited that, consequently, the argument about climate change is not an argument about science; rather, it is a policy debate. Since the mainstream science is settled, the only way to win—or at least to not lose the argument—is to introduce uncertainty. Dessler argued that this is a strategy taken directly from the playbook of tobacco companies in the last century. Just like climate skeptics today, tobacco companies in the 20th century knew that to win the policy debate, they had to push back on science—a strategy they executed successfully for almost four decades. Dessler argued that uncertainty is introduced by first redefining the term "expert" to mean anyone who agrees with the skeptics. This may include people who hold only bachelor's degrees in a technical field, such as, for example, many of the signatories of the Global Warming Petition Project.[1] Concurrently, people with real expertise in climate are dismissed as "minimally qualified" and accused of doctoring their findings on climate change to receive grant money. Dessler argued that scare tactics are often employed to dismiss the global warming argument by, for example, equating environmentalism to communism, or to an immoral ideology that goes against the grain of democracy and freedom. Portrayed in this way, he asserted, climate scientists are easier to dismiss as biased and corrupt.

Another technique to introduce doubt into the findings on global warming, according to Dessler, is producing reports that on the surface resemble the work of climate scientists but are geared toward dismissing the science and have very little to do with science at all. Those reports, such as the Nongovernmental International Panel on Climate Change's

[1] The Global Warming Petition Project is a petition urging the U.S. government to reject the Kyoto Protocol of 1997 and similar policies addressing global warming.

(NIPCC) research—created to offer a perspective different from that of the Intergovernmental Panel on Climate Change (IPCC) report—are prepared without a rigorous scientific process, without an open peer review, and without a process for selecting contributing scientists or writers. Reports like the NIPCC's provide an intellectual crutch for those who choose not to believe global warming is occurring in much the same way that the tobacco companies' reports provided a crutch to tobacco users to continue smoking.

This begs the question, why are tactics like this effective? Is it because people do not know enough about the science? Dessler argued that lack of knowledge is not the reason for opposition to the notion of global warming, citing results from work by Yale Law School's Cultural Cognition Project that have shown that the more educated people are, the more polarized they are on the issue of climate.[2] This polarization is identified as existing along ideological lines, suggesting that those to the right of political spectrum are less likely to acknowledge the science on climate change because they are ideologically opposed to it. They see the world in the way they want to see it by accepting only the evidence that is consistent with their worldview, a flaw in thinking and perception to which people on all sides of a debate are prone. Dessler argued that this is rational at an individual level. If you are a member of a group, it is rational to identify with the beliefs that are popular within that group. But he noted that what is rational for an individual is not always rational for the community, arguing that the climate debate is a prime example of the tragedy of the commons.

Seeking a solution to this problem, Dessler wondered how perceptions of climate change can be altered to more closely align with the prevailing scientific evidence. He argued that changing public opinion will not help. Instead we need to change how groups think about climate. For example, those on the right of the political spectrum need to understand that environmentally friendly policies do not necessarily mean big government. He argued that the opposite is true, as future environmental catastrophes brought about by climate change are likely to bring higher levels of governmental interference in our lives and freedoms.

The question-and-answer session after Dessler's lecture delved further into the realm of possible solutions to both the issue of the alternate reality and climate change generally. How can we decarbonize society if renewables are more of a boutique than a real energy alternative? Is there really an alternative to fossil fuel combustion? Dessler does not believe that there is a viable alternative in the short term, but he argues that renewables may be a viable alternative in the long term. However, he argued this can only happen if private industry gets involved, which, in turn, requires a price on carbon to facilitate a hospitable investment climate for non-fossil fuel energy resources. Dessler agreed with an audience member that change will be more difficult in developing countries such as China or India. He believes that the way to encourage these countries to comply with new climate goals is for developed countries to take the lead in creating inexpensive and easy-to-implement

[2] See Yale Law School's Cultural Cognition Project at http://www.culturalcognition.net/.

technologies. This has been the case with the protection of the ozone layer. He also argued that if the policies are not successful, we can always stop applying them.

