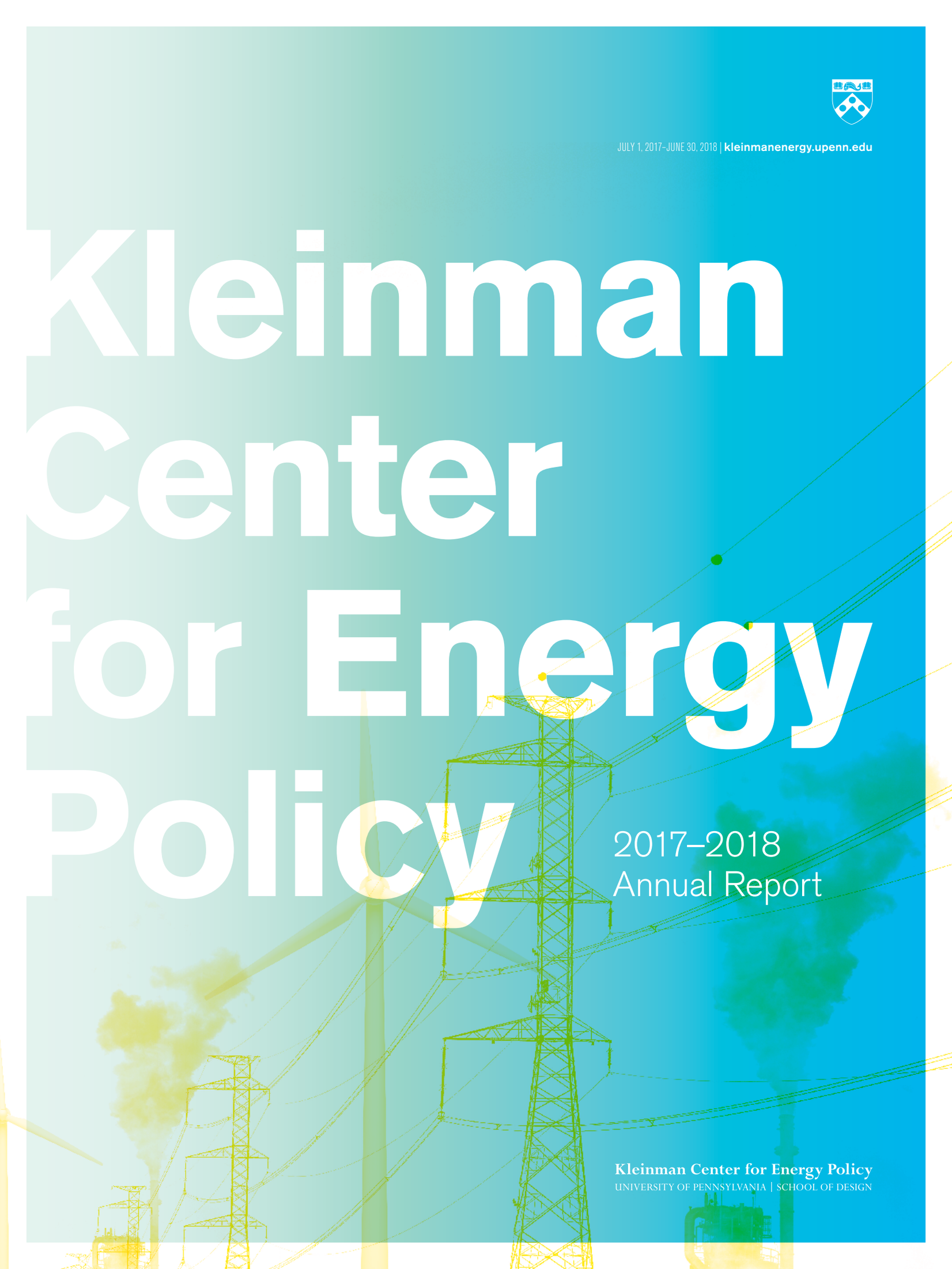
JULY 1, 2017–JUNE 30, 2018 | **kleinmanenergy.upenn.edu**

Kleinman Center for Energy Policy

2017–2018 Annual Report



Kleinman Center for Energy Policy
UNIVERSITY OF PENNSYLVANIA | SCHOOL OF DESIGN

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FROM THE DIRECTOR & DEAN

OUR PENN HOME

Since our founding four years ago, the Kleinman Center for Energy Policy has established itself as the home for scholars at Penn interested in energy policy. Our programming engages students and faculty from a wide array of schools across campus, including Law, Wharton, Arts and Sciences, Engineering and Applied Science, Annenberg, and, of course, Design. And we make these connections through a broad array of offerings, including research projects, publications, events, grants, courses, fellowships, and a visiting scholar program.

THE POWER OF PENN

Our energy thought leadership took on a new significance last spring with the launch of the $4.1 billion Power of Penn campaign. The campaign rests on seven pillars, including three devoted to areas of research: Behavior Change for Good, Transforming Healthcare, and Driving Energy Solutions.

Driving Energy Solutions relies on two Penn institutions: the Vagelos Institute for Energy Science and Technology and the Kleinman Center for Energy Policy. Together these institutions are well-positioned to move Penn into the first-tier of universities studying energy policy.

SMART DESIGN

One of our founding principles is that the School of Design is a compelling home for energy policy at Penn. The departments and centers of the school represent world-class research and teaching on fundamental aspects of energy production, consumption, and policy: old and new buildings, cities and regions, infrastructures and ecosystems.

The expertise of our PennDesign colleagues is manifest in the research projects we support, such as Dr. Erick Guerra's work on electric vehicles and parking policies. Guerra is parsing out consumers' willingness to pay for convenient parking versus convenient charging—research he believes will transform public infrastructure into a private commodity.

The enthusiasm of our PennDesign students is manifest in our classes, grants, and certificate program. We applaud PennDesign students like Mike Larson, who not only graduated with a degree in city and regional planning, but took classes taught by the Kleinman Center, and earned a certificate in energy management and policy.

Continue reading to find out more about Guerra, Larson, and the many others who have made the Kleinman Center their home for energy policy research and learning.

Sincerely,

Mark Alan Hughes
Founding Faculty Director, Kleinman Center

Frederick Steiner
Dean and Paley Professor, School of Design

KLEINMAN AT HOME

Our student and faculty grant recipients, senior fellows, and staff made more than 60 touch points this year, at home and abroad. The following pages highlight this information exchange and relationship building—from attending and presenting at conferences to pursuing field research and off-campus coursework.

LAS VEGAS, NEVADA
STUDYING CONSUMER FRICTION ON ELECTRIC VEHICLE PURCHASES

March 22–25

SURVEY RESEARCH. Wharton M.B.A. student Gabe Elsner conducted surveys at the National Automobile Dealers Association's annual meeting. He researched how dealers were responding to the growth of electronic vehicles in the car market.

READ MORE ON PAGE 27.

ALEXANDRIA, VIRGINIA
NATIONAL SCIENCE FOUNDATION AUTONOMOUS TRUCKS
June 29
Workshop

ASPEN, COLORADO
ASPEN INSTITUTE GLOBAL ENERGY SUMMIT
July 25–26
Conference

ATLANTA, GEORGIA
IEEE CYBER TASK FORCE
December 14
Workshop

AUSTIN, TEXAS
MID-YEAR MEETING OF THE INDEPENDENT PETROLEUM ASSOCIATION OF AMERICA
June 25–26
Conference

NATIONAL ENERGY FINANCE CASE COMPETITION
October 20
Case Competition

BALTIMORE, MARYLAND
ORGANIZATION OF PJM STATES BOARD MEETING
November 13
Meeting

NATIONAL ASSOCIATION OF UTILITY CONSUMER ADVOCATES (NASUCA)
November 14
Conference

BERKELEY, CALIFORNIA
MEETINGS WITH PARTNER ENERGY CENTERS
April 30–May 3
Meeting

BOSTON, MASSACHUSETTS
MIT ENERGY CONFERENCE
March 2–3
Conference

MIT'S INSTITUTE FOR WORK AND EMPLOYMENT RESEARCH
May 8
Workshop

CHICAGO, ILLINOIS
CLIMATE CHANGE AND ASIA
May 24
Conference

PES JOINT TECHNICAL COMMITTEE MEETING
July 20–21
Meeting

DURHAM, NORTH CAROLINA
ENERGY IN EMERGING MARKETS CASE COMPETITION
November 7
Case Competition

HERSHEY, PENNSYLVANIA
PENNSYLVANIA EXECUTIVE ENERGY SEMINAR
October 26
Conference

DECADE OF DISRUPTION: MARCELLUS SHALE AND REGIONAL ENERGY MARKETS
October 26–27
Conference

JACKSONVILLE, FLORIDA
PES GENERAL MEETING
January 10–12
Meeting

JERSEY CITY, NEW JERSEY
ORGANIZATION OF PJM STATES, SPRING MEETING
April 9
Conference

LAS VEGAS, NEVADA
STUDYING CONSUMER FRICTION ON ELECTRIC VEHICLE PURCHASES
March 22–25
Research

STAFF STUDENTS FACULTY FELLOWS

PHILADELPHIA, PENNSYLVANIA

- INTERNATIONAL AFFAIRS ASSOCIATION'S TABLE TALK
  October 24
  Meeting
- ALLIED SOCIAL SCIENCE ASSOCIATIONS ANNUAL MEETING
  January 4–5
  Conference
- WHARTON ENERGY CONFERENCE
  January 19
  Conference
- WHARTON ENERGY CLUB
  March 26
  Meeting
- HULT PRIZE IVY 2018
  April 7
  Competition
- RENEWABLE ENERGY ANALYST FELLOWSHIP
  May 14–August 10
  Fellowship
- PHILADELPHIA ENERGY CAMPAIGN FELLOWSHIP
  May 21–August 3
  Fellowship
- ENERGY OFFICE ANALYSIS FELLOWSHIP
  June 11–August 17
  Fellowship
- COMMUNICATIONS AND ENERGY POLICY FELLOWSHIP
  June 18–August 31
  Fellowship
- DANFOSS ENERGY EFFICIENCY WORKSHOP
  December 4
  Workshop

PITTSBURGH, PENNSYLVANIA

- PENNSYLVANIA ENVIRONMENTAL COUNCIL ENERGY FELLOWSHIP
  May 14–August 3
  Fellowship

PRINCETON, NEW JERSEY

- MIT CONFERENCE
  July 3–9
  Conference

SAN DIEGO, CALIFORNIA

- GREENTECH MEDIA SOLAR SUMMIT
  May 1–2
  Conference
- NARUC RATE SCHOOL PROGRAM
  May 14
  Course

SAN FRANCISCO, CALIFORNIA

- WHARTON ENERGY NETWORK ALUMNI RECEPTION
  February 15
  Meeting
- MEETINGS AT UC BERKELEY, STANFORD ENERGY CENTERS
  April 30–May 3
  Meeting
- DEEP CARBONIZATION PATHWAYS
  October 12
  Lecture

SEATTLE, WASHINGTON

- DIGITAL SUMMIT SEATTLE
  April 17–18
  Conference

SILICON VALLEY, CALIFORNIA

- SELF-DRIVING TRUCKS AND EFFICIENCY
  December 19–20
  Meetings

WASHINGTON, D.C.

- FERC BRIEFINGS ON GOVERNANCE
  October–April
  Meeting
- DEEP DECARBONIZATION PATHWAYS FOR THE U.S. ECONOMY
  November 7
  Lecture
- IEEE SMART GRID
  February 22
  Conference
- ENERGY AND GEOECONOMICS INTERNSHIP
  June 4–August 6
  Fellowship
- TECHNICAL AND ECONOMIC IMPLICATIONS OF THE CLEAN ENERGY TRANSITION
  August 22
  House Briefing

WASHINGTON, D.C.
IEEE SMART GRID CONFERENCE

July 2017

LEADERSHIP. Senior Fellow William Hederman served on the organizing committee for the Smart Grid conference, hosted by the Institute of Electrical and Electronics Engineers (IEEE). He also spoke on a panel about cybersecurity and distributed resources.

HERSHEY, PENNSYLVANIA
2ND ANNUAL EXECUTIVE ENERGY SEMINAR

October 27–28

PAPER PRESENTATION. Our study, *Pennsylvania's Gas Decade*, was released at this conference that included key industry leaders and policy makers. Report author Christina Simeone shared the podium with Robert Powelson, former chair of the Pennsylvania Public Utility Commission and recent commissioner at the Federal Energy Regulatory Commission, and Mauricio Gutierrez, chief executive officer of NRG Energy.

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KLEINMAN ABROAD

BERLIN, GERMANY
PENN IN BERLIN
SUMMER PROGRAM
June 10–23
Coursework

BONN, GERMANY
COP23
November 6–11
Conference

BUENOS AIRES, ARGENTINA
EAS 297: RENEWABLE ENERGY IN THE U.S. AND ARGENTINA
July 21–August 12
Coursework

DEVON, ALBERTA
QUANTIFYING THE U.S. COAST GUARD ECOLOGICAL RISK ASSESSMENT
June 15–August 1
Research

FORT McMURRAY, ALBERTA
OIL SANDS TOUR
October 18–20
Tour

GRONINGEN, NETHERLANDS
INTERNATIONAL ASSOCIATION OF ENERGY ECONOMISTS CONFERENCE
June 11–13
Conference

HAMBURG, GERMANY
OFFSHORE WIND IN EUROPE
March 3–10
Research

KUALA LUMPUR, MALAYSIA
WORLD URBAN FORUM
February 2–17
Conference

MONTREAL, QUEBEC
December 11–15
HYDRO QUEBEC TOUR
Tour

BUENOS AIRES, ARGENTINA
RENEWABLE ENERGY IN THE U.S. & ARGENTINA

July 21–August 12

COURSEWORK. This summer, we supported four Penn students interested in expanding their knowledge of renewable energy. As part of a travel–study course, they traveled on Kleinman Center grants to Argentina, stayed with host families, toured a regasification station, and helped install residential solar water heaters. Students included: Daniel Carrillo and Andrea Makamba (SEAS), and Melissa Frankil and Nicole Posadas (SAS).

READ MORE ON PAGE 36.

STAFF STUDENTS FACULTY FELLOWS

NEW DELHI, INDIA
November 1–3
CSIS U.S.–INDIA SUB-NATIONAL ENERGY WORKSHOP
Workshop

OXFORD, ENGLAND
November 12–16
DECISION-MAKING UNDER DEEP UNCERTAINTY ANNUAL CONFERENCE
Conference

PARIS, FRANCE
MIT ENERGY CONFERENCE
July 3–9
Conference

KLEINMAN BIROL FELLOWSHIP
May 21–August 3
Fellowship

PENANG, MALAYSIA
MEETINGS
February 12–16
Research

RECIFE, BRAZIL
INTERNATIONAL CONFERENCE OF INTEGRATED ASSESSMENT MODELS
December 4–6
Conference

REYKJAVIK, ICELAND
GREEN PROGRAM
March 4–11 & May 14–23
Research

ROTTERDAM, THE NETHERLANDS
PENN IN ROTTERDAM SUMMER PROGRAM
June 10–23
Coursework

SOGN OG FJORDANE, NORWAY
INTERNATIONAL YOUTH PEACE CONFERENCE: CLIMATE CHANGE
October 2–8
Conference

KUALA LUMPUR, MALAYSIA
WORLD URBAN FORUM

February 7–13

PRESENTATIONS. Delegates from the Kleinman Center, Penn Institute for Urban Research (Penn IUR) and Perry World House (PWH) collaborated to bring Penn expertise on sustainable development goals to the World Urban Forum (WUF9), the world's premier conference on urban issues. At the forum, Kleinman Center staff presented two papers.

