Wharton University of Pennsylvania RISK MANAGEMENT AND DECISION PROCESSES CENTER

Kleinman Center for Energy Policy

PENN PROGRAM ON REGULATION

Penn University of Pennsylvania FACULTY SENATE

CLIMATE RISK SOLUTIONS

30 Innovative Ideas from across the University of Pennsylvania

October 2019

TABLE OF CONTENTS

FOREWORD

The Intergovernmental Panel on Climate Change, synthesizing scientific consensus, warned last year that to avoid high risk of widespread disasters, an unprecedented and highly rapid transition to a carbon-free economy is required. The necessary shift will have economic and distributional impacts at a global scale, both within and across countries. Even if society achieves this ambitious goal, emissions from past decades will persist in the atmosphere causing continued physical risks to households, communities, and businesses in the near future and coming decades.

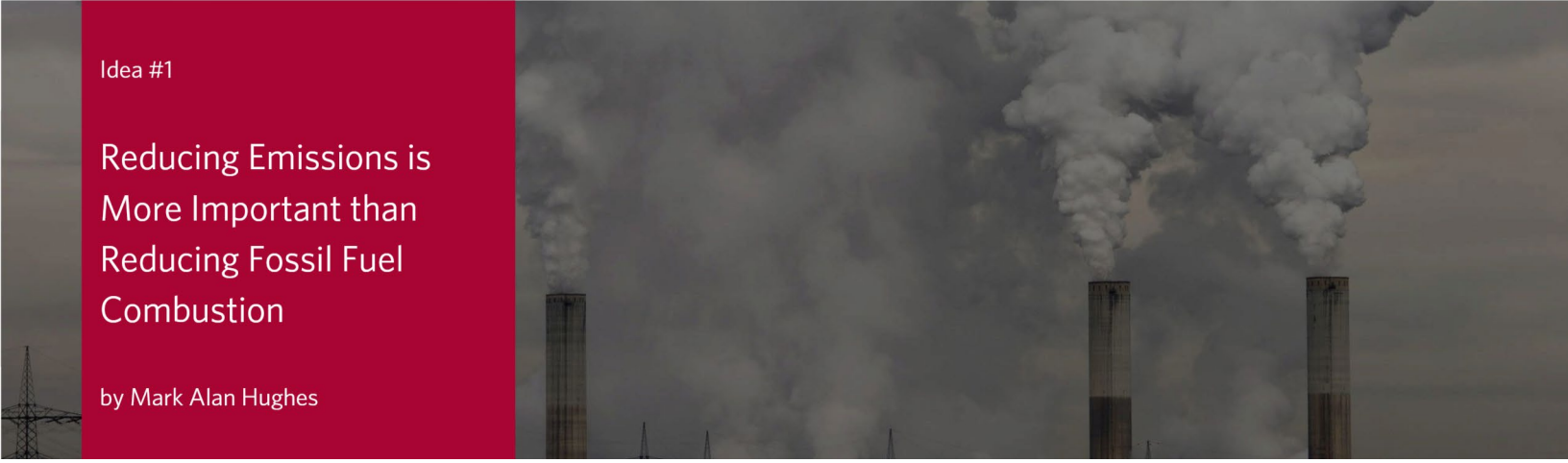
Over the Summer of 2019, the Wharton Risk Management and Decision Processes Center, the Kleinman Center for Energy Policy, the Penn Program on Regulation, and the Faculty Senate at the University of Pennsylvania hosted a virtual ideation session to generate new policy-relevant and solution-oriented ideas for tackling one or more of three interrelated types of climate risk:

- **Mitigation**: How do we reduce emissions rapidly to minimize the risks of catastrophic shifts in earth systems?
- **Adaptation:** How do we reduce the risks of physical climate impacts to households, communities, and businesses?
- **Transition**: How do we minimize the transition risks for businesses and communities as we shift to a carbon-free economy in the face of uncertainty?

Over the summer, researchers across the University of Pennsylvania proposed a total of 30 solutions to climate risks. These solutions are compiled here. Researchers from across multiple schools, departments, and research centers at the university are represented, highlighting the interdisciplinary nature of this project.

Although the challenge of addressing climate change can be daunting, with risks of potentially costly impacts affecting all sectors of the economy, the solutions proposed here showcase that this can also provide a source of optimism: solutions are possible everywhere. The solutions span the local to the global, the household to the federal government. Together, they demonstrate that anyone can begin improving climate risk management wherever they are located.

We are pleased to present these solutions that translate academic research into policy-relevant and accessible findings that address one of the most consequential challenges of our era. We hope this collection inspires both more solutions and more interdisciplinary collaborations.



Idea #1

Reducing Emissions is More Important than Reducing Fossil Fuel Combustion

by Mark Alan Hughes

Many people in the United States see reducing (as much as possible, and preferably to zero) the use of fossil fuels to be an intrinsically necessary means to mitigating climate change. But this chain of reasoning omits several links, and by doing so can be misleading and a barrier to democratic consensus among various policy options. A fuller representation of the chain goes like this:

The extraction, processing, delivery, and combustion of fossil fuels emit greenhouse gases (GHG) into the atmosphere, which in turn raises Earth's global mean temperature over time (at a possibly accelerating rate), which in turn has essentially permanent (in human terms) impacts on ecosystems that produce our food and provide our inhabitable settlements. Being able to survive on Earth with food and shelter, and hopefully with much of our civilization intact and capable of future progress, is our ultimate goal.

Limiting the extraction and use of fossil fuels is not intrinsically necessary. It is only an instrumental means to stop adding more GHGs into the atmosphere. This is a crucial point. The instrumental means that matters more to our ultimate goal of surviving on Earth is that we stop adding more GHGs into the atmosphere. Here's why.

According to the Global Carbon Project, the world in 2018 added a record-high 37.1 billion metric tonnes of CO2 from the use of fossil fuels. That helped drive the total concentration of CO2 in the atmosphere to another record-high level of 407 parts per million, which is 45 percent higher than the levels when the use of fossil fuels began the Industrial Revolution.

The insufficiency of reducing fossil fuel combustion as a means of reducing emissions was first established by the IPCC AR5 in 2013. The report presented 116 scenarios for reducing emissions at a rate consistent with meeting the 2C degree target, and 101 of them require some form of negative emission technology. Once negative emissions were established as necessary, the importance of reducing fossil fuel combustion became simply a function of how efficiently these negative emissions technologies could remove new emissions. In sum, reducing emissions is the key instrumental goal, not necessarily reducing fossil fuel combustion.

Negative emissions technologies, otherwise known as carbon removal, consist of configurations of technologies, business models, and regulatory frameworks that (1) capture CO2 at either a point source such as a smokestack or directly from the air, (2) isolate that captured CO2 from being released into the atmosphere either through a chemical transformation or by burying it in either geological or constructed formations, and/or (3) utilize the CO2 in other products or processes.