Lecture 2: The EPA's Clean Power Plan: Ambitiously Optimistic?—December 12, 2014
Megan Ceronsky, Director of Regulatory Policy and Senior Attorney at the Environmental Defense Fund, discussed the Clean Power Plan (CPP)[3] proposed by the U.S. Environmental Protection Agency (EPA) and the options available to Texas and other states in designing their compliance plans. Ceronsky began by noting that Section 111 of the Clean Air Act sets nationally consistent standards for sources of dangerous air pollution that are not addressed under sections dealing with ambient air quality and hazardous air pollution. Section 111 is a "backstop" or "catch-all" section. It directs the EPA to identify the best system of emission reduction (i.e., to define what is achievable on a state-by-state basis), which later becomes a standard for each state. Each state may choose the process it uses to meet those standards.

Ceronsky broadly described the process used by the EPA to develop the CPP and observed that, in the context of greenhouse emissions, it is difficult to identify the best way to reduce pollution. The EPA looked at what states and companies are doing to reduce carbon emissions and noticed they have been tremendously successful in achieving reductions in carbon emissions—not through "widgets" like carbon capture and storage technology, which are expensive and not widely deployed—but by deploying renewable energy, investing in demand-side energy efficiency, improving the efficiency of specific power plants, and shifting efficiency from the highest-emitting energy-generating sources to the lowest. This is possible thanks to a unique feature of the electricity grid: its integration. Adding cleaner sources of electricity onto the grid allows operators to "back out" those that are associated with the highest pollution levels. Based on these observations, the EPA concluded that the best system of emission reduction should be based on four pillars:

1. Heat rate improvements of coal power plants;
2. Shifts in utilization from coal to natural-gas generation;
3. Deployment of renewable energy and continuing use of nuclear energy; and
4. Deployment of demand-side energy efficiency.

This framework was applied to each state, and a target—an average emission rate that the state must meet between 2020 and 2029—was calculated for each. EPA allowed states flexibility in implementation of the plan, permitting them to build on existing policy or add new policies to achieve those standards. States may also meet their obligations by putting in place a trading program.

[3] As noted above, Ceronsky discussed the version of the Clean Power Plan proposed in June 2014. President Obama unveiled a final version of the rule in August 2015, announcing that it would be published in the Federal Register in September 2015.

Ceronsky described two mechanisms contemplated by EPA for achieving compliance with the CPP. First is a mass-based trading program, or cap-and-trade, that works best if paired with investment by the states into demand-side energy efficiency. As demonstrated by the experience of the Regional Greenhouse Gas Initiative (created by nine northeastern states), there are economic benefits to the cap-and-trade program, but they are greatest when paired with investment in demand-side efficiency because allowances are then freed up for other uses. Demand-side efficiency, all else equal, lowers utility bills and thus provides economic stimulus to the population. Demand-side energy efficiency can also be the cheapest way to reduce pollution from the power sector. The second option for achieving compliance through trading is a rate-based trading program wherein each fossil fuel has to achieve a specific emission rate either by lowering usage or by holding credits from renewable energy. This would incentivize a shift from coal to natural gas, for example. This approach is slightly different from the cap-and-trade programs since it requires that emissions reductions be explicitly quantified in the fuel choice of each generator.

Ceronsky noted that the top challenge arises because the framework created by the EPA is state-specific while electricity grids (other than Texas' grid) are not. The potential for emission reduction is different in every state, and power generators own generation facilities across the grid in different states. This is why the EPA encourages multistate solutions that combine emission reductions targets, thus allowing for joint compliance. Ceronsky noted that this is not an easy task since several states (or more accurately, their legislatures and executives) must agree on a path going forward.