OXFORD, ENGLAND
DECISION-MAKING UNDER DEEP UNCERTAINTY ANNUAL CONFERENCE

November 12–16

PRESENTATION. Deputy Director Cornelia Colijn and Founding Faculty Director Mark Alan Hughes attended the Society for Decision-Making Under Deep Uncertainty conference at the University of Oxford, where they presented research related to Philadelphia's energy landscape.

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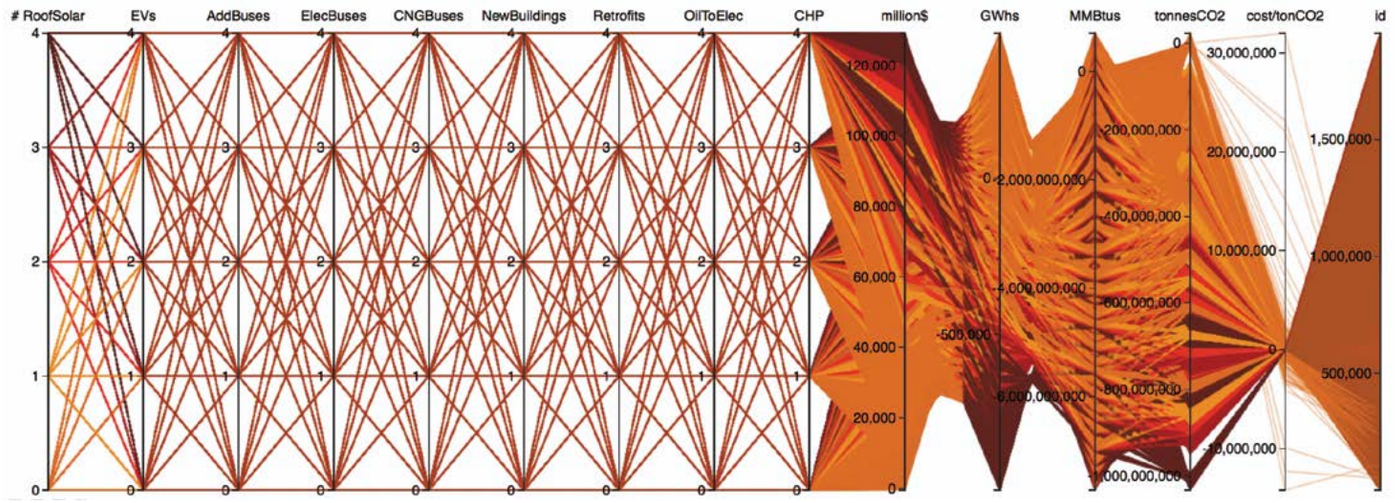
CENTER RESEARCH

Our center-driven interdisciplinary research projects gather teams of Penn scholars to tackle some of the most challenging energy policy questions.



DECISION-MAKING UNDER DEEP UNCERTAINTY

This year, the Kleinman Center began building research capacity to tackle projects and policy planning efforts that are faced with the challenge of deep uncertainty. Deep uncertainty describes future uncertainty that cannot be sufficiently minimized by gathering existing information about the primary drivers of future risk. This inability to effectively bound future risk makes traditional "predict then act" policymaking a challenge. Instead, decision-making under deep uncertainty (DMDU) requires an entirely different approach to future planning.

PROJECT TEAM

Cornelia Colijn, *Deputy Director, Kleinman Center*

Mark Alan Hughes, *Founding Faculty Director, Kleinman Center*

Oscar Serpell, *Research Associate, Kleinman Center*

Above: The varying degree and combination of strategies implemented have a range of outcomes that impact a variety of things including our regional economy and our contribution to greenhouse gas emissions.

Decisions made by future state, federal, and even international governments represent a source of deep uncertainty for local policymakers. Local governments make decisions about long-term programs and investments that are increasingly vulnerable to political polarization over climate change and the resulting variability in energy and environmental policy formation at higher levels of government. This policy uncertainty combined with the pace of technological innovation and the global impacts of climate change threaten the robustness of local decision-making.

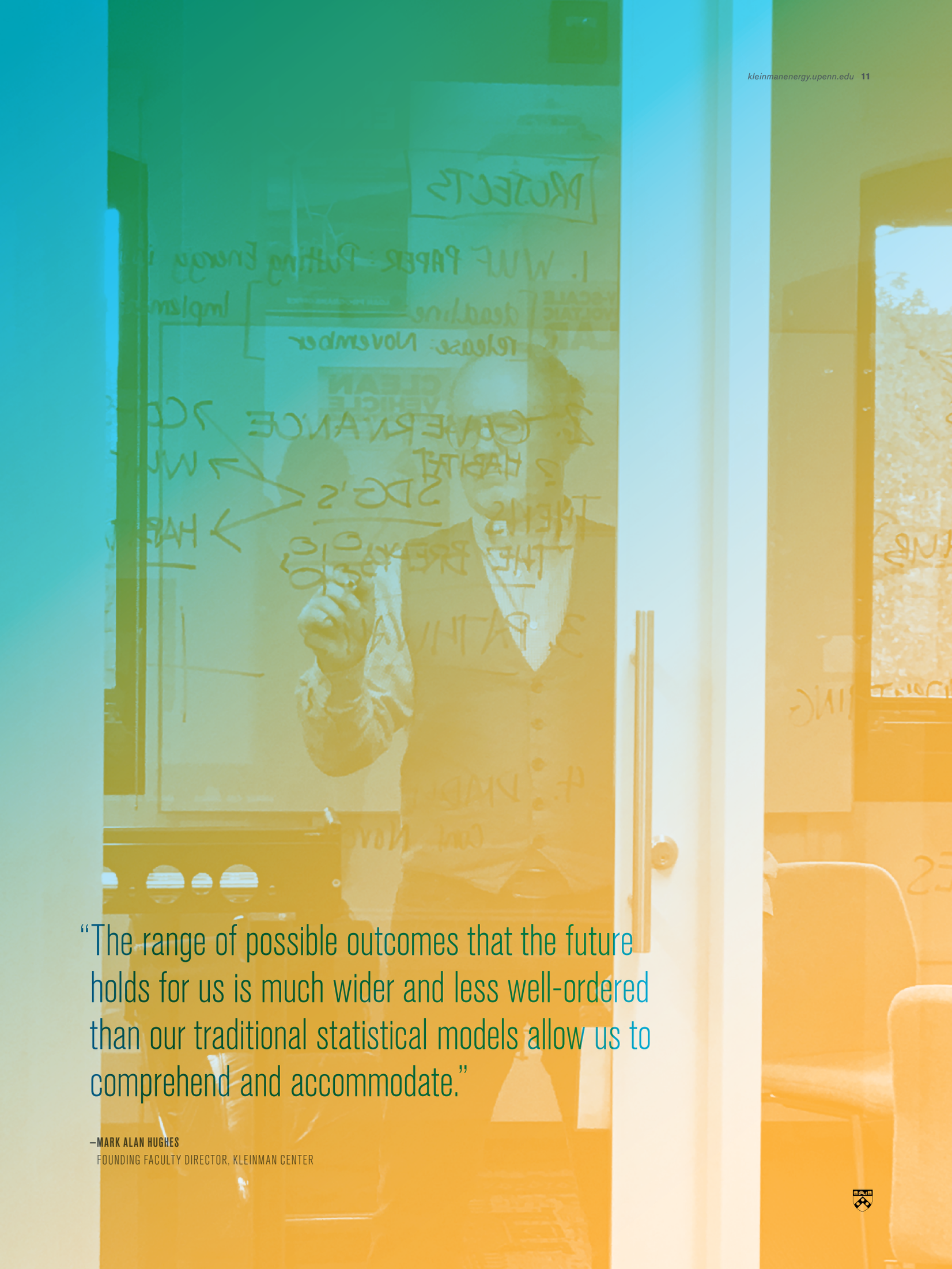
Through our ongoing research, we are finding ways to adapt existing modeling methods used by researchers studying deep uncertainty in hydrology, climate adaptation, and land planning efforts to inform energy policy.

One method that has been used extensively by other researchers studying DMDU is the Robust Decision-Making (RDM) model. The RDM framework first defines a goal, then establishes a set of strategies for achieving that goal, and finally tests those strategies against a full range of future uncertainties. Those strategies that perform best under the widest range of possible futures are deemed more "robust" than those that perform poorly, or only perform well under a very narrow set of possible futures.

These "robust" strategies can then be used to inform an Adaptation Pathways Framework model. This tool assesses each strategy's performance under each possible future condition—in this case, a state or federal policy change—and determines which strategy performs best, taking into account sunk costs and other strategy transition costs. This DMDU method creates a planning roadmap of sorts, showing decision makers the best possible strategy to adopt under any one of a set of possible futures as defined by the model.

Using this method, our team developed a working computer model that analyzes the impact of widespread regional uncertainties on eight energy strategies within the Philadelphia region, allowing for the comprehensive comparison of thousands of possible policy futures.

In the next phase, researchers at the Kleinman Center will continue to develop and refine decision-making frameworks that will provide the Philadelphia region with the data and tools to develop robust and efficient energy strategies, designed to adapt to future uncertain changes in the policy landscape.



"The range of possible outcomes that the future holds for us is much wider and less well-ordered than our traditional statistical models allow us to comprehend and accommodate."

–MARK ALAN HUGHES
FOUNDING FACULTY DIRECTOR, KLEINMAN CENTER

GLOBAL FOSSIL FLOWS

Using NOAA sea-level rise and SLOSH* model data, as well as inland infrastructure mapping, researchers at the Kleinman Center are developing an ArcGIS-based mapping tool to assess the future vulnerability of coastal energy infrastructure due to sea-level rise and storm surge.

In the United States, the vast majority of refining and storage facilities for petroleum, natural gas, and coal are located in close proximity to large coastal ports where flooding from sea-level rise and storm surge has become an ever-present and increasing threat. In addition to the regional energy service interruptions coastal flooding already causes, international trade of fossil fuels in and out of ports could come to a halt if shipping infrastructure became inoperable.

Although renewable energy generation is the fastest growing source of electricity, the United States will continue to rely heavily on petroleum, natural gas, and coal for many years to come. Fossil fuels have inherent properties, namely their high energy density and ease of distribution, that make them especially suited for transportation, heating, and—for the time being—fast-ramping electricity generation.

The United States is one of the largest importers of crude oil and the country is quickly positioning itself to be a major exporter of natural gas. These trade flows represent significant economic gains for the U.S. and its trading partners, but are vulnerable to chokepoint* interruptions.

We have built a database that includes:

1. Import and export data for oil, coal, and gas since 2012 into and out of every major port region in the United States
2. NOAA sea-level rise and storm surge layers for the Gulf Coast and East Coast, combined to show possible future scales of inundation
3. NOAA approximations on the rate of local sea-level rise at each port location
4. IEA map locations for 116 coastal energy facilities located in coastal regions.
5. OpenStreetMap visualizations
6. Aerial imagery

Over the upcoming year, we will design a public ArcGIS tool to demonstrate which sites are most vulnerable to sea-level rise and which ports are likely to be most impacted by sea-level rise and storm surge—providing guidance on where future energy infrastructure should and should not be sited.

By developing a system-wide understanding of the service vulnerabilities that our fuel economy faces, we can better plan for an energy future where fossil fuels are available when and where they are needed.

PROJECT TEAM

William Cohen, *Center Coordinator, Kleinman Center*

Cornelia Colijn, *Deputy Director, Kleinman Center*

Mark Alan Hughes, *Founding Faculty Director, Kleinman Center*

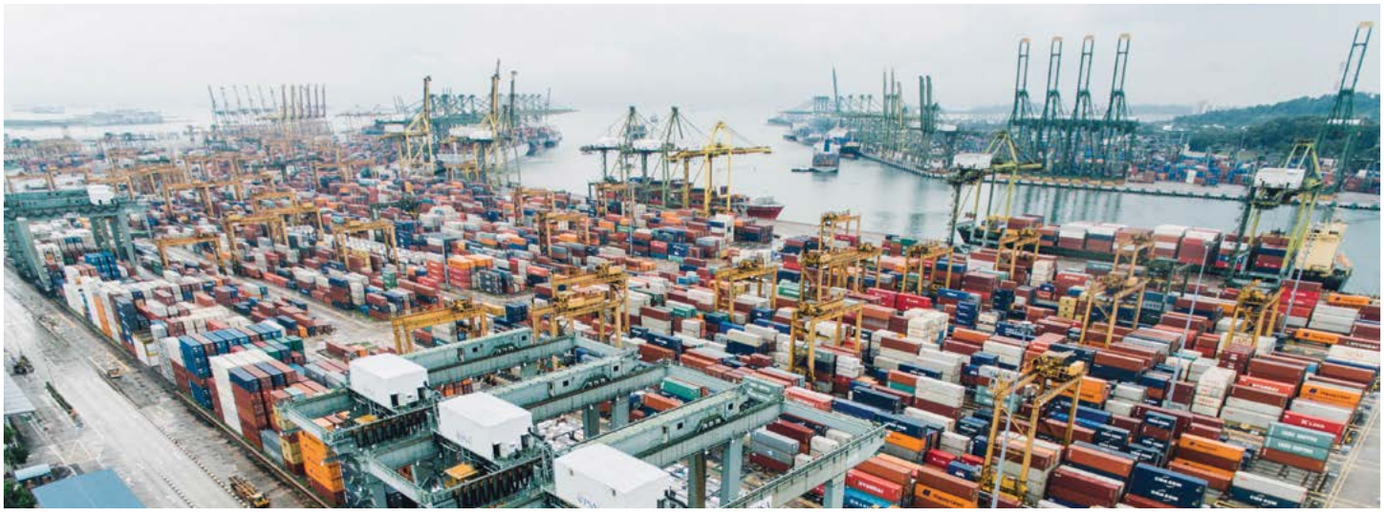
Oscar Serpell, *Research Associate, Kleinman Center*

CONSULTING ACADEMIC

Julianne Quinn, *Postdoctoral Researcher, Cornell University*

**SLOSH is the model used by the National Hurricane Center for forecasting storm surge. The acronym stands for Sea, Lake, and Overland Surges from Hurricanes.*

**Chokepoints are geographical or infrastructural bottlenecks of global trade that would have cascading effects on the global shipping market if they were ever blocked or damaged. Many busy ports are examples of chokepoints.*



During storm surge, abnormally high water levels generated by severe storms produce sea-levels much higher than normal high tide. This results in extreme coastal and inland flooding.

PROJECT LEAD

Christina Simeone,
Director of Policy and External Affairs, Kleinman Center

PJM GOVERNANCE

The Kleinman Center has helped focus the attention of federal regulators, grid operators, power grid participants, and academics on the issue of stakeholder governance in regional transmission organizations (RTOs) and independent system operators (ISOs) through its original research focused on PJM Interconnection, the operator of the Mid-Atlantic power grid serving 13 states and the District of Columbia.

RTO/ISO governance practices and procedures dictate how changes to market design, grid operations, and transmission planning are negotiated among users of the power system before being submitted to federal regulators for review and approval.

RTOs and ISOs are required by the Federal Energy Regulatory Commission (FERC) to maintain a collaborative stakeholder process in the development of rule change proposals. However, FERC has offered surprisingly limited guidance on governance requirements. In fact, it has been almost a decade since regulators formally opined on governance, meanwhile competitive markets have undergone significant changes disrupting the relative power balance among stakeholders.