In theory, these technologies need not place any limit on burning fossil fuels. The emissions would be mitigated by the strategies to the degree that they perform as designed. Proving that performance is a critical issue, but that turns this into an instrumental debate about the costs and benefits of achieving a just and efficient reduction in GHGs into the atmosphere.

And in an ironic twist, progress on carbon removal will benefit from (indeed, is likely to require) a policy of internalizing the external costs of carbon-based fuels, either through a carbon tax or mandatory caps. Carbon removal is a kind of remediation mechanism that fossil energy companies could use to pay for compliance costs under climate change mitigation policy.

It may seem at odds with the ultimate goal of surviving on Earth, but policy solutions like geo-engineering and carbon removal that leverage policy mechanisms like a carbon tax to reduce GHG emissions while simultaneously increasing combustion of fossil fuels may well provide the most just and efficient pathway to achieving that goal, especially when coupled with goals such as ending global energy poverty and other UN Sustainable Development Goals.

For example, the Unites States has an enormous and growing natural gas infrastructure that delivers affordable and reliable energy and will always do so by adding GHG emissions into the atmosphere. Today, there is a "yes or no" debate over that asset, rather than an "under what conditions" debate, including the condition that all emissions from combustion be removed. An "under what conditions" debate is the only way to find the most just and efficient paths to meeting our goals. Justly and efficiently reducing emissions, not reducing fossil fuels, is the proper measure of that debate.

Mark Alan Hughes is a Professor of Practice at the Stuart Weitzman School of Design and the founding faculty director of the Kleinman Center for Energy Policy.

Idea #2

The Very Effective Carbon Tax and its Political Hurdles

by Ioana Marinescu

Economists conventionally describe carbon taxes as the most efficient policy tool for curbing greenhouse emissions —with the added benefit of raising government revenue. The carbon tax is particularly effective because it raises the cost of carbon pollution, which incentivizes lower carbon emissions, as well as innovation to lower emissions in the longer run. Furthermore, unlike regulation that simply caps emissions for everybody, a carbon tax is more flexible and therefore more cost-effective: those economic agents who can reduce emissions at lower cost reduce them more, while those who face higher costs of reducing emissions can continue their activities with more limited emissions reduction.

While it has long been economists' pet policy, the carbon tax has also recently gained popularity among Americans: 50% of Americans in a 2016 survey say they support reducing greenhouse gas emissions by taxing carbon-based fuels, while 72% of Americans in a 2019 survey say they support requiring fossil fuel companies to pay a carbon tax .

Yet, despite the support of economists as well as the general public, the United States has yet to adopt a comprehensive carbon tax. In a recent working paper co-authored with Soren Anderson and Boris Shor, we use the first state-level carbon tax initiative in the US to shed light on the political obstacles to the carbon tax and pave the way forward for adoption.

In 2016, Washington State had on the ballot the first state-level carbon tax in the US (I-732). It lost with 40.8% of voters saying yes. In 2018, Washington state had a new ballot initiative (I-1631), similar to the first one but designed to appeal more to liberals. It lost again, albeit with a slightly higher vote share at 43.4%. We draw a number of lessons from analyzing these defeats.

First, ideology is the most important determinant of the carbon tax vote. Democrats are more likely to vote for a carbon tax, and a finer measure of ideology can predict votes even better. In comparison, pocketbook issues do not explain much of the difference between voters: whatever their ideology, everybody similarly dislikes the energy price increases entailed by the carbon tax. Ideology is what makes the difference in voters' choice: a liberal ideology can more than compensate for energy price increases.

Given that ideology is so important, for a carbon tax to pass, it must be carefully tailored to appeal to the majority of a constituency's ideology. In particular, spending the revenue of the carbon tax to

lower taxes appeals more to conservatives, while spending the revenue on green projects appeals more to liberals.

But ideology is not everything: political campaigns also matter. Washington state's experience suggests that an effective "no" campaign can torpedo an initially popular carbon tax. In particular, the "no" campaign spent twice as much as the "yes" campaign: $32 million vs. $16 million. One month before the election, an Elway poll of registered voters showed 50% support, but on election day I-1631 lost with only 43.4% "yes" votes. Therefore, for a carbon tax to pass, campaigns must be carefully planned and well financed. The recent creation of the Americans for Carbon Dividend political action committee is one avenue for financing campaigns for the carbon tax.

Finally, age matters: younger people are more supportive of a carbon tax than older people. Therefore, mobilizing young people may facilitate the passage of a carbon tax. In the longer run, as new generations replace older ones, support for the carbon tax may grow, just as support for gay rights has been growing among younger generations.

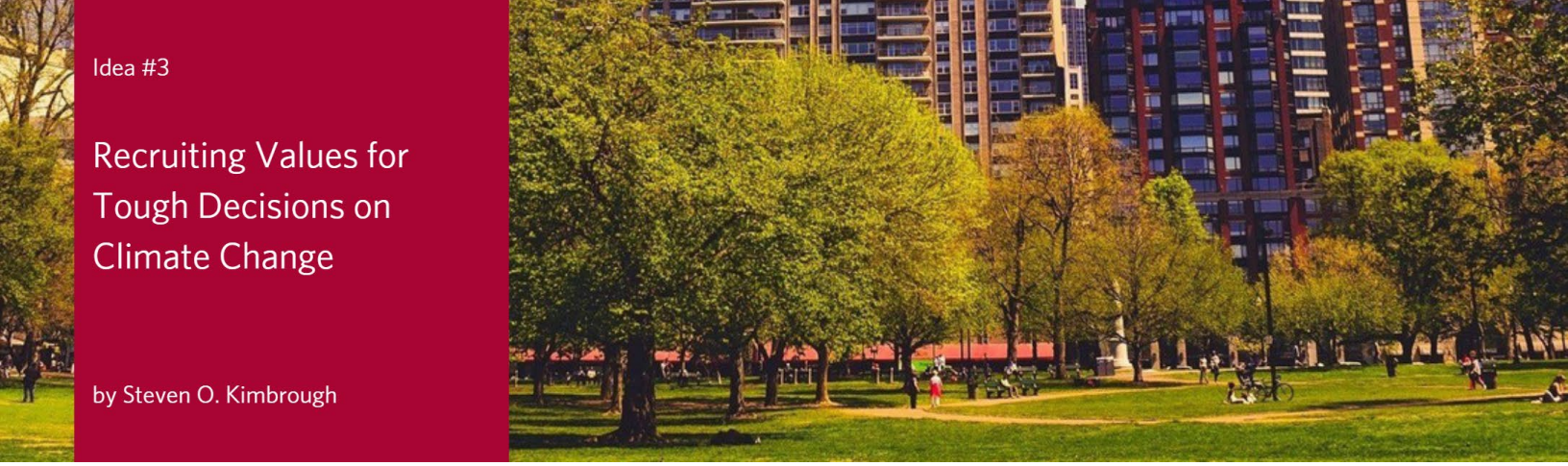
Overall, the carbon tax is a very effective tool to reduce carbon emissions at lowest cost. However, it faces significant political hurdles, which may be overcome by careful ideological positioning and vigorous campaign spending.