Ceronsky concluded her talk by observing that now is a very dynamic time for national environmental policy, as national standards on carbon emissions are being set for the first time. She reiterated that the EPA's framework will allow as much flexibility as possible to make compliance cost-effective and efficient, and that allowing states to design their compliance programs will maximize the co-benefits that can be achieved with carbon reduction. The EPA projects that approximately 25% of such pollution will be reduced by 2030 and that each dollar invested will bring about $7 back in returns through avoided costs and economic opportunities. She noted the health implications of compliance, including avoiding premature, pollution-related deaths and fewer asthma attacks, but added that these benefits derive from reduction of pollutants other than carbon. Ceronsky observed that the EPA analysis also indicates that if states employ energy efficiency, such investments will result in an 8% reduction in utility bills by 2030.

During the question-and-answer period, Ceronsky underscored that now is a great time for changes to occur, as natural gas prices are at historic lows and coal-powered infrastructure is aging. Flexibility and consistent signals will allow decision-makers to operate power plants optimally. Whether co-benefits will be achieved, and to what degree, depends on the path each state chooses. Ceronsky noted an interesting tension in this regard between portfolio and market-based approaches. She also acknowledged that methane leakages from natural gas production are a potential problem, as they would counteract any benefits captured from displacing coal with natural gas in power generation. However, the part of

the Clean Air Act applicable here deals only with carbon dioxide; the issue of methane leakage falls under a different legal domain.

Ceronsky also observed that we should pragmatically assess the possibility of energy price increases and reductions in reliability that some have argued will result if coal power plants are required to close.[4] She noted that similar concerns have been repeatedly voiced before but have never materialized. Also, the 10-year averaging period allows flexibility to manage reliability issues. In response to a question about the biggest challenge associated with the higher penetration of renewables, including grid management and reliability, Ceronsky said she hopes for more input from the scientific community—including progress in particular on energy storage—but she admitted it will be a challenge.

Lecture 3: The Value of Clean Air—May 8, 2015
Drew Shindell, Professor of Climate Sciences at the Nicholas School of the Environment at Duke University, explored a valuation framework for carbon and discussed how society can make informed choices about activities that simultaneously lead to climate change and poor air quality. He started by observing that humans look at emitting pollution into the atmosphere differently than we look at other types of pollution, such as garbage dumping or water pollution. We do not think much of the smoke we see coming from a factory chimney or of the smoke that is emitted from our cars' exhaust pipes.

Shindell posited that there are two reasons air pollution is treated differently. First is the issue of ownership. Land and water are clearly defined and, for the most part, have an identifiable owner. The owner will object to pollution on his/her property. Air, on the other hand, is not owned by a specific person or entity. Second, as a society we are more likely to focus on sudden and local impacts and to downplay chronic, broadly defined impacts. Thus, an aircraft crash will generate more newspaper coverage than thousands of everyday car accidents on our roads, despite the higher number of casualties caused by the car accidents. In the same way, slowly progressing air quality degradation and climate change, which are diffused through time and space, are less compelling issues than are immediate ecological disasters, such as an oil spill.

But why should we care about air quality degradation? Shindell argued that, to start with, air is absorbed into our bodies in much higher quantities than are water and food, and bad air quality is notorious for resulting in premature deaths. This consideration is not only important in developing countries where bad air quality is the leading cause of premature death in women and children, it is also valid in developed countries such as the US, where, Shindell noted, one in 20 people in California dies early because of poor air quality. Bad air quality also stunts plant growth, thereby affecting crop yield, as evidenced by the fact that up to one-third of wheat and rice yield is lost in India due to poor air quality. Thus, air quality is also an issue of food security. A variety of air pollutants also contribute to climate

[4] See, for example, "ERCOT Analysis of the Impacts of the Clean Power Plan," Nov. 17, 2014, http://www.ercot.com/content/news/presentations/2014/ERCOTAnalysis-ImpactsCleanPowerPlan.pdf.

change. Carbon dioxide is the biggest individual contributor to climate change, but methane, carbon monoxide, or black carbon (soot), when added together, contribute to climate change as much as CO_2.