The Kleinman Center's May 2017 report comprehensively reviews PJM's current stakeholder process, identifies weaknesses, and recommends areas for potential reform. The report was developed by systematically interviewing a representative sample of PJM market participants, analyzing PJM data, and performing detailed research on academic, government, and industry literature.

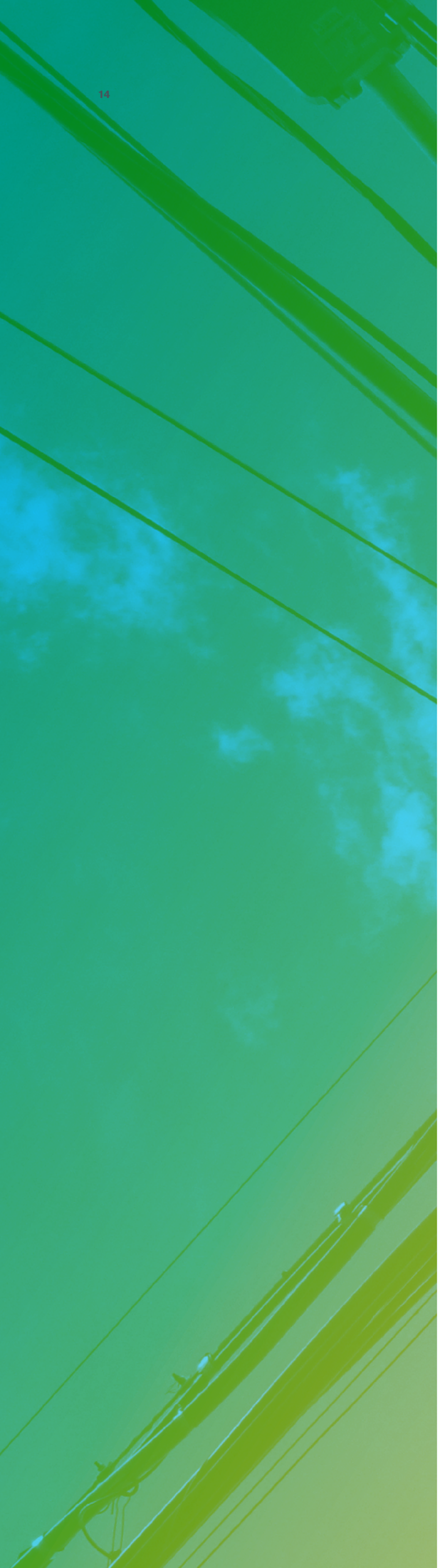
This year, the report gained significant attention. The center briefed all sitting FERC commissioners or their staff, PJM and PJM market participants, state utility regulators through the Organization of PJM States, the National Association of State Utility Consumer Advocates, PJM's Independent Market Monitor, clean energy project developers, environmental advocacy organizations, foundations, academic institutions and organizations, trade press, and others.

Most meaningfully, FERC leadership has publicly referenced the Kleinman Center report and the need to explore governance issues, while PJM began an investigation into governance process reform during the summer of 2018. In addition, several coalitions have formed to enhance clean energy advocacy in PJM's governance process, and Duke University has amassed a team of academic and legal assets to advance research on RTO governance.

Phase two of our governance research is underway, and will deliver a detailed set of enhanced governance principles for consideration by FERC, informed in part by a stakeholder survey and workshop.

PUBLICATIONS

Scholars work with us to publish their energy policy research as Kleinman Center papers and policy digests. These publications become part of our growing library.



SCHOLARLY REVIEW

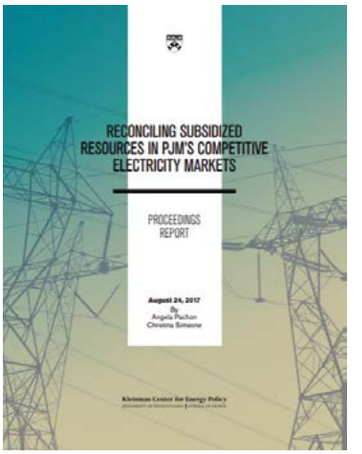
Since 2016, James R. Hines, Jr. has served as our lead academic reviewer for all papers and policy digests. Hines is the L. Hart Wright Collegiate Professor of Law and co-director of the Law and Economics Program at Michigan Law. He is also the Richard A. Musgrave Collegiate Professor of Economics in U-M's Department of Economics and serves as the research director of the Office of Tax Policy Research in U-M's Stephen M. Ross School of Business. He holds a B.A. and M.A. from Yale University and a Ph.D. from Harvard, all in economics.

PAPERS

In our long-format papers, Kleinman Center researchers take deep dives into today's energy challenges.

READ THESE PAPERS AT:
KLEINMANENERGY.UPENN.EDU/PAPERS

1



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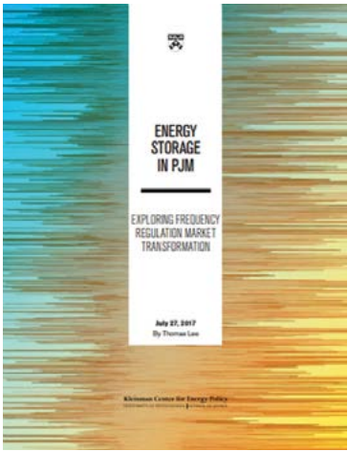
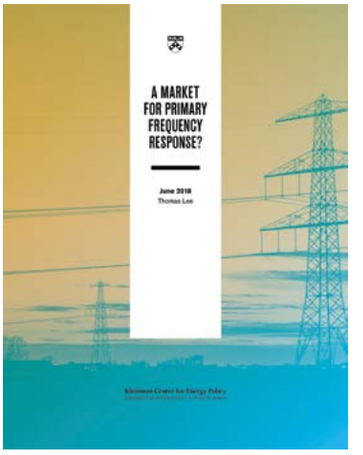


3

WORKING PAPER



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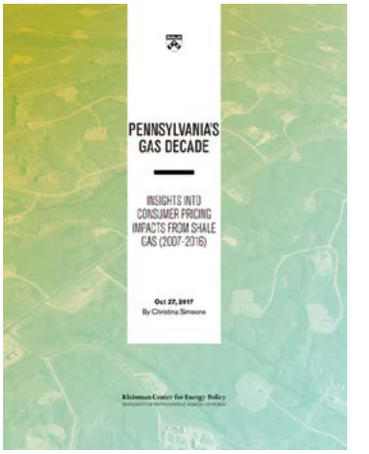


1
RECONCILING SUBSIDIZED RESOURCES

August 24 | Proceedings Report

Authors: Angela Pachon and Christina Simeone

In May 2017, the Kleinman Center organized a workshop to discuss integrating subsidized resources into PJM's competitive markets. This report captures the wide variety of perspectives, including a research agenda to inform future thinking.

2
ENERGY STORAGE IN PJM

July 27 | Research Paper

Author: Thomas Lee

Frequency regulation has played a large role in energy storage commercialization, and will continue to play a role. But how large a role depends on changes to the design of PJM's frequency regulation market.

3
WORKING PAPER
A MARKET FOR PRIMARY FREQUENCY RESPONSE?

June 17 | Working Paper

Author: Thomas Lee

While FERC sets standards for primary frequency response capability, it doesn't resolve the provision of headroom in a high-renewables future. A competitive market could spur innovation and cost-effective grid reliability service.

4
REIMAGINING PENNSYLVANIA'S COAL COMMUNITIES

April 24 | Report

Authors: Christina Simeone, Theodora Okiro, and DeShaun Bennett

With coal in decline, Pennsylvania's miners and communities are struggling. Appalachian states and localities are responding with innovative programs that retrain and revitalize.

RESULTS

The larger Penn community took an interest in this paper. Penn One Health invited the lead author to write a related blog post: "The Human Story of Coal's Downturn."

5
PENNSYLVANIA'S GAS DECADE

October 27 | Report

Author: Christina Simeone

It's been ten years since Pennsylvania's shale revolution began. Since then, the prevalence of gas-fired generation has skyrocketed, and Pennsylvania residents are experiencing gas bills 40 percent lower (on average) than they were a decade ago.

RESULTS

This report was featured at the 2nd Annual Executive Energy Seminar and grabbed attention from news outlets like: *E&E News*, *SNL*, *RTO Insider*, *The Philadelphia Inquirer*, *StateImpact*, and *Natural Gas Intel*.

OUTSIDE JOURNAL
MANAGING RISK IN THE ENERGYSHED

September 8 | Article

Authors: Mark Alan Hughes, Cornelia Colijn, and Oscar Serpell

In *LA+*, an interdisciplinary journal of landscape architecture, Kleinman Center researchers draw an instructive comparison between the management of watersheds and energy systems to reduce service-based risk. (Note: *LA+* cover not shown)

READ MORE ABOUT THE AUTHORS ON PAGE 59.

PAPER

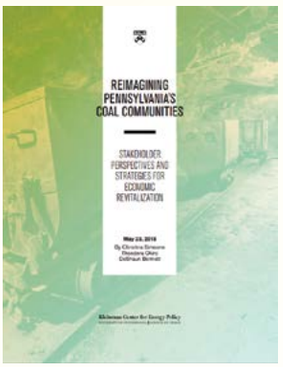
REIMAGINING PENNSYLVANIA'S COAL COMMUNITIES

AUTHORS

Christina Simeone, *Director of Policy and External Affairs, Kleinman Center*

Theodora Okiro, *Research Fellow, Kleinman Center*

DeShaun Bennett, *Research Fellow, Kleinman Center*



READ THE FULL ARTICLE AT:
KLEINMANENERGY.UPENN.EDU/WRITTEN-WORK

Pennsylvania's coal communities are struggling. While employment in the coal sector has been slowly declining for decades, the rise of Marcellus Shale natural gas prompted a rapid decline. But Appalachian states and localities are responding with programs intended to turn things around.

YESTERDAY'S BOOM

Pennsylvania's coal mining industry began in the mid-1700s and grew to warm countless homes, power the nation, and fuel the steel industry and the industrial age. In turn, coal's importance to Pennsylvania's economy grew. But then came machines and streamlined production, a slowdown in the steel industry, and, most recently, low-cost natural gas. All of these factors reduced the amount of coal used to produce electric power.

IN DISTRESS

While each community is unique, many coal communities in Pennsylvania share similar characteristics, including high unemployment, aging populations, deteriorating or insufficient infrastructure, and educational attainment levels that are lower than state and national averages.

Beyond revitalization strategies, the report also tells the human story of coal's downturn. Appalachia, home to many coal communities, has a higher death rate from diseases of despair—substance abuse, suicide, and liver cirrhosis—than other areas in the United States. Most notably, Appalachians in their prime working years (age 25 to 44) have a 70 percent higher mortality rate from diseases of despair than those living elsewhere in the U.S.

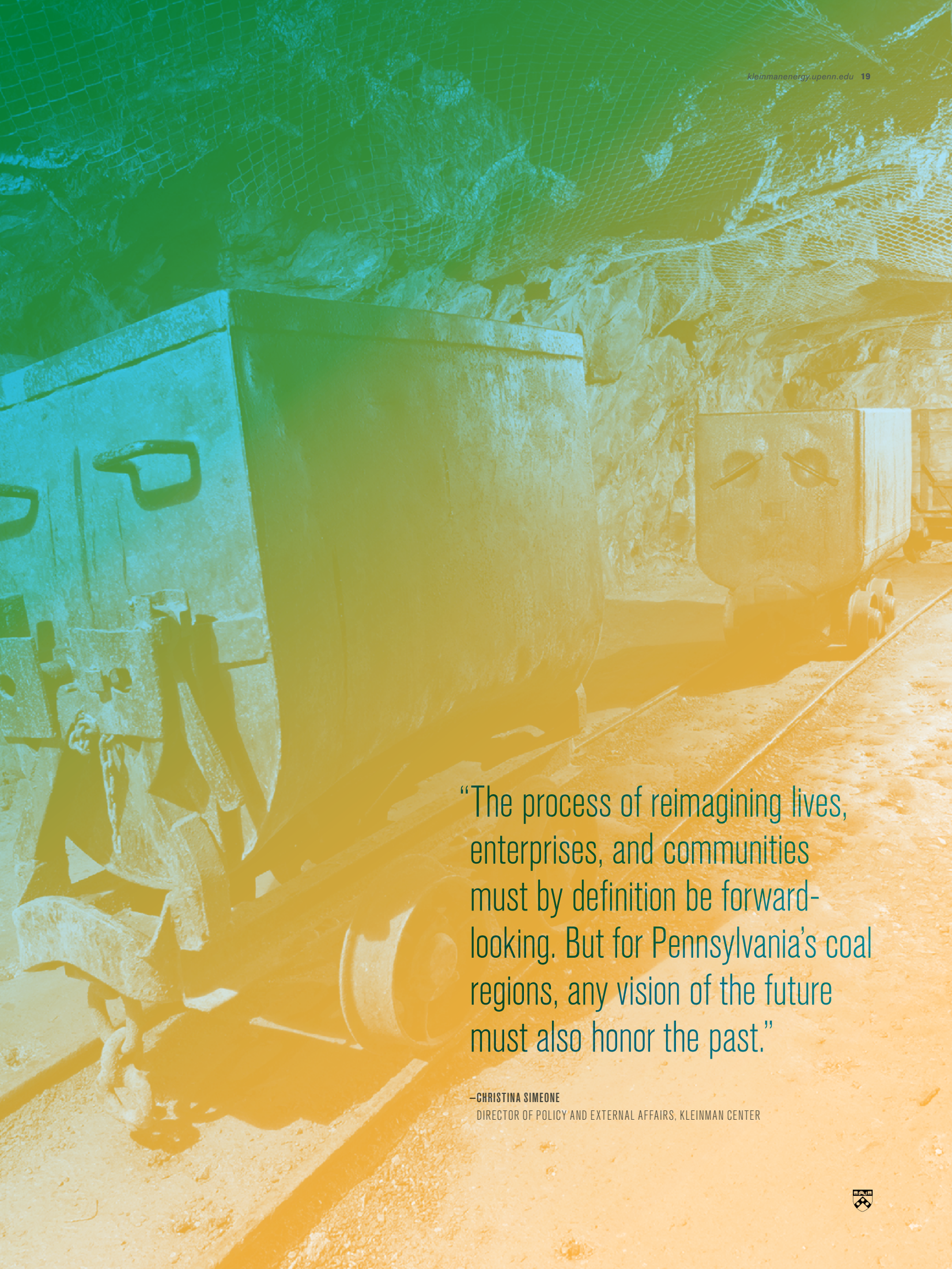
NEW CAREERS

Miners are most directly affected by the downturn in the coal economy, and there are many efforts to retrain them for new careers in high-demand fields. From entrepreneurship, to IT, to advanced manufacturing (like 3D printing), to jobs in the shale gas sector—efforts are underway to get displaced coal miners back into the work force. However, participation rates in some retraining programs are low, finding employment in a new sector is uncertain, and the inability to pay bills while retraining is a barrier for many.

NEW INDUSTRIES

Communities and businesses built to serve coal mining activities are indirectly impacted by the decline in coal use. Efforts to revitalize these communities include improving infrastructure, expanding broadband access, attracting new industries, and redeveloping abandoned spaces—like converting former coal land into farms, outdoor recreation areas, or government training facilities.

This report was funded in part through a grant from the Pennsylvania Small Business Development Centers by the U.S. Economic Development Administration as part of the Partnerships for Opportunity and Workforce and Economic Revitalization (POWER) Initiative.