Ioana E. Marinescu is Assistant Professor in the School of Social Policy and Practice and Faculty Research Fellow at the National Bureau of Economic Research.

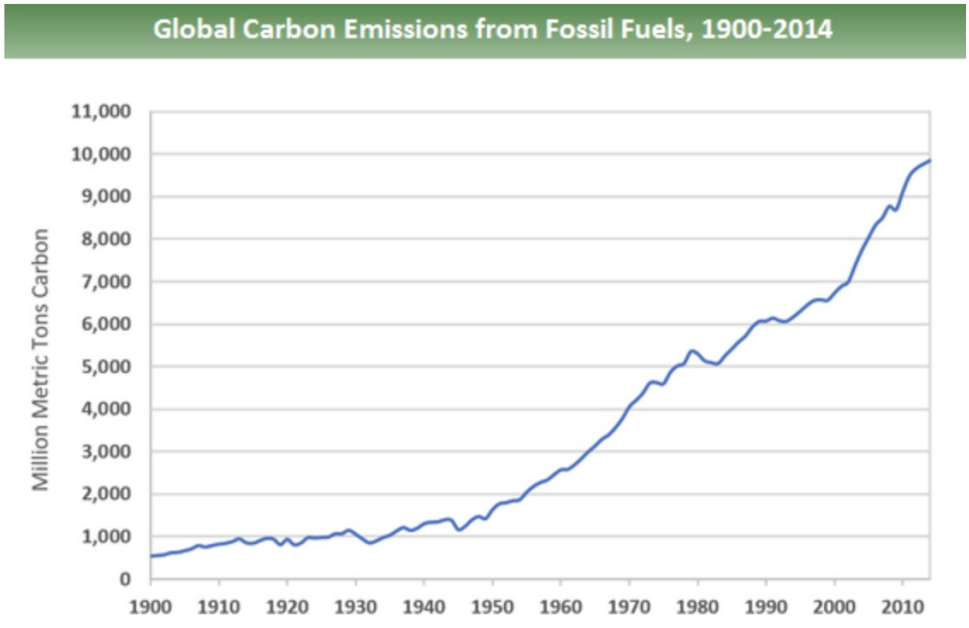
Idea #3

Recruiting Values for Tough Decisions on Climate Change

by Steven O. Kimbrough



Despite plummeting costs for–and rapidly growing adoption of—renewable energy in the form of wind and solar and battery storage, world-wide greenhouse gas (GHG) emissions continue to increase (see Figure 1 and "Greenhouse Gas Emissions Accelerate Like a 'Speeding Freight Train' in 2018"). Net GHG emissions are growing despite an onrush of renewable generation coming on line. Deep reductions in GHG emissions are urgently needed in order to avoid profoundly costly, disruptive, and indeed dangerous climate change. Low-carbon transitions across electricity, transport, heat, industrial, forestry, and agricultural systems are necessary (see here, here, here, here, and here). As the U.N. Secretary General António Guterres has said in this context, "The status quo is a suicide."



Source: Boden, T.A., Marland, G., and Andres, R.J. (2017). Global, Regional, and National Fossil-Fuel CO2Emissions. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tenn., U.S.A. doi 10.3334/CDIAC/00001_V2017.

Figure 1: From US EPA

These facts are well established and well known. The problem is what to do about them. That problem is complicated by the fact that action on climate change is often presented—accurately—as costly and difficult, but necessary. The following passage is typical:

Devising ways to sustain the earth's ability to support diverse life, including a reasonable quality of life for humans, involves making tough decisions under uncertainty, complexity, and substantial biophysical constraints as well as conflicting human values and interests (Dietz et al., 2003).

This "tough decisions" message, truthful as it is, is in fact a message that many people will not be receptive to, simply because it is tough. Lamentable as this may be, the brute fact is that change will happen faster the more people there are who see an immediate and direct benefit to themselves.

There are things that can be done, including behavioral interventions that circumvent biases and irrationality, effective framing, and research aimed at understanding human decision making. All of this is well and good, and should be vigorously pursued. My purpose here is to draw attention to different approach, one that is entirely complementary.

Consider the following passage appearing in a recent op-ed piece in the *Philadelphia Inquirer*. The author is discussing a proposal for handling storm water, which proposal she claims:

…creates community green space, revitalizes vacant lots, enhances recreational use, and even reduces illegal drug use in public spaces. It can reduce heat stress and energy use while improving air quality and contributing to climate change resiliency. And …can stabilize property values and reduce poverty through job creation.

In all, as we can see, she recruits ten values (create community green space; …; reduce poverty through job creation) that she adduces in favor of her proposed policy.

The proposal advocated by Jacquelyn Bonomo in the *Inquirer* piece is presumably not the cheapest—not the best on direct, immediate costs—of the proposals under consideration. Were it otherwise, she would have argued directly for it on the basis of cost. Instead, she appeals to other values to compensate for comparative weakness on the cost value.

Bonomo's strategy is entirely legitimate, and in fact is routinely and widely used. We may describe it as *recruiting values beyond the narrowly economic* to support a policy position. Much of what makes complex problems complex is that multiple values are in play. Climate change is a case in point. Here and in general, normatively proper decision making requires that all pertinent values associated with a decision be identified and considered in the deliberation for decision making.

The observation I would to make, the impetus for this blog post, is that recruitment of values beyond the narrowly economic has not been done thoroughly and systematically enough on

matters pertaining to the necessary transitions mandated by climate change. There is opportunity for the climate change community to do better. Proposers (Bonomo is an apt example) today must, on a case by case basis, identify and assess the wide range of values associated with policy initiatives.

Imagine instead that an organized, curated, maintained, and accessible body of information on recruitable values were available to help every Jacquelyn Bonomo making a policy proposal for climate change transitions. We might call this tool a *climate change values repository*.

Note that many, perhaps all, of the ten values Bonomo cites as favoring her proposal (above) are relevant to other transition issues. Knowledge assembled about one value—its benefits, its costs, its main characteristics—can be leveraged in multiple ways and on multiple issues.

Such a tool would bid fair to speed the development of transition policy proposals, and strengthen them in the process. It would also speed the identification of weaker ideas, serving to focus attention on more promising ideas. It could help to assemble policy bundles that would be broadly attractive. Log rolling is an essential, legitimate feature of compromise and accommodation of diverse interests. Also, because the values in play for climate change are wide-ranging, assembling a climate change values repository will serve to draw in and involve a correspondingly wide-ranging collection of people, skills, and interests.

Most important of all, the values recruitment approach, and any tool to support it, would afford ways of reaching people for whom the tough decisions messaging fails to convince. By systematically and thoroughly recruiting values beyond the narrowly economic and beyond a narrow focus on the primary targets of climate change transitions (for example, reducing GHG emissions), we can hope to find values and benefits that make tough decisions easier and even attractive for a wider circle of people.