Shindell posited that because climate change and air pollution are in fact one story, and sources of CO_2 are almost always tied to other pollutants, these issues must be treated together. He argued that there is no valid argument to dismiss the greenhouse properties of CO_2; those properties have been measured since the 19th century. The warming of the Earth is not a benign occurrence, Shindell noted, citing evidence of sea level rise, melting ice sheets, more intense and frequent weather events, and a higher propensity for the spread of tropical diseases and incidence of wildfires.

Although other examples of negative occurrences related to a warming climate can be found, it is important to notice that they are related to extremes, Shindell argued. We see only minimal changes in the averages but the distribution shifts significantly. Thus, an average 2°C increase in the Earth's mean temperature will correspond to much greater changes in extremes. However, climate change discussions are often centered on the global mean, with international negotiations focused on, for example, keeping global warming below 2°C. Unfortunately, Shindell said, in order to achieve this goal, we need to bring down the level of emissions today, and we are currently on a path where the planet warms between 4-6°C.

What can we do to avoid a catastrophic outcome? Shindell argued that carbon should be priced, and that the calculation of the cost of carbon should include many different factors. He described the Obama administration's intention to include in a presidential order a cost of carbon that incorporates estimated values of changes in agricultural production, property damage (from storms, droughts, etc.), ecosystem services, and health. He noted that carbon-trading systems have been, or are being, developed in many places, including China, California, and the EU.

But, importantly, local air quality is not included in these considerations: air quality analysis is distinct from analysis of climate change. The EPA analyzed the impact of air quality but stopped short of including the impact of the emissions on human health. Shindell argued that humans have arbitrarily separated climate effects from air quality effects, and this approach can lead to inefficient policies. For example, in China there is widespread concern about air quality but little appreciation of the issue of climate change. Thus, the solution to poor air quality would be to change the location of a power plant, which might move the pollution away from an area but would not impact carbon emissions, and would thus continue the negative impact on global warming. He observed that these tradeoffs are also often lost within the EU and the US power systems.

Similarly, Shindell argued that insufficient attention is given to the global warming potential and other problems (such as impacts on agriculture) caused by pollutants other than CO_2. For example, CO_2 causes damage to the climate by affecting temperature and

rainfall patterns, but this negative impact is offset to some extent by the fact CO_2 has a fertilizer effect on plants. Thus, when both effects are taken into account there is "only" a modest negative value put on CO_2 emissions. However, methane is not needed by plants, and therefore the climate-related damages from methane emissions are higher. It is much harder to grow food in a world where temperatures are 2°C higher due to methane than in one in which the temperature increase is driven by CO_2. This is an important consideration since 40-50% of deaths attributed to climate change are due to malnutrition.

Consequently, Shindell is working to develop a more comprehensive measure of the social cost of carbon that incorporates the effects of climate change and poor air quality on human health and agricultural productivity. He models responses to emissions of one pollutant at a time, considering pollutants other than CO_2 and including a valuation methodology for air quality and climate. He considers specifically whether the switch from coal to natural gas is indeed as beneficial in terms of climate gains as some claim it is. Since generating electricity using natural gas today is substantially cheaper than using nuclear, solar, or wind infrastructure, and because US coal power plants are aging, natural gas is becoming a fuel of choice. But Shindell argued that no one is taking into consideration the associated impacts such as emissions from natural gas production or transportation. If taken into account, he asserted, such considerations make natural gas more expensive than solar or wind. Coal performs even worse in terms of its societal cost. A gasoline car costs approximately $2,000 per year in environmental damages. An electric car powered by coal-generated electricity produces approximately $1,000 per year in environmental damages, and one powered by natural gas generated electricity costs $250 per year. Shindell noted that by not pricing those damages into the price of coal or natural gas, we are—as the World Bank puts it—effectively providing subsidies for fossil fuels.