"The process of reimagining lives, enterprises, and communities must by definition be forward-looking. But for Pennsylvania's coal regions, any vision of the future must also honor the past."

–CHRISTINA SIMEONE
DIRECTOR OF POLICY AND EXTERNAL AFFAIRS, KLEINMAN CENTER

POLICY DIGESTS

Our policy digests take a brief look at today's most pressing energy policy topics—translating complex issues while shining a light on policy implications.

READ THESE DIGESTS AT:
KLEINMANENERGY.UPENN.EDU/POLICY-DIGESTS

October 5

TILTING AT WINDMILLS: THE EMERGING U.S. OFFSHORE WIND ENERGY INDUSTRY

Author: Brandon Burke, *Master Student in Environmental Studies, SAS*

The first offshore wind turbines in Europe were deployed in 1991. America's first offshore wind farm came online in 2016. Is this the dawn of a new domestic industry?

December 14

CLIMATE POLICY IN A DISORGANIZED WORLD: SEPARATE VERSUS SINGLE MARKETS FOR EXTERNALITIES

Author: Jose Miguel Abito, *Assistant Professor of Business Economics & Public Policy, Wharton*

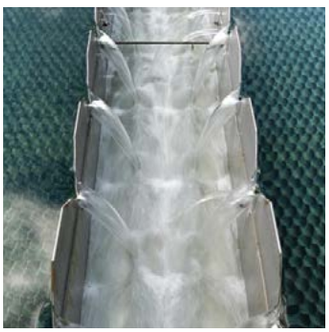
When it comes to carbon dioxide emissions, how inefficient are separate markets versus a single market? Separate market inefficiencies are mitigated when firms own plants across multiple markets.

January 11

WATER ISSUES IN CALIFORNIA

Author: Hong Yu Xiao, *Doctoral Student in Applied Economics, Wharton*

Guaranteeing water access has been a constant challenge for California's growing cities. Greater facilitation of water trading between agricultural and urban users can help policy makers to more efficiently manage this vital resource.



January 29

SEA CHANGE: DESALINATION AND THE WATER–ENERGY NEXUS

Author: Scott Moore, *Senior Fellow, Kleinman Center*

The cost of desalination is falling rapidly, but energy needs are still high. Renewables are critical to making desalination sustainable. More R&D investment and cost support is essential to solving the water–energy nexus.

March 8

WATER, WASTE, ENERGY: LESSONS FROM COCA-COLA IN AFRICA

Author: Sarah Byala, *Senior Writing Fellow, Center for Programs in Contemporary Writing*

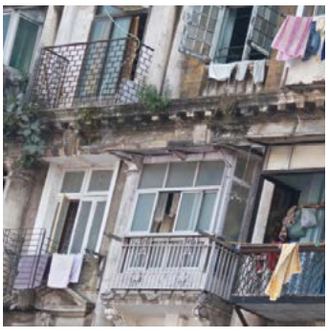
Coca-Cola has a presence in 54 African countries, impacting economies and the environment at local, national, and global scales. This case study in corporate sustainability takes a closer look at Coca-Cola's efforts in water conservation, solar energy, and waste management across the continent.

March 15

ENERGY AND THE BLOCKCHAIN: OPPORTUNITIES AND CHALLENGES FOR CLIMATE AND ENERGY GOVERNANCE

Author: Oscar Serpell, *Research Associate, Kleinman Center*

With the rise of blockchain networks, there is growing interest in applying this peer-to-peer verification technology to the energy industry—potentially revolutionizing the way we generate and distribute energy and monitor CO2 emissions.



March 22

PLUGGING IN: ENERGY DEMAND IN INDIAN RESIDENCES

Author: Radhika Khosla, *Visiting Scholar, Kleinman Center*

As India urbanizes, its residential electricity use has increased 50 times between today and 1971, yet India's per capita residential electricity consumption is less than a third of the world average.

April 10

POWER OVER THE TWENTY-FIRST CENTURY ELECTRIC GRID

Author: Ari Peskoe, *Visiting Scholar, Kleinman Center*

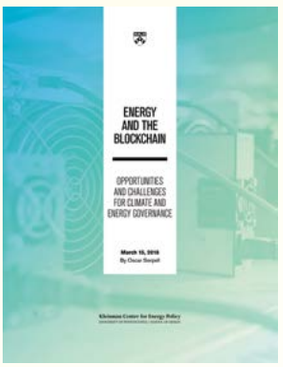
Today's electric grid is developing within the confines of a century-old regulatory system. This article provides an overview of power sector regulation and offers a legal path forward for the regulation of distributed energy resources.

POLICY DIGEST

ENERGY AND THE BLOCKCHAIN

AUTHOR

Oscar Serpell, *Research Associate, Kleinman Center*



READ THE FULL ARTICLE AT:
KLEINMANENERGY.UPENN.EDU/WRITTEN-WORK

With the rise to prominence of Bitcoin and other blockchain networks, there is growing interest in applying this peer-to-peer verification technology to the energy industry—potentially revolutionizing the way we generate and distribute energy and monitor CO2 emissions.

While the value of bitcoins and of hundreds of other similar "coins" indicates a growing interest in the application of this technology, there is a much-needed discussion of how blockchain networks can and should be used and regulated.

WHAT'S A BLOCKCHAIN?

Blockchains are network protocols that decentralize the storage of data, making that data highly redundant yet theoretically tamper-proof and independent of any single authority. Transactions are usually fast—sometimes faster than bank transactions—and each transaction is verified using extremely complex algorithms to prevent fraud.

ENERGY IMPLICATIONS

All of this security, however, comes at a cost: an energy cost. The amount of energy that is consumed by the Bitcoin network, currently the largest blockchain network, is difficult to know for certain because of its fluctuating demand and complex verification process. However, best estimates made during the most recent Bitcoin bubble suggest that the network was consuming 250 KWh per block verification—roughly equivalent to one week of electricity consumption by the average American household. If this energy demand were sustained, it would translate to between 32 and 34 TWh of electricity consumption by the network every year.

ENERGY OPPORTUNITIES

Over the last six months, cryptocurrency values have exploded, and so has discussion of how this technology could impact how we manage everything from personal data privacy, to energy generation, distribution, and emissions monitoring. Several of the largest cryptocurrency networks such as IOTA and Power Ledger specifically emphasize how their networks can be used in partnership with the internet of things and sources of distributed energy generation such as rooftop solar, vehicle charging stations, etc.

If a distributed solar installation were generating surplus electricity, it could communicate with nearby energy users and sell that electricity through the blockchain. It is not a stretch to envision how this network could be applied to other energy related services such as battery storage and carbon credits.

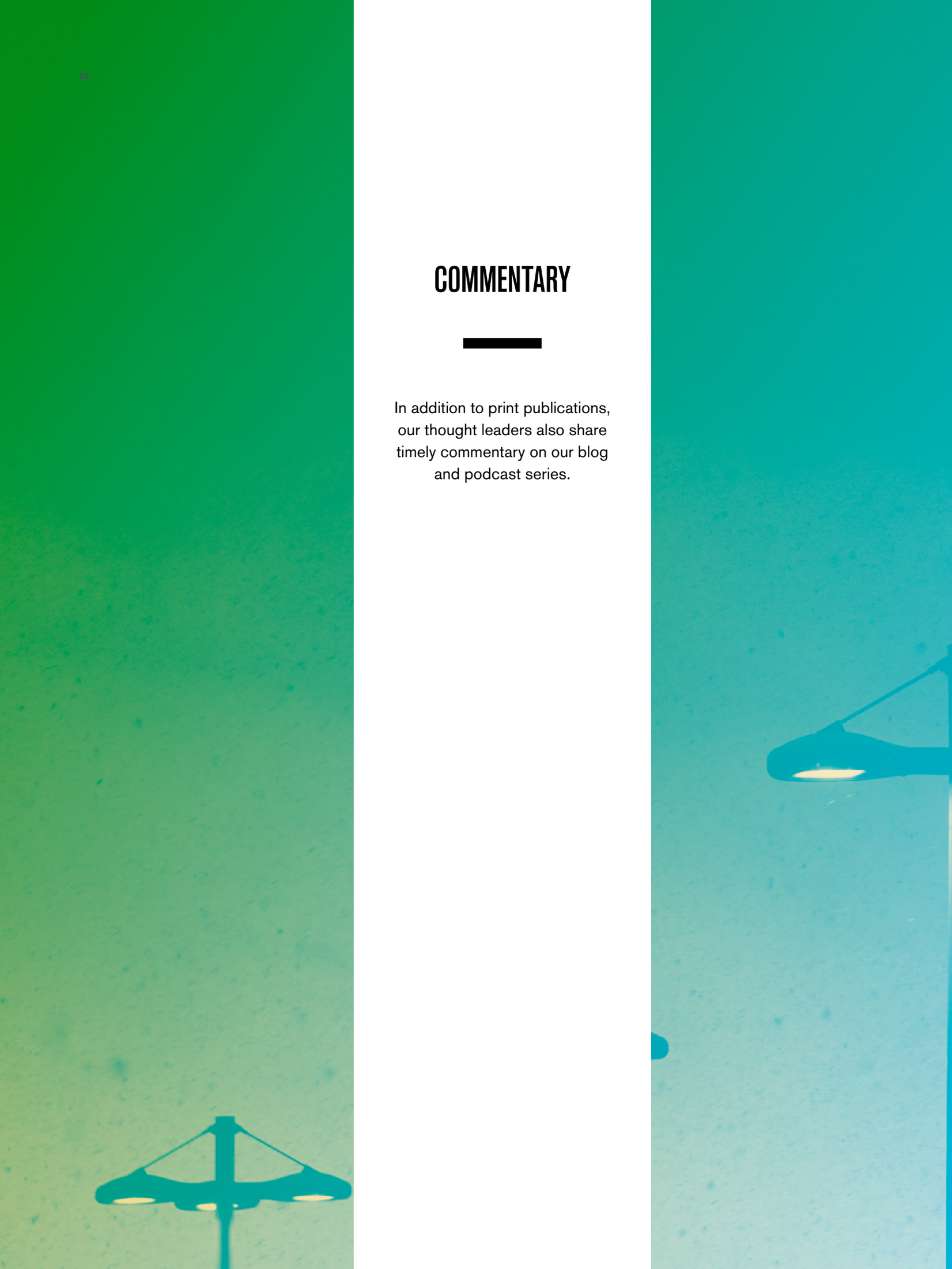
On paper, this sounds ideal. Fast and secure peer-to-peer energy transactions could improve grid efficiency and incentivize consumers to invest in efficient and clean technologies. However, it remains unclear whether these benefits outweigh the energy costs.

"Advocates of the blockchain promise a near future where appliances, solar cells, and vehicles could communicate with each other and send automatic payments using a secure and decentralized network; but at what cost?"

–OSCAR SERPELL
RESEARCH ASSOCIATE, KLEINMAN CENTER

COMMENTARY

In addition to print publications, our thought leaders also share timely commentary on our blog and podcast series.



BLOG

The Kleinman Center blog mixes thoughtful voices from across Penn campus. Faculty, staff, senior fellows, and students are all invited to contribute their research and perspectives.

FOLLOW OUR BLOG AT:
KLEINMANENERGY.UPENN.EDU/BLOG

THIS YEAR'S POSTS

JULY

- Solar Supporters, Be Aware… Changes Coming?
- Can't Go It Alone: Why States May Not Be Able to Uphold the Paris Agreement
- Side Effects Include… A Rare Opportunity for Pennsylvania
- Details Matter on Energy Storage Policy in PJM

AUGUST

- It's Time for a Market-Oriented Approach to Clean Energy Investment in Pennsylvania
- Pillars of Sustainability: How Cell Towers Can Transform the Energy Landscape, and Help Us Meet Global Energy Goals
- Pragmatism not Fearmongering Needed on Gas Deliverability
- Welcome back, FERC
- Total Eclipse of the Grid?
- Shot and Chaser
- DOE Reliability Study: Everything's Okay, for Now
- Plain as the Nose on Your Face: Nuclear Subsidy Food Fights Miss Market-Oriented Climate Solution
- Hurricane Harvey: Energy Markets Respond to the Flooding of a Major Energy Hub
- Zero Emissions Credits: An Overview

SEPTEMBER

- Big Natural Gas Customers Want Sustainability Reporting from Producers, Invite Stakeholder Comments
- Examining the Role of Early-Stage Venture Capital Investment in Energy
- Part 1: Artificial Arctic Feedback Loops: How Might Market Forces and Geopolitics Influence an Evolving North?
- Part 2: Artificial Arctic Feedback Loops: How Might Market Forces and Geopolitics Influence an Evolving North?
- A Looming Bust for U.S. Solar Industry?
- D.C. Appeals Decision; Ups Ante on PJM Stakeholder Agreement
- Power Down in Puerto Rico
- Perry's Regulatory Curve Ball to Bail Out Baseload

OCTOBER

- U.S. Crewed
- From Connecticut to Carnot: Meeting Gina McCarthy
- Calculating the Cost of Climate Change
- So What Are Utilities Doing About Storage?

NOVEMBER

- Major NatGas Customers Publish Indicators for Producers
- Let's Talk Government Ownership of Unprofitable Nuclear Power Plants
- Energy Transformation and Air Quality in India
- Big Advance for Cybersecurity Also Important for Energy Cybersecurity
- Russian Natural Gas Divides Europe. But Why?
- Navigating Regulation of U.S. Electricity Grids
- What the Heck is 'Enhanced Price Formation' in PJM?
- Initial Questions on PJM's Price Formation Proposal
- Pennsylvania Should Build Better
- Unpacking IEA's World Energy Outlook 2017

DECEMBER

- Russia's Troubles With Natural Gas
- Part 1: Cost-of-Service Retired More Coal
- Part 2: Future Coal Retirements and a NOPR Disconnect
- Part 3: Utilities Continue Coal Retreat, Advance on Gas and Renewables
- The World Bank Moves Away From Fossil Fuels
- China Introduces Emissions Trading System

JANUARY

- Polar Stress Test Revisits Gas-Powered Grids
- FERC Says No to Resilience NOPR
- Yamal LNG—A Big Win for Russian Gas?
- Clean Energy Costs Continue to Fall
- Solar Industry Growth Set to Slow

FEBRUARY

- Part 1: Philadelphia Energy Solutions Bankruptcy Basics
- Part 2: Philadelphia Energy Solutions Ch. 11 Fact and Fiction
- Part 3: Philadelphia Energy Solutions Investors Prioritized Stronger Investments
- Part 4: The Speculative Future of Philadelphia Energy Solutions
- New FERC Rule Grows Clean Energy's Role in Grid Resilience
- Assessing Competitiveness of Philadelphia Energy Solutions

MARCH

- Gazprom's Toughest Competitors May Be from… Russia
- Independent Monitor's View of PJM Markets
- 5 Ways to Power Down
- FERC Clean Energy Policy Roundup

APRIL

- Fuel Efficiency Rollbacks Are Bad for Consumers, Climate, and Public Health
- The (Yet?) Non-existent Pipeline that Already Divides Europe
- Manual Precision Work for Nord Stream 2
- Attack on PJM Markets Exhibits Zombie-Like Resilience
- Too Soft on Aviation

MAY

- Boosting EV Demand Is Vital to Meeting Sales Mandates
- Carbon Dioxide Hits Record High
- 5 Findings from Dealership Survey on EV Sales

JUNE

- China's Renewable Energy Curtailment Challenge
- Renewable Energy in the Land of Fire and Ice
- The Distribution Grid Gap on Cybersecurity
- History May Tell How Long Pruitt Will Last at EPA
- Natural Gas' Methane Problem
- Energy-Transmission Price Correlation

STUDENT BLOGGERS

This year, we were pleased to introduce even more student voices to our blog. Student blog posts were borne out of coursework, independent research, or experiential learning.