Steven O. Kimbrough is Professor of Operations, Information and Decisions at the Wharton School.

Idea #4

How Congress Might Address Climate Change: Two Lessons from Past Practice

by Jean Galbraith

To reduce greenhouse gas emissions, we must harness democracy. The United States needs more elected officials who are committed to mitigating climate change.

But once that happens – then what? How might Congress legislate with respect to climate mitigation? All ambitious attempts at climate legislation have failed to date, and indeed there has been no major legislation from Congress relating to air pollution since the Clean Air Act Amendments of 1990.

Here are two lessons for Congress to keep in mind, once political conditions make climate legislation more feasible. Both are drawn from thinking about legal design and its past interactions with climate.

Lesson 1: Pursue Many Paths to Climate Legislation Rather Than Aiming Exclusively for a Single Big Win

Internationally, the world poured decades of effort into achieving a major climate treaty under the auspices of the UNFCCC. Yet over this same time period, the thinking of activists shifted from single-mindedly focusing on a major treaty to trying to achieve climate mitigation across and within every possible organizational forum. The sought-after major treaty was finally achieved in Paris, but the ultimate success of climate mitigation will depend not only on the Paris Agreement but also on all kinds of other international agreements – bilateral arrangements, coalitions of states and cities, the recent amendments to the Montreal Protocol, and so much more.

There is a lesson here for Congress. There is an instinct to center efforts around grand legislation, such as a carbon tax, cap-and-trade program, or a Green New Deal. This isn't an impossible dream. But history shows that it will be a hard one to achieve, especially if the filibuster remains in the Senate. Activists should pursue the dream – but also pursue action on other fronts. There is now creative thinking about how climate might be addressed through Congress's reconciliation process, which bypasses the filibuster.

In addition to this, activists should be trying to get the strongest possible climate-related provisions into more general legislation, such as trade agreements and the annual National Defense Authorization Act (NDAA).

Trade agreements signed before July of 2021 will receive an up-or-down vote from Congress, without the risk of death in committee or a filibuster. A progressive administration moving quickly on a trade agreement could build strong climate-related commitments into it – commitments that would bind the United States and the country or countries with whom it is making the agreement.

The NDAA goes through Congress's ordinary legislative procedures and is subject to the filibuster. But its status as a "must pass" annual bill makes it a place where law really does get made. Even in 2018 – a time when Republicans controlled both Houses and the Presidency – the NDAA managed to include some notable climate-related provisions. A lot more could be done through it, and through other authorization acts as well.

Lesson 2: Legislate to Protect Progressive State and Local Governments

A more progressive Congress and President will hopefully lead to strong climate-related laws and regulations. But another lesson from history is that these progressive actors will be replaced in two, four, six, or eight years by less progressive ones. The cyclicality of U.S. politics at the national level has brought home the importance of climate mitigation by state and local governments. One of the most important things that a progressive Congress could do is thus to legislate in support of state and local governments seeking to go above a federal floor in their climate mitigation policies. Here are a few suggestions for what such protections could look like:

- Congress could specify in legislation that federal law on climate is a floor rather than a ceiling. Some pre-existing environmental laws have provisions along these lines, such as a provision in the Clean Air Act permitting California to set vehicle emissions standards that are higher than the federal floor as long as it gets a waiver from the executive branch permitting it to do so. Instead of requiring an executive branch waiver, the climate law could be structured to omit such executive branch supervision entirely or to require that, in order to stop a state from exceeding the federal floor, the executive branch must prevail in court and prove certain specified statutory criteria.

- Congress could try to craft legislation that protects progressive local governments from state governments. In many states, populous cities are more progressive on climate than are the state legislatures. Congress cannot directly ban state legislatures from setting limits on their localities (because of a constitutional principle known as anti-commandeering). But Congress would be on stronger (though not ironclad) constitutional grounds if it legislated to say that local governments have the option of taking certain climate-protective steps "notwithstanding any provision of state law".

- Congress could provide a blessing in general terms for state and local governments to enter into agreements with foreign counterparts with respect to climate mitigation. States and local governments are currently making these agreements anyway. But in order to ward off

any lingering concerns about the constitutionality of these agreements under the Constitution's Compact Clause, a congressional signal of support for these endeavors would be valuable.

By taking such steps, a progressive Congress would increase the likelihood that climate mitigation actions will continue regardless of national political changes.

Jean Galbraith is Professor of Law at the University of Pennsylvania Law School.

Idea #5

Addressing Climate Change in an Era of Denial

by Howard Kunreuther and Bob Meyer

Sixty-seven percent of people around the world believe global climate change is a major threat to their nation according to a Pew Research Center survey conducted among 27,612 respondents in the summer of 2018. In fact, it's seen as the top threat in 13 of the 26 surveyed countries, more than any other issue the survey asked about. According to the survey, 59% of respondents from the United States view climate change as posing a serious concern. Yet there has been little action taken at the federal level to address this issue. Nevertheless, there are ways that state and local governments can take effective steps to address the risks posed by climate change.

In our recent book, *The Ostrich Paradox: Why We Underprepare for Disasters,* we sketch out how this can be accomplished. The key, we suggest, is to design "psychologically smart" policies through a behavioral risk audit without constraining freedom of economic choice. The policies are thereby more likely to achieve widespread support among conservatives and liberals alike.

Although there may be many reasons why people are reluctant to support adaptation measures for reducing future losses from natural disasters exacerbated by climate change, we suggest that these reasons can be distilled down to a series of six psychological biases that we all share. They are: (1) *myopia* (we focus on short time horizons); (2) *amnesia* (the tendency to forget too quickly the lessons of recent disasters such as Hurricane Sandy); (3) *optimism* (if scientists say that the world could warm anywhere from 1 degree to 5 degrees over the next fifty years, our instinct is to focus on the 1 degree scenario); (4) *inertia* (a tendency to do nothing if we are unsure of the best action to take); (5) *simplification* (the tendency to selectively attend to a subset of relevant factors when taking or not making choices); and (6) *herding* (when in doubt, imitate what others do).

Once we have a handle on these six biases, we can design a playbook that can nudge people toward cost-effective adaptive behavior *without* requiring that their fundamental attitudes toward climate change be changed. As an example, consider the bias of inertia—the tendency to look for easy ways out of difficult choices by choosing the "status quo" option. Choices that will protect us against climate impacts tend to be the ones that require greater mental and economic effort; it is time consuming and costly to install water recycling systems in the face of drought risk, buy flood insurance to protect against increasing flood damages, or install solar panels to reduce greenhouse gas emissions and the consequences from climate change.

But there is an easy way for this cognitive liability to become a cognitive asset: turn the tables such that it is the *sustainable or safer choice that is the status quo*, not the opposite as is almost always the case. For example, even conservatives are likely to support legislation that requires water recycling systems be a default component of any new home design—but one that potential buyers could elect to opt out of if they so choose. Such a policy would not limit economic freedom of choice. The major difference is that the burden of thinking is now shifted from whether one wants to opt-into adopting a measure to whether one wants to opt-out of a measure already in place—a change that would likely greatly enhance rates of adoption.