Unfortunately, there is difficulty in putting a number on the deaths caused by air pollutants. Shindell estimates that approximately 100,000 heart attack deaths a year are because of air pollution, but he added that these are diffuse problems that are not easy to quantify and therefore escape our full attention. Attaching values to environmental damages caused by fossil fuel combustion will enable us to better internalize those damages through market mechanisms and to provide appropriate regulatory oversight. Moreover, an appropriate valuation of the costs of various pollutants aid in facilitating a societal understanding of damages, and are therefore crucial for arguing for emission reduction. Shindell hopes that his work developing simple methods to estimate the value of environmental damages is a step in the right direction.

Following his talk, Shindell addressed a variety of questions from the audience, ranging from how to measure "premature deaths" to how to account for the difference in the effects of CO_2 and methane over time. Shindell and Baker Institute health economist Vivian Ho also discussed the implications of low-cost energy versus higher-cost energy sources that may be more environmentally benign and how best to consider the competing values of different factors on human welfare.

In response to a question about how much time remains to address climate change concerns, Shindell said that humankind should have acted long ago, asserting that we are already committed to some warming, but the degree to which warming will occur can still be influenced. Shindell believes that the Earth will experience, and most likely surpass, the 2°C warming level, but he emphasized that there is a difference between warming by 2.5°C and by 6°C. If we continue on the path we travel today, he argued, we are likely to hit the upper end of that range, which could be catastrophic. Regardless of the efforts currently ongoing, there will be consequences from a warming climate.

Shindell, who will attend the climate change talks in Paris in December 2015, stated that he anticipates the achievement of "fairly impressive sounding" commitments, but notes that it will take many years to actually judge their effectiveness. For example, the recent U.S.-China agreement, wherein China committed to reduce emissions after 2030, does not mean much since there is no real commitment to address rising levels until that date. Emissions may in fact rise to very high levels prior to 2030.

Addressing carbon capture and storage (CCS), Shindell noted that the technology could offset all emissions but the problem lies in the engineering challenges. Studies have shown that for CCS to work we would need a network of pipelines comparable to that for oil and gas, which is a vast engineering endeavor. Shindell argued that geo-engineering is also problematic because it changes the amount of sunlight received in different parts of the globe, which may affect temperature, rainfall, and other parameters. Humankind does not know what the true effect of these changes would be. He also pointed out that the issue of governance remains a big question looming over geo-engineering, in particular, because the impacts of such efforts are largely unknown.

Lecture 4: Climate Change: Water as a Bridge to Mitigation and Adaptation—June 11, 2015
John Matthews, Secretariat Coordinator for the Alliance for Global Water Adaptation (AGWA), focused on the manner in which institutions make consistent, systematic decisions to change how water is managed around the globe. AGWA is a group of regional and global development banks, government agencies and ministries, NGOs, and private sector organizations focused on managing water resources in a sustainable way. In general, by examining technical knowledge, experience, and decision-making, AGWA has a mission to ensure that solutions for sustaining water are commensurate with the specific challenges faced by the global community today.

Matthews described Hoover Dam as a "poster child" for climate mitigation and adaptation. Designed for far more water than is there currently, the dam will effectively become useless as water levels continue to decline. The dam is a great example for highlighting two issues: one, water is deeply embedded through institutions, economies, and governance relationships, and two, environmental relationships are mediated through long-lived infrastructure.

Matthews identified two challenges facing water management systems today. First, the number of dams around the world is growing, along with increasing investment associated with their construction and upkeep. Most of the new dams will be built in the developing world since the U.S., Australia, and Europe have tapped most of their potential in this regard. Today, annual global expenditures on water exceed $750 billion, but most of these capital investments—particularly those in developing countries—are narrowly defined and lack any large environmental impact framework built into the decision-making process. At most, projects in developing countries are aimed at alleviating poverty and facilitating growth. At the same time, dams are built to last a very long time, while policy actions are focused more on the short-term and may not adequately consider the long-term environmental implications.