HIGHLIGHTS

August 17

Total Eclipse of the Grid?

Author: Mollie Simon, *Master of Environmental Studies, SAS*

With our reliance on solar, is the energy grid ready for the big light in the sky to go out?

Photo courtesy of NBC News

May 2

Boosting EV Demand Is Vital to Meeting Sales Mandates

Author: Gabe Elsner, *M.B.A., Wharton*

Targeted education and resources are needed to help consumers understand the benefits of making the switch to electric vehicles.

Photo courtesy of Pexels

April 23

Too Soft on Aviation

Author: Benjamin Paren, *Master of Science and Engineering, SEAS*

UN's CORSIA and Vision for the Future of aircraft emissions won't do enough to decrease global warming.

Photo courtesy of stock.tookapic.com

June 11

China's Renewable Energy Curtailment Challenge

Author: Yu "Vera" Tian, *Master of Environmental Studies, SAS*

China's ambitious solar and wind projects are shining stars in clean energy efforts, but delivering that energy isn't always easy.

Photo courtesy of Pexels

PODCAST

In its second year, our podcast series *Energy Policy Now* offers insights in the policy issues that define our relationship with energy—exploring the impact on society and the environment.

SUBSCRIBE TO OUR PODCAST AT:
KLEINMANENERGY.UPENN.EDU/ENERGY-POLICY-NOW

Above: Billy Fleming, of PennDesign's Ian L. McHarg Center, and Jeff Goodell, contributing editor at *Rolling Stone*, join us in the podcast studio to discuss coastal cities and rising sea water.

THIS YEAR'S EPISODES

Balancing the Benefits and Costs of Environmental Regulation
Alan Krupnick, *Resources for the Future*
Cary Coglianese, *PennLaw*

The Road Forward for Electric Vehicles
John Paul MacDuffie, *Wharton*

Where Coal Mining Brings Environmental Benefits
Greg Driscoll, *Blaschak Coal Corporation*
John Stefanko, *Pennsylvania Department of Environmental Protection*

The Future of the EPA and Clean Power
Gina McCarthy, *EPA (former director)*

Building Resilient Coastlines
Ellen Neises, *PennDesign*
Billy Fleming, *PennDesign*

A City Blazes Its Clean Energy Trail
Adam Agalloco, *City of Philadelphia*

Distributed Energy's Wholesale Opportunity
Ari Peskoe, *Harvard Law*

India's Now or Never Climate Opportunity
Radhika Khosla, *Centre for Policy Research in India*

Grid Operator PJM Talks Details of Energy Price Formation
Stu Bresler, *PJM Interconnection*
Christina Simeone, *Kleinman Center*

Corporations Deepen Clean Energy Commitments
Ken Kulak, *Kleinman Center*

The Local View of Fracking
Daniel Raimi, *Resources for the Future*

Envisioning a Low Carbon Lowest Cost Grid
Jesse Jenkins, *MIT*

The Future of Nuclear Host Communities
Jennifer Stromsten, *Institute of Nuclear Host Communities*
Saqib Rahimm, *E&E News*

The Promise and Peril of Self-Driving Trucks
Steve Viscelli, *Kleinman Center*

Lessons from a Decade of Cap & Trade
Arthur van Benthem, *Kleinman Center*

Rising Seas and the Future of Coastal Cities
Jeff Goodell, *Rolling Stone*
Billy Fleming, *PennDesign*

The Legal Limits to State Climate Action
Cary Coglianese, *PennLaw*
Shana Starobin, *Bowdoin College*

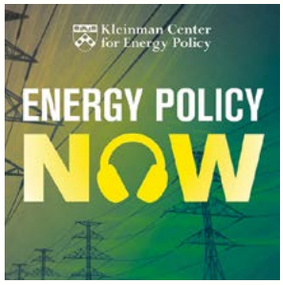
An EPA After Scott Pruitt
Cary Coglianese, *PennLaw*
Daniel Walters, *PennLaw*

Distributed Energy's Cyber Risk
William Hederman, *Kleinman Center*
Steve Kunsman, *Institute of Electrical and Electronics Engineers*

PODCAST

DISTRIBUTED ENERGY'S CYBER RISK

May 1 | Episode # 35



In this podcast episode, cybersecurity experts discuss the vulnerabilities of the electric distribution system, and political and technological means of addressing cyber risk.

ABOUT THE GUESTS

William Hederman is a senior fellow at the Kleinman Center and a former senior advisor to U.S. Secretary of Energy Ernest Moniz.

Steve Kunsman is chairman of the Cyber Security Subcommittee at the Institute of Electrical and Electronics Engineers (IEEE) and director of Product Management and Applications at ABB North America.

Above: Former *Forbes* reporter Andy Stone hosts our bi-weekly podcast series.

ABOUT THE EPISODE

In recent months the threat of cyberattack on the nation's electricity system has come into urgent focus. Earlier this year the FBI and Department of Homeland Security made public a series of cyberattacks that penetrated the control systems of several nuclear power stations. Another recent attack on a network of natural gas pipelines threatened fuel supply to gas-fired power plants in the eastern United States. And both breaches came in the wake of a 2015 cyberattack on three Ukrainian electric utilities that left more than 200,000 people without power.

Yet even as awareness of cyber threats has risen, vulnerability to such attacks continues to grow. At the distribution level, behind-the-meter technologies like rooftop solar, battery storage, and demand response make the electric system more efficient, but also provide attackers with new points of entry into an electric system that was, by and large, built without cyberthreats in mind.

GRANTS

Students, doctoral candidates, and professors with an interest in energy policy seek our support for learning opportunities and research projects.

RESEARCH GRANTS

Last fall we sought requests for support from Penn faculty and doctoral students on topics that leverage existing research and address timely energy policy needs. In the spring, we selected eleven projects representing diverse expertise from four different schools. Each of these projects will culminate in a published policy digest.

FACULTY SCHOLARSHIP

Unilateral Incentives to Self-Impose Emission Limits: Is There a Case for Pennsylvania and RGGI

Author: Jose Miguel Abito, *Business Economics and Public Policy, Wharton*

The Regional Greenhouse Gas Initiative (RGGI) is a CO2 emissions allowance program that covers Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont. In this project, we look at Pennsylvania's incentives to join RGGI.

Socio–Spatial Carbon Collaborative

Author: Daniel Aldana Cohen, *Sociology, SAS*

This project will establish a third-generation, household-based, neighborhood-level carbon footprint database for the United States. It aims to clarify how carbon moves spatially through the economy, built environment, and everyday life; how these processes intersect with a range of social and spatial inequalities that also shape well-being; and how exposure to potential carbon-pricing would impact different communities.

Energy in the Global Economy: History and Future

Author: Jesús Fernández-Villaverde, *Economics, SAS*

Part 1 of the project asks: what can we learn from the history of energy about how transitions from one source of energy to another have occurred? Part 2 of the project asks: what can we think, formally and quantitatively, about the new world of the oil industry after the tight and shale gas revolution?

Valuation of Electric Vehicles and Parking Policies in Philadelphia

Author: Erick Guerra, *City and Regional Planning, PennDesign*

Co-Author: Ricardo Daziano, *Cornell University*

In this study, researchers separate out residents' willingness to pay for convenient charging systems from their willingness to pay for convenient parking spaces.

Oil and Growth: The Role of Commuting in Skill-biased Technical Change

Author: Nikolai Roussanov, *Finance, Wharton*

Since expenditures associated with commuting (e.g., gasoline) are more significant as a share of income for low-skill workers, fluctuations in oil prices have a larger impact on their labor supply. This project aims to understand the role of energy costs, and specifically oil prices, in skill-biased technological change.

A Data Driven PV Power Forecasting Model

Author: Jorge Santiago-Aviles, *Electrical and Systems Engineering, SEAS*

Solar Photovoltaics (PV) are one of the most rapidly growing renewable energy sources around the world. For sunny tropical locations such as Puerto Rico, and after the electric energy debacle following Hurricane Maria, forecasting solar power is necessary for the efficient application of the resource.

DOCTORAL SCHOLARSHIP

Preemption, Contracting Frictions and Investment Efficiency in Shale Gas Extraction

Author: Aymeric Bellon, *Finance, Wharton*

Co-Author: Tong Liu, *Finance, Wharton*

This project aims at understanding how the selling of exploitation rights for mineral reserves as well as the contractual terms between landowners and gas firms shape the speed at which resources are exploited.

The Unforeseen Consequences of Regulations: How Past Regulations Affect the Adoption of Innovative Technologies in the Shale Gas Industry

Author: Paul H. Décaire, *Finance, Wharton*

"Oil field unitization" enabled firms to assemble all tracts of land that shared common access to an oil pool and to operate them as one individual unit, distributing the entire costs and benefits from the pool across all members. This study investigates the role of a joint venture, such as unitized tracts of land, on investment decisions.

Disasters in the Delta: Oil Spills, Externalities, and Militant Competition in Nigeria

Author: Jonah Rexer, *Business Economics and Public Policy, Wharton*

The aims of this study are twofold: 1) to combine data on oil spills and economic outcomes to estimate the effects of spills on investment and productivity, and 2) to study the dynamics of oil-related violence in the context of a 2009 policy in which the Nigerian Federal Government granted militants of the region amnesty from prosecution in return for ceasing attacks on the oil industry.

The Impact of Renewable Energy Procurement Auctions in Brazil

Author: Gabrielle Vasey, *Economics, SAS*

Renewable energy development is of utmost importance in Brazil, a country facing future energy supply shortages. This study examines the role of renewable energy in Brazil's electricity grid and compares the different methods of awarding renewable energy contracts.

FACULTY GRANT

ENERGY ACROSS THE AGES

"The main constraint for the output of goods and services is energy."

—Jesús Fernández-Villaverde,
Professor of Economics, SAS

The key to understanding our energy future is to have a clear understanding of our energy past, asserts Jesús Fernández-Villaverde, professor of economics in Penn's School of Arts and Sciences.

And this is why he is writing a book on global economic history—with several chapters dedicated to the history of energy. A Kleinman Center grant is helping support that research.

"I'm very interested in understanding the innovations in energy," says Fernández-Villaverde, whose book will cover energy transitions over the past six millennia, including the introduction of fossil fuels, which spurred the industrial revolution, as well as renewables, and the recent shale gas revolution.

From an economic perspective, he is most interested in how energy drives production and how we measure that productivity. In the past, he has worked on data-driven projects that measure the economy through electricity usage or road congestion. These studies prove that higher consumption is directly related to higher economic productivity.

"The main constraint for the output of goods and services is energy," he explains. This is a concept he has been teaching his students for years as part of his economic history class at Penn.

In class, he asks students to imagine themselves as farmers before the industrial revolution. "The main constraint is how to harness energy. You have your own body, but the most energy you can produce is 3 to 4 horsepower. You may have horses or buffalo, but they are costly to maintain. You have to feed them. Maybe you can use a little bit of wood to create some energy…"

In class, he asks students to imagine themselves as farmers before the industrial revolution.

Humans have lived with minimal energy resources for the bulk of their existence (and more than a billion still do). Yet, during the past 300 years, that scenario changed dramatically.

With fossil fuels, "we have produced a lot of stuff," says Fernández-Villaverde. "But we have been relying on energy that nature has accumulated for the last millions of years." These fossil fuel resources are limited and using them has major climate ramifications.

"Now we need to move beyond economy that is fossil fuel driven," he says.

While his book will not prescribe that future, Fernández-Villaverde hopes his historic overview of our energy economy will inform students, researchers, and policy makers to design better solutions for the future.

KLEINMAN BIROL FELLOWSHIP

'ABOVE AND BEYOND' SUMMER IN PARIS

"The IEA fellowship offered specific experience in the field of energy… and this is where I want my career to go."

—Khushboo Goel,
2018 Kleinman Birol Fellow

ABOUT THE FELLOWSHIP

The Kleinman Birol Fellowship was named in honor of Fatih Birol, executive director of the International Energy Agency and 2016 Carnot Prize recipient. The fellowship brings a Penn student to Paris for an in-depth summer work experience at IEA headquarters.

When Wharton M.B.A. student Khushboo Goel received two competing summer offers—one at United Nations and the other at the International Energy Agency (IEA) in Paris—the decision was "surprisingly easy," she said.

STRATEGIC SUMMER

"While I knew that I wanted to work in an intergovernmental organization, the IEA fellowship also offered specific experience in the field of energy," said Goel. "And this is where I want my career to go."

As this year's Kleinman Birol Fellow, Goel spent her summer researching deep decarbonization strategies in India and the United States—research that will culminate in an insight paper that will be published on the IEA website.

CROSS-CULTURAL CONNECTIONS

"I picked this project because I'm invested in what's happening in India and the U.S. And I see myself working in one of these countries," said Goel, who is originally from Delhi and is currently president of the Wharton India Economic Forum.

WHY ENERGY?

Goel became interested in energy while working at a large consulting firm in India. She worked on an array of projects, but particularly enjoyed the public sector and all things energy. She worked on a port development project focused on optimizing operations at India's twelve major ports. Later, she worked on identifying and developing the bi-lateral trade strategy focused on energy investments between India and Spain.

With a bachelor's in commerce from Delhi University and relevant work experience, Goel entered Wharton's M.B.A. program. Her interest in energy continued at Wharton, where she served as the team lead on a project in Kenya to help women in clean energy. She also worked on a school project with the Philadelphia Energy Authority, to help develop financial instruments for attracting funding for the city's distributed solar program.

MENTORS & MORE

This summer at the IEA, Goel was assigned to the gas, coal, and power team. Because of the cross-disciplinary nature of her research, she interfaced with other teams, including those in technology, renewables, and energy efficiency.

Goel says her experience at the IEA has been "above and beyond" what she hoped for. Unlike a typical internship, Kleinman Birol fellows get to select and design their own projects, she explained. Because of this, she was connected to internal experts who mentored and directed her. And these types of connections went beyond the walls of the IEA. Near the end of her fellowship, IEA Executive Director Fatih Birol arranged a meeting to introduce Goel to India's ambassador to France. Goel was able to personally share her research with the ambassador—one of the highlights of her summer.

"I would say this is an opportunity you don't get often. The opportunity to access all of the top knowledge in world energy. The opportunity to work with people from around the world. The opportunity to learn and work on something you are interested in—while at the same time coming home with an international publication."

–KHUSHBOO GOEL
2018 KLEINMAN BIROL FELLOW

STUDENT GRANTS

This year, we funded 41 students and groups across campus who demonstrated an interest in energy policy. During the year, these students dived into internships, fellowships, case competitions, conferences, travel–study programs, research projects, and more.