Myopia is another reason people have a hard time seeing the benefits of protecting against the future effects of climate change. Our tendency to consider only short future time horizons when making decisions often precludes people who live in hurricane-prone areas from making investments that would make their homes more resilient to wind and flood. An easy fix: provide long-term loans to property owners that spread the cost of adaptation measures over the life of their mortgages. This does not change the cost of the improvements, but makes a decision less psychologically difficult and more economically feasible, particularly if it leads to a reduction in the homeowner's insurance premium given lower expected claims payments. Existing programs to encourage widespread adoption of renewable energy might serve as a model for loans for reducing future disaster losses. For example, to encourage investments in renewable energy to reduce carbon emissions, some companies are paying the upfront costs of installing solar panels on homes and recouping the cost with a loan tied to the mortgage. The savings in electricity costs are normally greater than the loan costs in many areas of the country.

We concede of course, that while psychological nudges such as these can help, they are no substitute for forceful legislation such as regulations and standards designed to protect property (e.g. well-enforced building codes) and our environment (e.g. land-use restrictions). Ultimately, we have to hope that our leaders will learn to see the wisdom of distant foresight to preserve our environment for future generations.

Howard Kunreuther is James G. Dinan Professor Emeritus of in the Operations, Information and Decisions Department at the Wharton School and Co-Director of the Wharton Risk Management and Decision Processes Center.

Robert Meyer is the Frederick H. Ecker/MetLife Insurance Professor of Marketing at the Wharton School and Co-Director of the Wharton Risk Management and Decision Processes Center.

Idea #6

Can the Federal Mortgage Finance System Help Manage Climate Risk?

by Benjamin J. Keys

As climate change has increased both the frequency and severity of storms and hurricanes, and forecasts of sea level rise have become more urgent, property owners and those who provide credit to develop and invest in physical structures should be aware of the risks they face. Fannie Mae, Freddie Mac, and the FHA/VA mortgage lending programs make up the majority of the current mortgage landscape, and likely face dramatic exposure to climate-induced losses on the long-term (frequently 30-year) mortgages they insure. While these agencies bear climate risk, they are currently doing little to manage three climate-related risks to property: (1) acute storm events, (2) declining values from diminished access due to nuisance flooding, and (3) gradual inundation from sea level rise.

Instead, the burden of managing climate risk in the federal government has fallen disproportionately on the National Flood Insurance Program (NFIP), a program originally motivated by controlling floodplain use. Unfortunately, the NFIP is heavily in debt because of outdated flood maps, insufficient premiums for the riskiest areas, and problematic incentives to rebuild and re-insure in the most flood-prone areas. An alternative approach that broadens the management of climate risk to the federal mortgage finance system could alleviate some of the most problematic pressures on the NFIP, encourage physical adaptation, and foster managed retreat along America's most vulnerable coastlines.

The U.S. mortgage finance system is unique among developed countries in the direct involvement of the government in the mortgage market, especially with Fannie Mae and Freddie Mac likely to remain in conservatorship for the foreseeable future. Mortgage-backed securities insured by the Federal Government (so-called "Agency MBS") through Fannie Mae, Freddie Mac, or FHA/VA programs account for over 60 percent of the outstanding residential mortgage debt in the U.S., totaling $6.7 trillion.

This remarkable degree of exposure to residential property markets should spur action on climate risk from these large public mortgage insurers. Although disaster-related losses have not yet been significant for these agencies, loans in areas affected by hurricanes have greatly elevated delinquency rates well after the storms have passed, and climate-related risks are likely to rise sharply over the next 30 years. And yet, there has been relatively little public action on the part of the Federal Housing Finance Agency (FHFA), which oversees Fannie and Freddie, or the FHA/VA lending programs, to formally study their exposure to storm surges, increased nuisance flooding,

and eventually permanent sea level rise. Both the NFIP and the government mortgage market bear the risks of climate change, but the large mortgage entities have thus far not addressed and acknowledged the degree of their exposure, or taken steps to accurately price and manage the risks of climate-related disasters.

A thorough investigation of risk exposure to climate change would in all likelihood indicate that these government agencies are actively insuring mortgages in every coastal neighborhood in the U.S., but not differentially pricing heightened flood risk in these communities. Interest rates for loans backed by these agencies generally vary by the size of the down payment and a borrower's credit score, but very little else. The decision not to price flood risk by Fannie and Freddie is a political choice, and one that may not persist in our current political landscape.

In earlier research (Hurst et al. 2016), my co-authors and I found that Fannie Mae and Freddie Mac fail to price foreseeable regional default risk, such as that stemming from falling house prices or rising unemployment, which are to some degree predictable from year to year. We interpreted these results as suggestive of political barriers to regional risk-based pricing. However, our current political coalitions are unlikely to continue to support subsidizing building and re-building in exposed areas. In addition, the underwriting and lending decisions of Fannie Mae and Freddie Mac can be altered through its powerful regulator in conservatorship, the FHFA, rather than requiring the passage of legislation.

Another potential tool at the disposal of federal mortgage-insuring agencies is to further enforce the NFIP's mandatory insurance purchase requirement. This rule mandates flood insurance for properties located in flood-prone areas if a mortgage on the property is made or held by federally-regulated lending institutions or guaranteed by federal agencies, including Fannie Mae and Freddie Mac. However, the degree of compliance with the mandate is little studied, and reviews of take-up rates suggest that it is not universal. By further enforcing compliance, and ideally linking flood insurance policy data to mortgage data, these agencies can help reduce adverse selection among the pool of insured properties while moving flood risk out of the mortgage system.

Accurately pricing loans' regional climate risk at a local level, using the most sophisticated statistical models available, would sharply increase the cost of borrowing in many coastal communities. These rising mortgage costs would wisely promote managed retreat by steering lending and development away from the most exposed coasts. Furthermore, by offering discounted rates for properties that are elevated, or meet certain construction standards, the federal mortgage agencies can provide incentives to make remaining structures more durable and communities more resilient.

Fannie Mae and Freddie Mac are also central to the financing of multifamily housing development. Both agencies provide crucial mortgage support to the affordable housing space, and

could use their influence in multifamily development and financing to direct investment and development away from at-risk areas that the NFIP does not sufficiently deter. The multifamily mortgage underwriting of these federal agencies can help private developers navigate away from the riskiest low-lying areas and promote affordability in a climate-conscious way.

In sum, the public obligation to address climate change at the federal level can be uniquely addressed through the governmental mortgage market. Mortgage pricing can reflect true expected losses, and incentives to repeatedly rebuild in the riskiest areas should be mitigated, amplifying the broader risk management mandate of the NFIP. The burdens of climate risk would fall more directly on those property owners willing to bear it, which will encourage adaptation and retreat. While there will undoubtedly be issues related to rising mortgage costs for at-risk communities if federal mortgage insurers adopt risk-based pricing, many of these communities need to actively address the risks of climate change sooner rather than later. These risks are instead being borne by the federal government and the American taxpayer. By pricing regional climate-related risk, the federal mortgage finance system could initiate the difficult discussions related to choices coastal communities face regarding adaptation and retreat.