The second challenge relates to the eco-hydrological systems in which rivers exist. Rivers respond dynamically to many impacts, including climate change. In contrast, human-made water management systems are generally much less dynamic in nature. This can create problems for policymakers if the time horizon they are able to investigate is too short. For example, Hoover Dam was built on the basis of 30 years of data about the Colorado River (from 1890 to 1922). Unfortunately, those years happened to have been some of the wettest in the river's history. Consequently, there is a mismatch between the infrastructure and the long-term characteristics of the Colorado River. With water levels declining at a high rate, Matthews estimates that we could reach the so-called "dead pool" (when water is too low to be released from the dam without pumps) between 2026 and 2035.

What are the possible solutions to those two challenges? Matthews argued that a bottom-up approach is needed for a robust vulnerability analysis. Instead of using exclusively top-down approaches such as climate modeling, the specific stakeholders (people living in the river basin, local governments, etc.) should be involved in defining what success and failure mean for the area. Bringing in technical data, including paleo-data and climate modeling, should be the next step. This would allow a better understanding of the full context in which decisions are made. The solution would then involve stakeholders and provide quantitative output for engineers engaged in the design and implementation of water management projects.

A second solution involves integrating more flexible and holistic approaches into economic analysis. Today, decisions are often made based on a planning horizon of 20-30 years, but the infrastructure that is being set in place has much longer life span. Therefore, AGWA is working on an approach to consider multiple options across time—a metromap that will integrate economic tools involving flexibility. Green bonds[5] also fall into this paradigm. These have become popular globally since their introduction by the European Investment Bank in 2007, but there are no standards to appropriately value the bonds because there are no guidelines to determine how "green" a bond really is. AGWA is working to develop a

[5] Green bonds are debt instruments used to fund projects that meet certain environmentally friendly criteria.

set of standards in order to establish a common ground for valuing investments from a climate perspective. The standards, Matthews stipulated, will need to include consideration of both climate mitigation and climate adaptation.

Matthews addressed a variety of questions following his presentation. In response to an inquiry about democratizing decision-making around the world, Matthews noted that in defining solutions for the 21st century it is important to be more inclusive. Regarding transboundary water management, Matthews observed that the issue is huge. Over sixty percent of Africa's land area consists of transboundary lake and river basins. In Bangladesh, 58 of the country's rivers are transboundary. Matthews also noted that the issue is not only water but also of electric power. Laos is currently completing a dam that will provide power to upstream Thai manufacturers, but will also have negative impacts on downstream sediments and rice plantations in Vietnam. Matthews noted that one program run by the U.N. Economic Commission of Europe (UNECE) includes a transboundary climate adaptation secretary. This entity has global reach and develops explicit diplomatic approaches to help set up functional systems.

In response to questions about desalination and the often negative reaction to the use of the technology as a solution for water scarcity, Matthews discussed a number of examples. The most extensive projects are on the Arabian peninsula, namely in Dubai and Abu Dhabi. These projects require very high energy use, but the countries have cheap energy at their disposal as well as growing water demand. California is also exploring desalination as a solution to water scarcity. Matthews said that desalination is still an immature technology, but that one day it may become as common and accepted as today's micro-hydro installations. Regarding negative attitudes toward desalination, Matthews listed the issues of brine disposal, impact on ecosystems, and cost as the most oft-cited reasons.

When asked if the recent G7 goal for non-fossil fuels by 2100 is attainable and whether hydropower could be part of the solution, Matthews responded that hydropower will be important. However, although the impacts of hydropower are visible, they can be difficult to quantify. Today, Austria has 5,000 micro-hydro projects in progress, with a rapidly decentralizing power grid. In the Himalayas, more than 300 additional medium- to large-size dams are under some stage of construction. Matthews observed that hydropower is the first base for green energy, but there is a growing realization that it is not easy to deliver the benefits that hydropower was previously thought to possess. Matthews reiterated that it is important to sustain environmental flow, ecosystems, and more, while at the same time capturing the benefits of hydropower.