KLEINMAN BIROL FELLOWSHIP

Khushboo Goel, *M.B.A., Wharton*

KLEINMAN CENTER SUMMER FELLOWSHIPS

City of Philadelphia
Anna Cheyette, *Environmental Studies, SAS*

Pennsylvania Environmental Council
Carlos Garcia, *Master of Environmental Studies, SAS*

Philadelphia Energy Authority
Mahvish Ilyas, *Master of Environmental Studies, SAS*

Keystone Energy Efficiency Alliance
Bailey Smith, *Master of Environmental Studies, SAS*

Clean Air Council
Alexander Tablan, *Master of Environmental Studies, SAS*

Council on Foreign Relations Internship
Charles Zhang, *Undeclared, Wharton*

PENN UNDERGRADUATE RESEARCH MENTORING (PURM)

Harnessing the Cold of Outer Space to Meet our Growing Water Needs
Advisor: Aaswath Raman, *SEAS*

Baran Kayim, *Undeclared, SAS*

Sergio Roman, *Engineering and Applied Science, SEAS*

CONFERENCES, COMPETITIONS, AND EVENTS

Deep Decarbonization in PJM Working Lunch
Lauren Brunsdale, *Master of Science in Applied Geosciences, SAS*

Duke and UT Austin Case Competition
Michael Alexander, *M.B.A., Wharton*

Miguel Cebrian, *M.B.A. and International Studies, Wharton and SAS*

Karl Chan, *M.B.A., Wharton*

Huy Le, *M.B.A. and International Studies, Wharton and SAS*

Thomas Witmer, *M.B.A., Wharton*

Greentech Media Solar Summit
Winston Chen, *M.B.A., Wharton*

San Francisco Networking Event with Alumni's and Energy Firms
Khalid Quidwai, *M.B.A., Wharton*

Wharton Energy Conference
Wharton Energy Club

Wharton Latin American Conference
Wharton Latin American Conference Team

RESEARCH PROJECTS

Comparative Analysis of Policy Mechanisms Used By East Coast Municipalities to Reduce Emissions Associated with Energy Usage
Gee Paegar, *Master of Environmental Studies, SAS*

Feasibility of Small Scale Solar for Penn Students
Nicholas Zhu, *Environmental Students, SAS*

Quantifying the U.S. Coast Guard Ecological Risk Assessment on Dilbit: A Product for Risk Managers & Energy Policy Analysts
Eric Nielsen, *Master of Environmental Studies, SAS*

Shale Gas Policy in Pennsylvania Municipalities
Justin Royer, *Master of Environmental Studies, SAS*

Studying Consumer Friction on Electric Vehicle Purchases
Gabriel Elsner, *M.B.A., Wharton*

Waste-to-Energy Technology: Powering our Future with Trash
Richard Ling, *Systems Engineering and Earth Science, SEAS and SAS*

TRAVEL

International Youth Peace Conference: Climate Change
AnnaClaire Akoto, *Biological Basis of Behavior, SAS*

Adoma Boateng, *Psychology, SAS*

Chiemela Ohanele, *Biology, Psychology, Biological Basis of Behavior, SAS*

Offshore Wind in Europe
Brandon Burke, *Master of Environmental Studies, SAS*

Penn Class: Renewable Energy in the U.S. and Argentina
Daniel Carrillo, *Electrical Engineering, SEAS*

Andrea Makamba, *Systems Science and Engineering, SEAS*

Melissa Frankil, *Environmental Studies, SAS*

Nicole Posadas, *Earth Science, SAS*

Penn Summer Abroad in Berlin and Rotterdam
Vicky Gallivan, *Economics, Wharton*

Emma Loving, *Environmental Studies, SAS*

Nathan Ng, *Electrical Engineering and Business, SEAS and Wharton*

Maria Odongo, *Electrical Engineering, SEAS*

GREEN PROGRAM

The GREEN Program is an off-campus organization that helps support sustainable learning out of the classroom and around the globe. This year, we worked with the GREEN Program to help fund travel study opportunities for the Penn students in Iceland.

Joe Vincent Abdo, *Systems Science and Engineering, SEAS*

Richard Ling, *Systems Engineering and Earth Science, SEAS and SAS*

Gregory Robinov, *Mechanical Engineering and Applied Mechanics, SEAS*

Maher Abdel Samad, *Systems Science and Engineering, SEAS*

#ENERGYATPENN: HANDS-ON LEARNING

kleinmanenergy
Atlantic/Reykjavik

♡ 15 Likes

kleinmanenergy 🌲👍🏽 Fighting #CO2 naturally: Our summer grant students on the @greenprogram recently took part in one of the largest #reforestation programs in Europe. In two hours, they planted 2000 trees in #Iceland. #EnergyAtPenn

kleinmanenergy
Fort McMurray, Alberta

♡ 7 Likes

kleinmanenergy This week, grant recipient Eric Nielsen visited the heart of #oilsands development, Fort McMurray in Alberta, Canada. 🇨🇦 Heavy oil sands can still be found along the river banks (pictured). The oil is separated from the sand and clay using hot water, producing #bitumen. #EnergyAtPenn ☀️

kleinmanenergy
Amsterdam, Netherlands

♡ 14 Likes

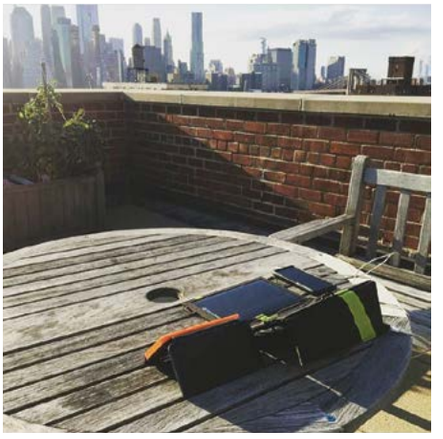
kleinmanenergy Find our summer grant recipient Maria Odongo in the mix! 🌎🌍🌎 She was sponsored to participate in the "Penn in Berlin and Rotterdam" program, where she is learning about energy policy in Europe. #🇩🇪 #🇳🇱 #EnergyAtPenn #PennSummer #UPenn

kleinmanenergy
Devon Research Center

♡ 10 Likes

kleinmanenergy First day at @naturalresourcescanada Devon Research Center! Grant recipient Eric Nielsen is researching the chemical composition and #fate and transport of diluted #bitumen when spilled in #freshwater environments. 🇨🇦 #EnergyAtPenn

kleinmanenergy



♡ 11 Likes

kleinmanenergy Are busy college students willing to make the effort to switch to #solar to charge their phones and devices? 📱 ☀️ Grant recipient Nicholas Zhu is examining various panel options and comparing convenience, cost, portability, and adaptability. #EnergyAtPenn

kleinmanenergy
City of Philadelphia Government

♡ 16 Likes

kleinmanenergy Anna Cheyette, summer fellowship recipient, is #interning with the Energy Office with the City of Philadelphia, where she is energy #benchmarking municipal buildings and working to get the One Parkway Building #EnergyStar certified for 2018. 🏙️ #EnergyAtPenn

STUDENT GRANT

TRANSFORMATIONAL OPPORTUNITY

"The travel grant, the writing opportunities, the research position, the certificate program, the Carnot Prize event with Gina McCarthy—have all been transformational."

—Brandon Burke,
Student Grant Recipient

Last December Brandon Burke started waking up at three o'clock every morning. He brushed his teeth, had a glass of water, and started working down the list of phone numbers.

THE EARLY BIRD

"If you want to catch someone, you call them at nine in the morning," says Burke, a graduate student in environmental studies.

He was eager to connect with European leaders at energy nonprofits, government agencies, and companies. His particular interest was in offshore wind—an industry in its infancy here in the United States but mature in Europe, where enormous turbines at sea have generated clean energy since 1991.

MAKING CONNECTIONS

Burke wanted not only to learn from European experts, he wanted to meet with them in person. As a former litigator, he knew the value of face-to-face conversations. Finally, after about a month of cold calling—"bam," Bent Christoffer of the WindEnergy Network in Rostock, Germany generously shared his contact list of key offshore wind experts throughout Germany.

Burke quickly lined up four meetings. He then applied for a Kleinman Center travel grant.

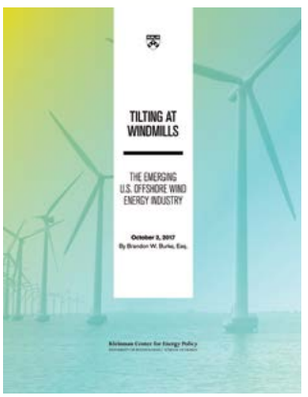
With grant support, Burke traveled to three cities in Germany (Varel, Hamburg, and Berlin), and met with representatives of offshore wind nonprofit groups, developers, and the German Federal Ministry for Economic Affairs and Energy (*Bundesministerium für Wirtschaft und Energie*, or "BMWi").

GETTING PUBLISHED

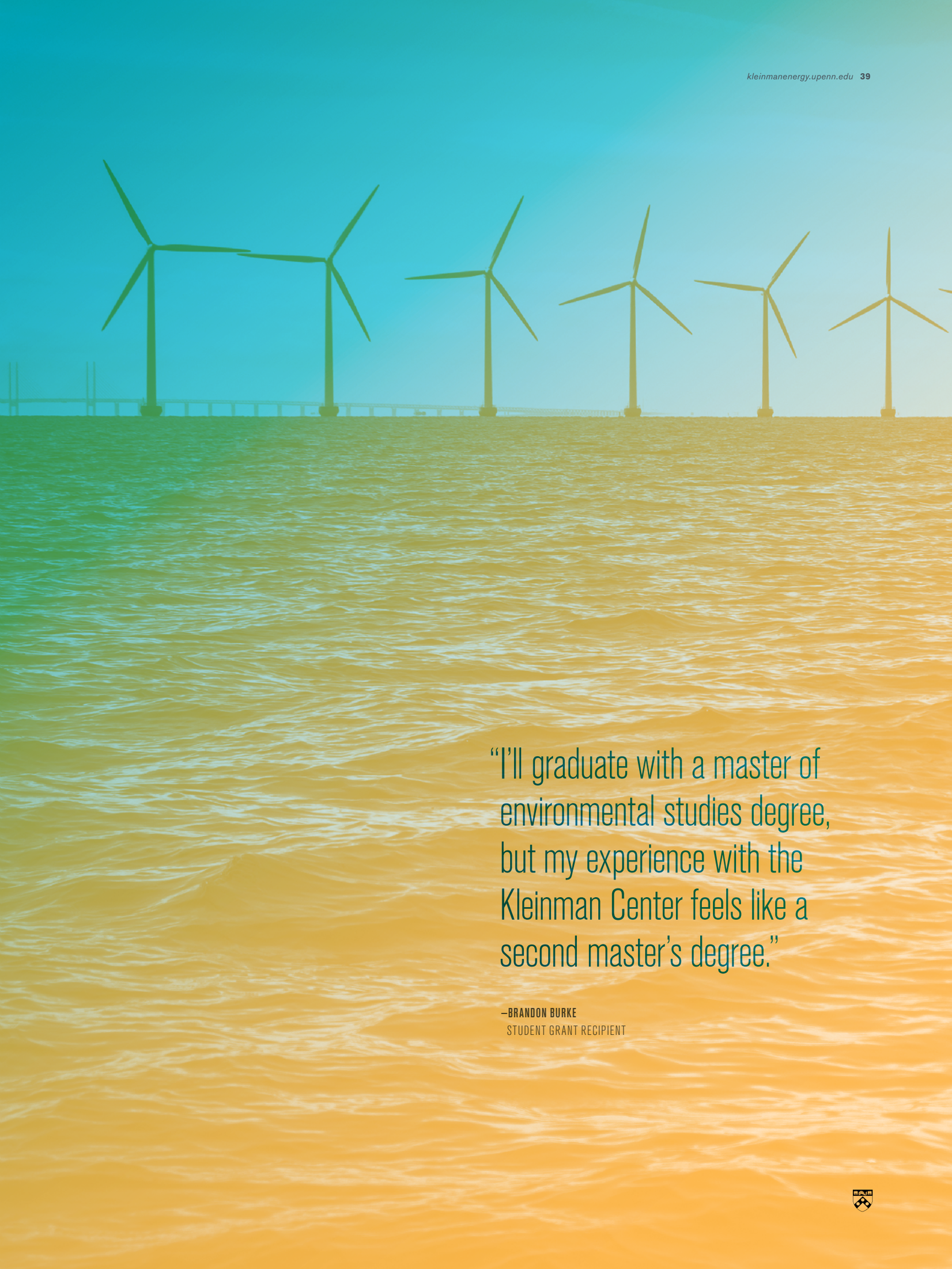
Burke, now a Kleinman Center research fellow, has already written a policy digest and paper on the emerging offshore wind industry in the United States. As a result of this international "on-the-road" research, he is now writing a paper that focuses on European offshore wind.

Burke came to Penn in the fall of 2016, interested in wave and tidal energy systems. He quickly realized that this technology was "something that wasn't commercially viable." He wanted to find a new yet proven clean energy path.

It was then that he learned about the Block Island wind farm. Located off the coast of Rhode Island, Block Island was the first offshore wind farm in the United States. This was the proven technology Burke had been looking for. With his newfound interest, and newfound home at the Kleinman Center, he began pursuing offshore wind as a research topic. He now has his eye on a future career in offshore wind.



This year, Burke published a Kleinman Center policy digest on offshore wind.



"I'll graduate with a master of environmental studies degree, but my experience with the Kleinman Center feels like a second master's degree."

—**BRANDON BURKE**
STUDENT GRANT RECIPIENT

CERTIFICATE PROGRAM

Penn graduate students interested in adding an understanding of energy policy to their qualifications have the opportunity to enroll in our cross-disciplinary certificate program.

CERTIFICATE PROGRAM

MORE THAN A CREDENTIAL

"Tackling the issue of climate change requires interdisciplinary thought. I'm glad that we have the Kleinman Center as an aggregator and convener."

—Winston Chen,
Certificate Student, Kleinman Center

Like many graduate students, Winston Chen came to Penn to pivot his career. He had encountered the energy sector during his work in generalist private equity and strategy consulting. However, he knew he wanted to focus his long-term career on clean energy.

THE MOST IMPORTANT ISSUE

"If you are someone who believes that climate change is an important issue—and I think it's the most important issue—then you should move your career in a direction that helps address it. For me, that involves working in the clean energy sector."

As Chen was applying to Wharton's M.B.A. program, he also found the Kleinman Center website and learned about our Certificate in Energy Policy and Management. This was something he knew he wanted to pursue.

"It looked like a great opportunity to get some interdisciplinary training—to comprehensively understand energy," Chen says.

Chen is now enrolled in the certificate program and has completed his first year at Wharton—next year, he will serve as co-president of the Wharton Energy Club. He has already taken several certificate courses, including his favorite: "Energy Law and Climate Change" taught by Kleinman Center Senior Fellow Kenneth Kulak and Professor Edward Comer at PennLaw.

In addition, he took "Energy Markets and Policy" taught by Wharton professor Arthur van Benthem. The course focused on electricity and energy markets—from an economist's view—with an emphasis on oil extraction, cap and trade, and unintended policy consequences, among other topics.

AN ENERGY FOUNDATION

Chen also took "Energy Finance," taught by Jérôme Taillard. Although the material primarily covered finance in oil and gas (not clean energy), he says he appreciated the foundation it offered him.

"The transition from fossil fuels to low carbon energy is happening, but there's a lot of work ahead. There are valuable lessons from the oil and gas industry that can be applied to clean energy, particularly around financial innovation."

"The transition from fossil fuels to low carbon energy is happening, but there's a lot of work ahead."

—WINSTON CHEN

ADDED BENEFITS

While Chen says the main reason he pursued the certificate program was to catch the attention of future employers, he also saw the benefits beyond just the credential. Because the certificate program is interdisciplinary, with course offerings at several schools, he has made friends with like-minded students from Engineering, PennLaw, Arts and Sciences, and Wharton.

Being a certificate student also connects you with the many resources at the Kleinman Center, Chen points out. Accessing the latest energy research, being mentored by leading energy experts, and attending key events (like former EPA Administrator Gina McCarthy's visit), have all "been very beneficial."