Benjamin J. Keys is Associate Professor of Real Estate at the Wharton School.

Idea #7

Plant Trees Strategically and Wisely

by Frederick Steiner

Design is how we articulate and visualize different possibilities for our future. Design can address mitigation, adaption, and transition in response to climate change. All three require that we follow Ian McHarg's advice and "design with nature." The Kentucky poet Wendell Berry tweeted about the power of nature on June 1, 2019: "Nature is a party to all our deals and decisions, and she has more votes, a longer memory, and a sterner sense of justice that we do." We have designed against nature for too long.

To design with nature requires ecological literacy. We need to know how to read landscapes and to act on that knowledge. Ecological knowledge is what we can learn from our interactions with the natural and cultural worlds around us. The ecosystem services concept can help us understand the values we derive from nature and then to mitigate, adapt, and transition with the changing climate. These services account for the direct and indirect contributions of the natural world to human well-being.

The Green Business Certification Inc.'s SITES rating system is grounded in ecosystem services and should prove especially helpful in adapting built outdoor environments to change. The system enables designers to rate how different environmental elements – soil, water, and plants – are employed in the planning for a park, a campus, an office complex, a waterfront, a parking lot, or a cemetery. The SITES system addresses almost anything outside beyond the building envelope. Such places can be designed to contribute to ecosystem services, conserve energy, and reduce greenhouse gas production. SITES can be employed on projects with or without buildings.

Chazdon and Brancalion (2019) have identified an urgent need to replenish tree canopy cover to avoid the devastating effects of climate change. In a recent *Science* article, Bastin and colleagues (2019) note that tree restoration is among the most effective strategies for climate change mitigation. Trees alone can do much to mitigate climate change, especially in temperate regions and SITES provides guidance about how to use trees and other vegetation. Trees help reduce stormwater runoff, improve water and air quality, and absorb atmospheric carbon. Through absorbing carbon, trees lower greenhouse gases that contribute to global warming. Shade from trees cool areas, making them more pleasant, and minimizing urban heat islands. In addition, tree shading can help lower energy use in buildings. To take advantage of shade, the vegetation needs to be planted strategically. Trees are especially effective when designed to cast shadows on air conditioners, windows, and/or walls. Furthermore, their location on the side of the building

receiving the most solar exposure can be useful. Rows of trees and shrubs can be deployed as windbreaks to improve the microclimate in some places.

With the SITES rating system, the emphasis is on conservation of plants as well as special status and native vegetation. Through the use of this system, site plans need to optimize biomass, reduce urban heat island effects, and minimize building energy use. For trees to flourish, they need good soil, ample water, and sunlight. SITES provides practical guidance about how to design these elements together. In addition to what we gain, other species benefit from vegetation as well. Through the use of the SITES system, the design team accumulates points for positive actions with plants.

Meanwhile, we should be aware that the trees, especially in tropical flooded areas, are a source of methane . Generally, trees store more carbon than the methane they emit. Overall, trees are generally good for the climate and have many other positive benefits. In addition, trees in temperate regions produce less methane then their counterparts in the tropics. As a result, we need different planting strategies for temperate and tropical regions. SITES, for example, was developed for temperate region site design. It should be redesigned for the tropics or a new system conceived entirely.

Designing with nature, including planting trees strategically and wisely, can help mitigate the effects of climate change as well as adapt to those fluctuations. More ambitiously, if we can apply ecological knowledge to all our designs and plans, we can transition to a future free from the deleterious consequences of climate change.

Frederick "Fritz" Steiner is Dean and Paley Professor at the University of Pennsylvania Stuart Weitzman School of Design.

Idea #8

Think Globally, Act Locally… Think Globally Again

by Anna Mikulska

The “think globally, act locally” slogan has been an integral part of climate action. It embodies the idea that instead of waiting for grand breakthroughs to “fix the world,” we should implement environmentally conscious solutions into everyday decisions and actions. Though on their own of negligible impact, in aggregate, these can have a globally transformative effect.

The idea is straightforward and seemingly easy to adopt. However, it also runs the risk of oversimplification if one assumes that the environmentally focused actions occur in a vacuum, i.e. when we don’t consider unintended consequences and trade-offs.

Take coal for example. Though its use in the developed world is on the decline, the level of demand for this fuel is expected to remain stable over the next two decades as the developing world picks up the slack (for a detailed discussion see here). In fact, by depressing prices, decreases in the demand for coal in the developed world could even give additional impetus for coal use elsewhere—making it more competitive against other, cleaner energy sources like natural gas or renewables.

Similarly, an increase in electric vehicle (EV) use could send the prices of crude down, fueling (so to speak) the appetite for oil either in other countries or outside of the transportation sector, i.e. in the petrochemical industry. And what if the electricity that powers the EVs is generated on the basis of fossil fuels, especially coal? For example, China is an undisputed, global leader when it comes to available EV stock: 1,227,770 EVs compared to 762,060 in the U.S. and 205,350 in Japan. But the country also leads in terms of operating and planned coal capacity: 972,514 MW operating capacity compared to 261,037 in the U.S. and 198,600 MW planned capacity compared to India’s 93,958 MW. A new study by Buchal et al. gives us some insight here. The authors find that under current German electricity mix, when production and recycling of the batteries are taken into account, the electric Tesla Model 3 is responsible for ¼ to almost ½ more CO_2 emissions than the diesel engine of Mercedes C220

Lastly, let’s take a look at the issue of reducing or even eliminating the use of plastics (especially single-use). The move could potentially serve many environmental goals that include, most prominently, the reduction of marine litter. Elimination of plastics could also seem consistent with climate action since plastic production requires fossil fuels as a feedstock. However, as pointed out in this piece by Rachel Meidl, plastics alternatives such as cotton, paper, cork, or wood are actually

more energy intensive, which—similar to the EV example above—may become an issue when electricity generation is based on fossil fuels. These products also release methane and carbon during decomposition, which contrasts with plastics that actually sequester carbon and decompose very slowly.

The above examples point to several issues:

First, there is a prominent rift between the developed and developing world in terms of their environmental goals and preferences. The wealthy, developed countries are not experiencing serious growth in their energy demand given their slower economic and population growth. They can also afford to pay more for cleaner energy options. In contrast, high levels of economic development and population growth in regions such as China, India, or the remaining countries of South-East Asia imply a dramatic increase in the need for affordable energy sources that could lift millions from poverty.

Second, climate action does not take place in a vacuum. In an environment where not all participants put CO_2 emissions and eliminating fossil fuels as their first objective, cuts in demand by some can boost the demand elsewhere. Thus, local action geared toward reducing CO_2 emissions may bring negligible cumulative effects. In addition, citizens in developed countries who are willing to pay more for clean energy may paradoxically be subsidizing fossil fuel use in other countries if lower global demand for those fuels depresses prices.