Public Policy and Climate Change—Reflections and Key Takeaways

A core purpose of this series of lectures was to illuminate the breadth and complexity of issues that are implicated in or affected by climate change. Many uncertainties remain, and there are reasons to be cautious yet optimistic. Technology offers potential options to address the challenges that are faced (for example, through carbon sequestration techniques, more efficient power plants, advancements in battery storage, and more) but there are definite economic costs. The Center for Energy Studies seeks to engage meaningfully in the debate about how to navigate the challenges presented by climate change, and the speakers in this lecture series brought a variety of perspectives to bear on numerous issues. Here, we attempt to highlight certain recurring themes and offer some broad policy goals.

As all our speakers underlined, humanity is faced with the pressing challenge of how to adapt to a changing climate and mitigate unwanted changes where possible. Although uncertainties remain about the extent and regional impacts of climate change, Earth's climate is changing, and all affected stakeholders must define a path forward to address potential damages through meaningful policy dialogue. This raises the important point that debate and dialogue are healthy, even when contentious, and opposing sides of an issue cannot simply be cast out under a veil of ideological differences. In any public policy discussion, there are motivations for certain policy directions that vary—sometimes subtly, other times sharply—along a wide scale. Given the importance of broad stakeholder engagement, extreme ideological arguments should not be used to stereotype an entire policy position. Rather, individual positions are often nuanced, and it is important to address uncertainties and concerns while engaging in healthy debate with the reasonable, more moderate majority. The true task of policymakers is to build broad, ideologically diverse coalitions to drive action supported by data and, to the extent possible, consensus. Only then can policy be successfully designed and implemented.

Indeed, stakeholder participation in the development of policy to address the deleterious impacts of climate change is both necessary and desirable. Although climate change is a global phenomenon, the impacts will be felt very differently by disparate geographic locales around the globe. Moreover, modern society's high degree of connectivity means that impacts directly felt in one region of the globe will be felt by others through transportation networks, infrastructure, trade, and population movements. Thus, it will become increasingly important to achieve stakeholder alignment in different regions in order to minimize any negative impacts.

While challenges exist in engaging stakeholders across industries and regions within an individual country, even larger challenges are faced by policymakers wrestling with developing global or cross-national solutions. Cultural differences, economic differences, and a general tension between the developed and developing world make agreeing on limits for fossil fuel combustion difficult to achieve. Moreover, even if an international agreement were reached, the matter of enforcement to ensure compliance must be

addressed and may be the biggest challenge of all, particularly in a world where international law enforcement mechanisms are weak.

Key to good climate change policy is flexibility and the ability of the rules to accommodate multiple uncertain scenarios. The extent of the social, environmental, and economic impacts of climate change—both globally and, perhaps more importantly, on a regional basis—is still largely unknown, and, as such, policies must be sufficiently flexible to accommodate a range of outcomes. This flexibility must be achieved while minimizing the economic cost of new policy directions, meaning there is a need for policies that ensure there are no exorbitant electricity rates hikes or rolling blackouts as a result of new rules on carbon emissions. Moreover, we must reexamine the full set of costs and benefits associated with large, high fixed-cost infrastructure projects that have long lives and lasting impacts. Importantly, a full cost-benefit assessment must consider environmental, social, health, and cultural impacts.

Another factor that can inject flexibility into the policy approach is the fact that other gases, such as methane, are very potent greenhouse gases, and their mitigation may be more cost effective than lowering CO_2 emissions. Therefore, scientists and policymakers must ensure they analyze and understand environmental systems holistically, rather than focusing on one element of change to the exclusion of others.

In order to formulate policies that are low-cost, effective and successful, it is important to see continued investment in research relating to climate change mitigation and adaptation, including inquiries designed to enhance our understanding of the climate system and to develop new technologies that will bear returns for our energy future. Moreover, deeper research into market-oriented mechanisms will facilitate a better understanding of the types of policies that could be used to leverage existing market systems to promote change at a low cost.