CERTIFICATE PROGRAM OVERVIEW

Once again, we admitted new students into our Certificate in Energy Management and Policy program. Students in the program take a foundation course, Introduction to Energy Policy, taught by the Kleinman Center. They also have the opportunity to take energy courses across schools and disciplines.

CURRENT CERTIFICATE STUDENTS

Gregory Arpino, *Juris Doctor, PennLaw*

Brandon Burke, *Environmental Studies, SAS*

Winston Chen, *Business Administration (M.B.A.), Wharton*

Jonathan Hess, *Juris Doctor, PennLaw*

Andre Marcarian, *Business Administration (M.B.A.), Wharton*

Evan Shaver, *Juris Doctor, PennLaw*

Julie Ufford Keenahan, *Business Administration (M.B.A.), Wharton*

2017-2018 CERTIFICATE GRADUATES

Mike Larson, *City and Regional Planning, PennDesign*

Catherine Nabukalu, *Environmental Studies, SAS*

Aishwarya Raja, *Environmental Studies, SAS*

ENMG503: 21ST CENTURY ENERGY REVOLUTIONS

As part of our certificate program this year, we offered a Kleinman Center elective course, 21st Century Energy Revolutions.

Energy markets at the beginning of the 21st century have been revolutionized by several stunning developments. Some of these developments are complementary; others are contradictory. Senior Fellow Anna Mikulska taught this course as a directed study, guiding students in selecting an energy revolution for their own research and writing.

SEE ALL COURSES AT:
KLEINMANENERGY.UPENN.EDU/ENERGY-COURSES

EVENTS

The Energy Forum is our gathering place for important lectures and conversations. Our events cover a wide array of energy policy topics and attract students, researchers, and industry experts.


Kleinman Center for Energy Policy
CARNOT PRIZE
for distinguished contributions to energy policy

CARNOT PRIZE: GINA McCARTHY'S CLEAN ENERGY VISION

On October 3, we awarded the 2017 Carnot Prize to the Honorable Gina McCarthy, former administrator for the United States Environmental Protection Agency and champion of the Clean Power Plan.

"It's an honor to receive this award and to join the many individuals who have changed how we see and how we solve our greatest energy and public health challenges," said McCarthy.

In her remarks, McCarthy encouraged students to use what they've learned to make a positive difference in the world, "by defending science and creating innovative tools and policies to tackle our greatest environmental threats so we can save lives and build a healthier future."

ABOUT THE PRIZE

The Carnot Prize is named in memory of French scientist Sadi Carnot, who in 1824 published Reflections on the *Motive Power of Fire,* which is recognized as the first statement of what is now known as the second law of thermodynamics.

Carnot recognized that the power of the steam engine would "produce a great revolution" in human development. The Carnot Prize is intended to honor those leading revolutions in energy policy to further progress and prosperity.

Above: PennDesign Dean Frederick Steiner, Board Member Lynn Scarlett, Founding Donor Scott Kleinman, Carnot Prize Recipient Gina McCarthy, and Founding Faculty Director Mark Alan Hughes

Right: Gina McCarthy offers some remarks following her acceptance of the Carnot Prize.

GINA McCARTHY

Highlights

13th EPA Administrator under President Barack Obama

Finalized the Clean Power Plan

Current Work

Institute of Politics Fellow, Harvard University's Kennedy School of Government

Richard L. and Ronay A. Menschel Senior Leadership Fellow, Harvard's T.H. Chan School of Public Health

Past Work

Assistant Administrator for the EPA's Office of Air and Radiation

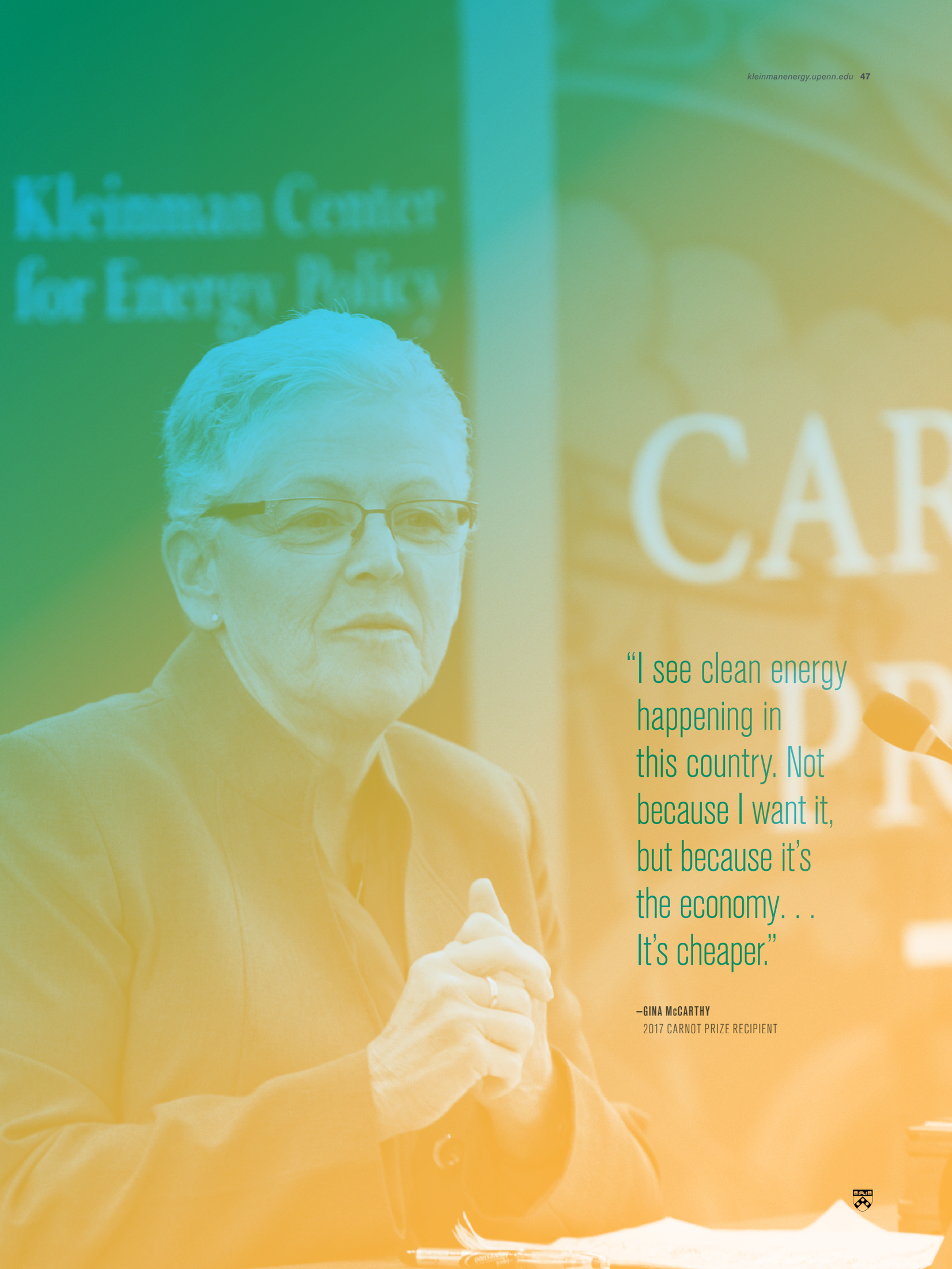
Commissioner of the Connecticut Department of Environmental Protection

Environmental Advisor to both Democratic and Republican governors of the state of Massachusetts

Education

B.A., Social Anthropology, University of Massachusetts Boston

M.Sc., Environmental Health Engineering and Planning and Policy, Tufts University



"I see clean energy happening in this country. Not because I want it, but because it's the economy. . . It's cheaper."

–GINA McCARTHY
2017 CARNOT PRIZE RECIPIENT

"Pull up your big-girl pants, your big-boy pants, your gender-neutral pants and do something. Keep hope alive. Fight for this country."

—GINA McCARTHY
2017 CARNOT PRIZE RECIPIENT

"Gina McCarthy's career exemplifies the courage, creativity, and commitment required to make great changes in energy policy. She is an inspiration to the rising generation of leaders at Penn and around the world."

—MARK ALAN HUGHES
FOUNDING FACULTY DIRECTOR, KLEINMAN CENTER

THANK YOU, GINA McCARTHY

Students across campus mobilized to welcome McCarthy and celebrate her Carnot Prize achievement. In a tribute video, they expressed their thanks.

"Thank you for standing so firmly on climate change."

—Tabeen Hossain, *Master of Environmental Studies, SAS*

"Thank you for inspiring my work as a woman in science and policy."

—Gavriella Reiter, *Master of Nonprofit Leadership, SP2 (C'17)*

"Thank you for putting a real actionable plan in motion."

—Aran Fox, *Philosophy, Politics and Economics, SAS*

"Thank you for all the ways you've supported the future work of environmental policy experts."

—Julia Lesko, *Economics, Wharton*

Opposite page:
Gina McCarthy is interviewed for an episode of the *Knowledge@Wharton* live radio show; the Carnot Prize pocket watch.

THIS YEAR'S EVENTS

We lined up the chairs and turned on the microphones for several public events in the Energy Forum this year. From our annual Carnot Prize award ceremony to roundtables, workshops, and policy lectures—we gathered often for meaningful discussions.

Roundtable

September 27, 2017

ENERGY POLICY ROUNDTABLE IN THE PJM FOOTPRINT: THE FUTURE OF DYNAMIC PRICING, PRICE RESPONSIVE DEMAND & DEMAND RESPONSE AND IMPROVING PRICE FORMATION IN WHOLESALE ENERGY MARKETS?

SPEAKERS

Betty Ann Kane, *Chairman, Washington, D.C. Public Service Commission*

Greg Poulos, *Executive Director Consumer Advocates of the PJM States*

Paul Centolella, *Principal, Centolella & Associates*

Matthew McCaffree, *Senior Director of Regulatory and Government Affairs, ITRON*

Peter Langbein, *Manager of Demand Side Operations, PJM*

William Hogan, *Professor, Harvard Kennedy School of Government*

Harry Singh, *Vice President, U.S. Power Trading Group, Goldman Sachs*

Catherine Tyler, *Senior Economist, Monitoring Analytics*

Adam Keech, *Executive Director Market Operations, PJM*

MODERATOR

Jonathan Raab, *President, Raab Associates, Ltd.*

HOST

Kleinman Center

Lecture & Award Ceremony

October 3, 2017

2017 CARNOT PRIZE

RECIPIENT & SPEAKER

Gina McCarthy, *Former Administrator, EPA*

SPEAKER

Lynn Scarlett, *Co-Chief External Affairs Officer, The Nature Conservancy*

HOST

Mark Alan Hughes, *Founding Faculty Director, Kleinman Center*

Policy Series Lecture

November 8, 2017

POWER OVER THE U.S. ELECTRIC GRID

SPEAKER

Ari Peskoe, *Senior Fellow, Harvard Environmental Policy Initiative*

MODERATOR

Cary Coglianese, *Director and Professor of Law, Penn Program on Regulation*

Co-Sponsor: Penn Program on Regulation

Policy Series Lecture

November 15, 2017

UNPACKING INDIA'S ENERGY AND CARBON FUTURE

SPEAKER

Radhika Khosla, *Fellow, Centre for Policy Research in India*

Co-Sponsor: Center for the Advanced Study of India

Roundtable

November 28, 2017

ENERGY POLICY ROUNDTABLE IN THE PJM FOOTPRINT: ENSURING RESILIENCE & RELIABILITY IN PJM'S COMPETITIVE MARKETS

SPEAKERS

Robert F. Powelson, *Former Commissioner, Federal Energy Regulatory Commission*

Alison Silverstein, *Consultant, Alison Silverstein Consulting*

Ralph Izzo, *CEO and President, PSEG*

Stu Bresler, *Senior Vice President for Operations and Markets, PJM Interconnection*

Joseph Bowring, *President, Monitoring Analytics*

Donald Santa, *President and CEO, INGAA*

Richard Kruse, *Vice President, Enbridge*

MODERATOR

Jonathan Raab, *President, Raab Associates, Ltd.*

HOST

Kleinman Center

Policy Series Lecture

February 1, 2018

GETTING TO ZERO: PATHWAYS TO ZERO CARBON ELECTRICITY SYSTEMS

SPEAKER

Jesse Jenkins, *Fellow, Researcher, MIT*

HOST

Mark Alan Hughes, *Founding Faculty Director, Kleinman Center*

Leadership Series

February 15, 2018

PROSPECTS FOR THE GLOBAL OIL & GAS INDUSTRY

SPEAKER

Felipe Arbelaez, *Regional President for Latin America, BP*

Co-Sponsor: Wharton Energy Club

Leadership Series

February 27, 2018

THE EVOLUTION OF WHOLESALE ELECTRICITY MARKETS

SPEAKER

Andrew L. Ott, *President and CEO, PJM Interconnection*

Co-Sponsor: Wharton Energy Club

Policy Lecture

April 3, 2018

THE FRACKING DEBATE: A CONVERSATION WITH DANIEL RAIMI

SPEAKER

Daniel Raimi, *Senior Research Associate, Resources for the Future*

MODERATOR

Cary Coglianese, *Director and Professor of Law, Penn Program on Regulation*

Co-Sponsors: Penn Wharton Public Policy Initiative, Penn Program on Regulation

ENERGY ECONOMICS & FINANCE SEMINAR

For a second year, Faculty Fellow Arthur van Benthem hosted a seminar series that has become the gathering place on Penn campus for energy research discourse.

FACULTY PRESENTATIONS

Separate Markets for Externalities: Regional Versus State-by-State Regulations of a Global Pollutant
Mike Abito, *Wharton*

Drill Another Day? An Empirical Analysis of Real Option Exercise Decisions
Erik Gilje, *Wharton*

Relinquishing Riches: Auctions vs. Negotiations in Texas Oil and Gas Leasing
Richard Sweeney, *Boston College*

Asymmetric Information, Drilling Distortions, and Oil and Gas Leases
Evan Herrnstadt, *Harvard/Compass Lexecon*

Increasing the Influence of CO2 Emissions Information on Car Purchase
Ricardo Daziano, *Cornell*

The Economic Benefits versus Environmental Costs of India's Coal-Fired Power Plants
Akshaya Jha, *CMU Heinz*

Investment Productivity and Coordination Frictions Across Firms
Erik Gilje, *Wharton*

Forced Cooperation vs. Competitive Holdouts: Efficient Land Use Policies in the Oil and Natural Gas Industry
Ashley Vissing, *University of Chicago*

Compatibility and Investment in the U.S. Electric Vehicle Market
Jing Li, *MIT Sloan*

The Efficiency of Dynamic Electricity Pricing Schemes
Arthur van Benthem, *Wharton*

DOCTORAL STUDENT PRESENTATION

What's Killing Nuclear Power in U.S. Electricity Markets? Drivers of Wholesale Price Declines at Nuclear Generators in the PJM Interconnection
Jesse Jenkins, *MIT*

MASTER STUDENT PRESENTATION

Path Dependence in the Optimization of Electricity Generation Portfolios with Intermittent Renewable Resources and Delayed Externality Pricing
Thomas Lee, *SEAS and Kleinman Center*

STAFF PRESENTATION

Quantifying Environmental and Price Impacts of Pipeline-Driven Increases in Pennsylvania Shale Gas Production
Angela Pachon and Christina Simeone, *Kleinman Center*

EVENT

Policy Series Lecture

PATHWAYS TO ZERO CARBON ELECTRICITY SYSTEMS

"Electricity is the lynchpin in our efforts to decarbonize the economy."