Third, not all environmentally focused initiatives are compatible with climate action goals. Some environmental actions, for example, reducing use of single-use plastics by banning plastic straws and/or plastic bags and replacing them with alternatives may be highly effective in helping marine environment but could actually increase the level of CO_2 emissions.

In this context, the simple idea of local action supporting global goals becomes much more nuanced and requires striking a difficult balance. This is especially important in a globalized economy where commodities such as oil, natural gas, and coal can move relatively easily to center(s) of demand and nullify effects of individual, local, or even country-level climate initiatives.

As such, these initiatives—if not evaluated in the light of their influence on the behavior of others (persons, countries, regions)—become just symbolic. Or, worse, they could have negative effects and obstruct the formulation of well-rounded policy solutions. To be sure, more holistic solutions are much more difficult and much slower to implement. They also do not bring the instant gratification of closing another coal-fired power plant, or buying an EV, or using a paper straw in a drink. Instead, we may have to move slower as we look into ways in which to make clean energy a truly global goal, i.e. worthwhile to both the developed and developing world.

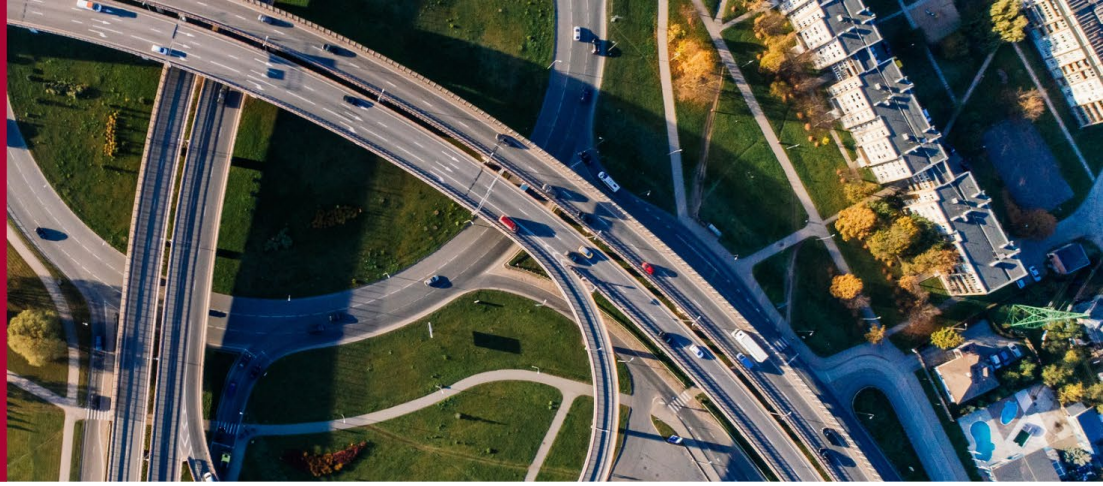
Hence, policy on the matter needs to consider a range of global implications and engage not only environmental science or technology but also other disciplines, including global, macro- and microeconomics, sociology, and political science. Solutions such as EVs or plastic alternatives need to be evaluated not only from the perspective of their immediate use but also from the life cycle perspective. This includes assessment of the environmental footprint of their production and disposal. Going further, evaluation of such policies should not only consider whether or not they have achieved their goals but what trade-offs did or would they require in the process. We need to think globally and—yes, act locally—but make sure that global implications of our actions are considered. Thus, one cannot overstate the role of well-designed and holistic policy solutions that can serve as organizing principles to concerted local and individual actions.

Anna Mikulska is a Senior fellow with the Kleinman Center for Energy Policy at the University of Pennsylvania and a Nonresident fellow with the Center for Energy Studies at Rice University's Baker Institute.

Idea #9

It's Time to Rethink Our Roads

by Erick Guerra



The first Highway Capacity Manuals—the guidebooks for how, where, and what types of roads get built in the United States—are refreshingly upfront about why we built our current road system: "to serve traffic." In this respect, our national roadbuilding project has been a tremendous success. We have more roadway per capita and vehicle miles of travel than any other large industrialized country.

There is also a strong relationship between where we have built the most roadway and where we drive the most. Across metropolitan areas, each additional road mile per capita is associated with two-to-three thousand more daily miles of driving per capita. Metropolitan areas with a standard deviation more roadway per capita on average have almost twice as much driving per capita as those with a standard deviation less roadway. New road investments appear to do such a good job of serving traffic that empirical studies, like those conducted by my dissertation advisor Robert Cervero (UC Berkeley) and Wharton's Gilles Duranton, find a one-to-one relationship between road investments and vehicle travel. New roads beget new traffic.

Alas, our national roadbuilding experiment's record is less stellar by other measures. Metropolitan areas and counties with more roadway are no healthier, happier, or wealthier than those with less roadway. In fact, our poorest metropolitan areas tend to have the most roadway. Each ten percent increase in roadway per capita is associated with around a 4% decrease in GDP per capita. Places with more and bigger roads per person also have more traffic fatalities per person. While there is variation in happiness across places, people in metropolitan areas with a lot of roadway are no happier than those in metropolitan areas with only a little bit of roadway per person.

While roads are an essential part of urban and rural life, serving traffic was never a great justification for where, how many, or what types of roads to build. In an era of climate change, serving traffic is deeply problematic. Road-based vehicle travel accounts for around a quarter of all US CO_2 emissions and roughly four-fifths of emissions from the transportation sector. New traffic begets new CO_2 emissions.

In addition to a climate change crisis, declining gas tax revenues and increasing road-maintenance obligations are creating a general funding crisis that could help lead to a paradigm shift in how we raise and spend money on transportation. I recommend three broad, ambitious, and somewhat aspirational shifts for public policy.

First, stop subsidizing new roads with public dollars. The economic and social benefits are questionable and frequently do not justify the expenditure. The economic and social costs of increased CO_2 emissions, by contrast, are apparent and substantial. Instead, new roadways should generally be financed through tolls. If tolls are insufficient to cover construction and operating costs, this suggests that the road is probably not worth as much to those using it as it costs others to pay for it. Financing these types of roadways would certainly help explain the inverse relationship between GDP and roadway across metropolitan areas.

Second, develop national, state, and regional systems for downgrading roads. Highways, arterials, and local roads need to be rebuilt periodically and often at great expense. With the exception of replacing the occasional damaged urban freeway with an urban arterial, reducing roadway capacity is rare. We need a mechanism for ratcheting back an overbuilt road system that, at the margin, probably does more harm than good in most US urban areas. Instead, our current financial and political models tend to support expansion, road widening, and rebuilding. We can ratchet up, but not back, regardless of population trends, the economy, or fiscal health.

These relationships are not causal, but they do suggest that road building has not produced anything like the promised economic benefits.