—Jesse Jenkins,
Ph.D. Candidate, MIT;
2018 Visiting Scholar

The electric grid has been called the largest machine ever built. Now more than a century old, it is also our single largest source of greenhouse gasses. This spring, visiting scholar Jesse Jenkins presented new research that identifies the least expensive paths to a carbon-free grid, in hopes of bringing such an electric system closer to reality.

DEEP DECARBONIZATION

Jenkins, a Ph.D. candidate and researcher from the Massachusetts Institute of Technology, and a group of MIT engineers have modeled and priced "deeply decarbonized" electric systems that would make the global CO2 reductions both technically and economically viable.

"Electricity is the lynchpin in our efforts to decarbonize the economy," Jenkins said in his presentation at the Kleinman Center on February 1.

In a low-carbon future, cleanly generated electricity reduces the carbon footprint of light bulbs and TVs. Critically, however, clean electricity also "helps to decarbonize transportation, heating, and industry," says Jenkins. "Electricity demand may double as a result."

AN IDEAL MODEL

While modeling future low-carbon electric grids isn't new, Jenkins and his MIT colleagues' research stands out for its use of a detailed model that includes not only investments but also detailed engineering constraints that mimic how power systems operate. They also account for a wide range of uncertain assumptions about technology.

"In a 99% carbon-free electricity system the shares of wind and solar power decline, and nuclear or other low-carbon 'flexible base' resources dominate and totally displace natural gas," Jenkins said.

"Don't set a 100% renewable energy requirement. Instead, set 100% decarbonization as the goal. Invest in technologies needed for each of the key roles in the power system. Keep our options open."

–JESSE JENKINS

The nuclear power plants would be of the "variable" type currently operated in France, Germany, and Switzerland, which can raise or lower output in response to changing electricity demand.

Other flexible low-carbon resources could include geothermal and hydropower dams with large reservoirs. Gas and coal would only survive if paired with carbon capture and storage, which has yet to be proven economical.

VISITING SCHOLARS

During the academic year, we welcomed three visitors to our campus for collaborative weeklong residencies. Each scholar that comes to the Kleinman Center gives a public lecture, participates in our podcast, and publishes a policy digest.

FOR FULL BIOS, VISIT:
KLEINMANENERGY.UPENN.EDU/VISITING-SCHOLARS

JESSE JENKINS

Ph.D. Candidate, Massachusetts Institute of Technology

Invited and Hosted By: Kleinman Center

Jesse Jenkins is a Ph.D. candidate in engineering systems at MIT's Institute for Data Systems and Society and a researcher with the MIT Energy Initiative's Electric Power Systems Center. Jenkins harnesses optimization methods and empirical data to improve planning, operations, regulation, and policy in the rapidly evolving electricity sector. He focuses in particular on two important trends: the transition to zero-carbon power systems and the proliferation of distributed energy resources. Jenkins earned a M.S. in Technology and Policy at MIT in 2014 and previously directed the Energy and Climate Program at the Breakthrough Institute, a public policy think tank. He has published peer-reviewed papers in *Applied Energy*, *The Energy Journal*, *Economics of Energy and Environmental Policy*, *Energy Policy*, *Nuclear Technology*, and *WIREs: Climate Change*. He has delivered invited testimony before the United States Senate Committee on Energy and Natural Resources, and his research and writing has been featured in major media outlets including NPR, *The New York Times*, *The Wall Street Journal*, *The Washington Post*, and *Time Magazine*. Jenkins has received fellowships from the National Science Foundation, MIT Energy Initiative, and Martin Family Society of Fellows for Sustainability, and served for three years as co-president of MIT's Electricity Students Research Group.

PODCAST: ENVISIONING A LOW CARBON, LOWEST COST GRID

LECTURE: GETTING TO ZERO: PATHWAYS TO ZERO CARBON ELECTRICITY SYSTEMS

SEMINAR: ENERGY ECONOMICS & FINANCE SEMINAR

RADHIKA KHOSLA

Fellow, Centre for Policy Research in India

Invited and Hosted By: Center for the Advanced Study of India

Radhika Khosla is a fellow at the Centre for Policy Research in India. She works on the integrated nature of India's energy sector to examine the linkages between energy, development, and climate change, particularly in urban areas. She also focuses on the demand-side of Indian energy, with attention to the technological, institutional and behavioral aspects of energy use and its lock-in to a rapidly growing built environment. In addition, her work examines the analytic and strategic dimensions of India's energy and climate policies. Khosla is a visiting scholar at MIT's Energy Initiative and her other appointments include the India Fellow for the India Centre for Sustainable Development at the University of Oxford. She was the staff scientist with the Natural Resources Defense Council in New York, where she led research and implementation on building energy policies in Indian states. Khosla holds a Ph.D. in geophysical sciences from the University of Chicago and an undergraduate and master's degree in physics from the University of Oxford.

PODCAST: INDIA'S NOW OR NEVER CLIMATE OPPORTUNITY

LECTURE: UNPACKING INDIA'S ENERGY AND CARBON FUTURE

POLICY DIGEST: ENERGY DEMAND IN INDIAN RESIDENCES

ARI PESKOE

Director, Electricity Law Initiative, Harvard

Invited and Hosted By: Kleinman Center

Ari Peskoe is the director of the Electricity Law Initiative at Harvard Law School's Environmental and Energy Law Program. He has written extensively about electricity regulation, on issues ranging from electric vehicles to Constitutional challenges to states' energy laws. Prior to the Policy Initiative, Peskoe was an associate at a law firm in Washington, D.C. where he litigated before the Federal Energy Regulatory Commission about the Western Energy Crisis. Before that, he was a Peace Corps Volunteer in Ghana and spent two years trying to bring the 2012 Olympics to New York. He received his J.D. from Harvard Law School and graduated from the University of Pennsylvania with degrees in electrical engineering and business.

LECTURE: POWER OVER THE U.S. ELECTRIC GRID

POLICY DIGEST: POWER OVER THE TWENTY-FIRST CENTURY ELECTRIC GRID

PODCAST: DISTRIBUTED ENERGY'S WHOLESALE OPPORTUNITY

ADVISORY BOARD

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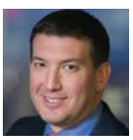
PAUL BONNEY

Paul Bonney is the senior vice president of legal and regulatory strategy for Pepco Holdings at Exelon Corporation.

MARK BROWNSTEIN

Mark Brownstein is the vice president and chief counsel of the U.S. Climate and Energy Program at the Environmental Defense Fund.



SCOTT KLEINMAN

Scott Kleinman is Co-President and Lead Partner for Private Equity at Apollo Global Management and founding donor of the Kleinman Center.

SONNY POPOWSKY

Sonny Popowsky served for more than two decades as the consumer advocate of Pennsylvania.

JOHN QUIGLEY

John Quigley is Lecturer in Sustainability and founding director of the Center for Environment, Energy & Economy at the Harrisburg University of Science and Technology.

MARVIN SCHLANGER

Marvin Schlanger is the former chairman of the Supervisory Board of LyondellBasell Industries N.V.

FREDERICK STEINER

Frederick Steiner is dean and Paley Professor of PennDesign at the University of Pennsylvania.

ADVISORY BOARD

WELCOME

We were pleased to grow our advisory board by adding two outstanding new members this year, Emily Duncan from National Grid and Lynn Scarlett from The Nature Conservancy.

EMILY DUNCAN

Director of Federal Relations, National Grid

Emily Duncan is a director of federal relations at National Grid, an electric and natural gas transmission and distribution utility with customers in Massachusetts, New York, and Rhode Island. Previously, she was director of government affairs and counsel at the Solar Energy Industries Association, the national trade association for the solar industry. Before joining SEIA, Duncan was an energy attorney at Winston & Strawn LLP in Washington, D.C., where she represented various utilities and development companies before the Federal Energy Regulatory Commission and the Nuclear Regulatory Commission. She graduated from the University of Pennsylvania and earned a law degree from Duke University.

LYNN SCARLETT

Co-Chief External Affairs Officer, The Nature Conservancy

Lynn Scarlett is the co-chief external affairs officer and climate strategy lead at The Nature Conservancy. She is the former deputy secretary and chief operating officer of the U.S. Department of the Interior. As deputy secretary, Scarlett initiated and chaired the department's Cooperative Conservation Working Group and its first-ever Climate Change Task Force. She chaired the nation's Wildland Fire Leadership Council. She served on the executive committee of the President's Management Council and co-chaired the First Lady's Preserve America Initiative. She is author or co-author of publications on climate change adaptation; ecosystem services; large landscape conservation; and science and decision-making. She received her bachelor's and master's degrees in political science from the University of California, Santa Barbara, where she also completed her Ph.D. coursework and exams in political science and political economy.

FELLOWS

SENIOR FELLOWS

FOR FULL BIOS, VISIT:
KLEINMANENERGY.UPENN.EDU/FELLOWS

KARL HAUSKER

New Fellow

Karl Hausker is a senior fellow in the climate program at the World Resources Institute. His research interests center around deep decarbonization.

MICHAEL LEVY

New Fellow

Michael Levy is an associate professor of epidemiology at Penn's Perelman School of Medicine. He works at the interface of epidemiology, climate change, and statistics to prevent the transmission of disease in changing environments.

WILLIAM HEDERMAN

William Hederman is an independent senior adviser at Deloitte and Touche, LLP and an executive adviser at Agile PQ, Inc. He was senior advisor to Secretary Ernest Moniz at the U.S. Department of Energy.

KENNETH KULAK

Kenneth Kulak is a partner at the law firm of Morgan Lewis where he advises clients on energy regulation and complex energy transactions. His clients include utilities, developers, investors, and cooperate energy users.

ANNA MIKULSKA

Anna Mikulska is a nonresident scholar in Energy Studies at Rice University's Baker Institute. Her research interests center around European energy markets and energy policy.

SCOTT MOORE

Scott Moore is a political scientist focused on environmental politics and policy reform, especially climate change and water resources. He was a Young Professional with the World Bank Group's Water Global Practice, and is now director of the Penn Project on the Future of China.

STEVE VISCELLI

Steve Viscelli is a lecturer in Penn's department of sociology. His research focuses on work, labor market economics, and economic regulation. He is currently working to improve fuel efficiency in the trucking industry.

FACULTY FELLOW

ARTHUR VAN BENTHEM

Arthur van Benthem is a professor of business economics and public policy at Wharton. Before his doctoral studies he worked as an energy economist at Royal Dutch Shell.

STAFF

WILLIAM COHEN

Center Coordinator

Bill oversees office needs, supervises public events, tracks our budget, and provides technical support across many platforms. When possible, he dives into design and research projects.

CORNELIA COLIJN

Deputy Director

Cory envisions, plans, and manages all center programming, while building connections with students, faculty, and leaders in the energy industry.

MARK ALAN HUGHES

Founding Faculty Director

Mark provides the vision and direction for all center activities while also leading several major research projects, including Decision-Making Under Deep Uncertainty.

ANGELA PACHON

Research Director

Angela manages our faculty grants program and develops scholarship and research collaborations across campus and beyond. She is also the author of many policy digests.

LINDSEY SAMAHON

Director of Communications

Lindsey manages all things communications. She helps direct the voice of the center, manages all digital and print media, prepares content for publication, and serves as press contact.

OSCAR SERPELL

Research Associate

Oscar is a researcher, writer, and data analyst. He is part of several key research projects and also writes blog posts and policy digests on timely energy policy topics.

CHRISTINA SIMEONE

Director of Policy and External Affairs

Christina interfaces with industry leaders to develop content and projects that are impactful and relevant. She is the author of many papers, digests, and blog posts.

MOLLIE SIMON

Administrative Assistant

Mollie oversees scheduling, assists with student grant programming, and supports communications and marketing. She also enjoys writing for our blog.

RESEARCH FELLOWS

DESHAUN BENNETT

Master of Education Policy and Public Administration, GSE & SAS

BRANDON BURKE

Master of Environmental Studies, SAS

JULIE UFFORD KEENAHAN

M.B.A., Wharton

SAMANTHA KLUG

M.B.A. and Master of Environmental Studies, Wharton & SAS

THOMAS LEE

*Electrical Engineering, SEAS**

THEODORA OKIRO

Master of Public Administration, SAS

**Thomas Lee graduated from Penn in the fall and now works as a quantitative research analyst for an investment management firm.*

PUBLICITY

Publicity grew this year with nearly a hundred media mentions—almost double the mentions earned last year. Our *Directory of Experts*, published and distributed in the fall, helped connect journalists with leading energy scholars at Penn.

***THE ATLANTIC*:**

"The truck port idea is great for a lot of reasons: Congestion, fuel economy, which brings in greens and transportation planners, even your average commuter is going to be thrilled to have 10,000 trucks out of L.A.'s 4 o'clock congestion."

–STEVE VISCELLI
SENIOR FELLOW, KLEINMAN CENTER

***FORBES*:**

"In terms of cost, shale gas has been a clear win for consumers."

–CHRISTINA SIMEONE
DIRECTOR OF POLICY AND EXTERNAL AFFAIRS, KLEINMAN CENTER

***U.S. NEWS & WORLD REPORT*:**

"China and the U.S. are basically taking different paths with respect to environmental protection. China has decided that it's actually really important both for its economic growth as well as for its political stability to do much more in terms of environmental protection and to ensure that its citizens have clean water, clean air."

–SCOTT MOORE
SENIOR FELLOW, KLEINMAN CENTER

***THE WALL STREET JOURNAL*:**

"If restrictions were imposed on LNG exports, only a few domestic manufacturers would gain a small advantage, while the broader benefits to the rest of the economy would be lost."

–ANNA MIKULSKA
SENIOR FELLOW, KLEINMAN CENTER

***WASHINGTON POST*:**

"There is a long tradition of bipartisan cooperation on the energy committee, often because the leaders from both parties are from producing states."

–WILLIAM HEDERMAN
SENIOR FELLOW, KLEINMAN CENTER

SOCIAL MEDIA

In August of 2017, we ramped up our social media efforts—building our presence on Twitter, Facebook, Instagram, and LinkedIn. We shared content and connected with groups and thought leaders. By the end of the year, our efforts paid off with exponential audience growth.

ABOUT

MISSION

Our mission is to create the conditions for policy innovation that support a just and efficient transition to sustainable energy.

VISION

Transition from an energy system with uncompensated external costs to one that optimizes energy productivity through smart demand, internalized impacts, and sustainable supply.

APPROACH

The Kleinman Center focuses on projects that:

- Foster thoughtful and impactful energy research
- Develop the next generation of energy leaders
- Create conditions for stakeholders to explore options and develop agendas

DONORS

The Kleinman Center's innovative and independent research and teaching is made possible through the generous support of our donors.

SCOTT KLEINMAN

Co-President & Lead Partner, Private Equity, Apollo Global Management, LLC

The Kleinman Center for Energy Policy was established in July 2014 with a generous $10 million gift to University of Pennsylvania's School of Design from Scott (C'94, W'94) and Wendy Kleinman.

CARL GOLDSMITH

Founding Partner, Co-CEO and Co-CIO, Beach Point Capital Management

In 2017, Carl Goldsmith (W'88) established the Goldsmith Research Fund. This unrestricted gift helps support our center's independent research agenda.

STEVEN LEFKOWITZ

Founding Partner, Sagewind Capital LLC

In 2018, a generous gift from Steven and Clarissa Lefkowitz opened our endowment fund. The endowment fund helps ensure long-term support for a wide range of activities, including: student programming, faculty research, and decision-maker support.

Kleinman Center for Energy Policy

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