Third, stop treating the fuel tax like a user fee. Although there is a natural fiscal argument for paying for roads out of gas taxes, the external economic costs of driving, including things like congestion and pollution, are estimated at nearly twice the gasoline tax. With an EPA-estimated social cost of CO_2 of $45 per metric ton, road-based transportation created $7 billion dollars of CO_2-related harm, equivalent to around a fifth of the total annual revenue raised by federal gas taxes, in 2017. These funds should be used to offset and reduce harm not to build new roads that generate more traffic and create more harm.

Although there is an opportunity to reconsider how and where we fund roadways, I am not particularly optimistic. Our national dialogues tend to treat transportation investments as inherently good and productive. Rebuilding infrastructure is presented not just an economic imperative but a moral one. The media and politicians frequently refer to federal and state transportation finance bills as nostalgic examples of bipartisan politics or contemporary opportunities to set aside political differences to invest in the future. We should really be more careful about the kind of future we are investing in.

Erick Guerra is Associate Professor of City and Regional Planning at the University of Pennsylvania Stuart Weitzman School of Design.

Idea #10

Transition to Net Zero: No Single Silver Bullet

by Julie Keenahan

Carbon-free power is within sight. Significant progress has been made toward lowering the cost of wind and solar generation, and new low and zero-carbon generation solutions are being deployed every day. However, forecasts for renewables penetration in transportation and heating remain dismally low. Considering that transportation alone contributes 14% of global greenhouse gas emissions, the planet still has a long way to go in transitioning to clean energy.

In response to this challenge, "electrify everything" has become a rallying point for climate activists and thought leaders around the world. As grid emissions intensity continues to decline, electrifying all of global heat and transportation could slash net 2050 emissions by 126 $GtCO_2$, while increasing generation capacity needs to over 30% the forecasted levels.

Meeting this additional power demand, at least 3,950 TWh of which will come from electric vehicles alone, is a challenge on its own. But another is that for many applications, electricity is an inferior source of energy. Supply must match demand, instantaneously. This essential law is inconsistent with how we use much of our energy today.

Power has Limits

Combustion fuels, like oil and gas, have two essential advantages over electricity: portability and storability. These characteristics enable the flexibility that is essential for transportation applications and provide resilience and redundancy in climates with severe or very cold weather.

For example, while electric heat pumps are desirable options for heating and cooling in mild climates, they are less efficient and economical in cold environments, and lack the redundancy that fuel-powered furnaces provide. Imagine that you are a senior living alone in upstate New York. A blizzard hits, and the power goes out. Adding to the issue, battery efficiency and electric vehicle range also decline significantly when the mercury dips below zero. These kinds of energy consumers can't rely on instantaneous power to save them – energy must be available, stored on site.

Without enough distributed energy storage options, grid reliability becomes essential. Just as utilities are working to build resilience against intense storms from climate change, cyberattacks, and solar flares, climate hawks are calling for total energy dependence on electricity. Without careful planning, this could leave millions of people vulnerable to energy insecurity.

The Challenge of Storing Electrons

Storing electrons in batteries is getting cheaper every year. However, batteries are currently built with rare earth metals like lithium and cobalt, which have supply chain transparency and sustainability issues. Wind and solar assets themselves also require rare materials that are in limited supply. Many of these supply chains are controlled by China, presenting a risk to other nations hoping to develop affordable clean technology. Will mining of these materials meet the world's demand for the renewable generation and battery capacity we need? Just electrifying the UK's vehicle fleet by 2035 could require twice the world's current cobalt production. Extrapolating that to the globe, and piling on heating and backup battery power for many homes and businesses seems nearly impossible. And we haven't even discussed air travel, commercial shipping, or industrial energy use.

Renewable electrification of much of the world's energy is possible and desirable, but storage and resilience present challenges. The advantages of combustion fuels are hard to ignore, especially for applications in transportation, cold climates, and vulnerable grids. To transition, smarter, greener fuel alternatives must be prioritized with the same enthusiasm as electrification.

Alternatives

Opportunities for fuel alternatives abound. Rather than stranding or wasting existing infrastructure and technological assets, we could use them to our advantage to implement renewable fuels. Much of the U.S. has existing natural gas infrastructure that could help deliver alternative fuels like biogas from landfills or syngas (a synthetic gas fuel formed from carbon monoxide and hydrogen) from captured CO_2 to homes, businesses, and industrial customers. Biofuels like ethanol can be swapped into internal combustion engines, reducing lifecycle emissions by 34% (although depending on how they are produced, land use and deforestation impacts can counter these improvements). Excess peaks in renewable power generation could be "stored" by powering hydrogen or other alternative fuel production when grid demand can't ramp up fast enough.

There are some bright spots where progress is being made. Japan is already committing to hydrogen fuel to fill gaps in its energy demands. Shell is developing biofuels for trucking, hydrogen for commercial applications, and municipal solid waste for jet fuel. Still, greater investments and public awareness campaigns must be made to scale critical fuel alternative technologies quickly enough to meet our climate goals. Vehicle electrification and renewable power are exciting, but they won't solve all of society's clean energy needs. As the world transitions to clean energy, all strategies must be encouraged.

Julie Keenahan is a Research Fellow with the Kleinman Center for Energy Policy.

Idea #11

Listen to National Security Professionals on Climate Change's Risks

by Mark P. Nevitt

Climate change is having a moment. Following a devastating wildfire and hurricane season, it is increasingly clear that climate change is not just an environmental issue — it also creates enormous national security risks. As Professor Richard Lazarus of Harvard has pointed out, climate change is properly conceptualized as a "super-wicked" problem affecting numerous disciplines, including national security. Today, national security professionals — which includes military officers and the intelligence community — are sounding the alarm about climate change's multifaceted national security risks. Despite recent partisan attacks on climate science and the current Administration's withdrawal from the Paris Climate Accord, the national security community has largely held steady, addressing the climate risks facing the nation and the world in a blunt, sobering manner. We should listen.

So what are the national security risks posed by climate change?

Domestically, climate change acts as a "threat accelerant," increasing the intensity and severity of extreme weather events such as wildfires, hurricanes, and storm surge. It worsens sea level rise and nuisance flooding. In turn, climate change stresses emergency response assets and harms valuable national security infrastructure. Witness the most recent hurricane season that ravaged military installations on the Florida and North Carolina coasts. Internationally, climate change acts as a "catalyst for conflict." Indeed, nations increasingly struggle with droughts, food and water insecurity, and extreme weather — all exacerbated by climate change.

We must listen carefully to national security professionals on these climate risks. Besides being the right thing to do, there are several pragmatic reasons why we need to listen closely.

First, national security professionals and the intelligence community bring a balanced, non-partisan, and highly respected voice to the climate change discussion. Indeed, national security leaders approach climate risk through a pragmatic culture rooted in operational risk assessment and planning. As climate change is replete with "known unknowns," a thoughtful, planning-based approach is essential.

Relatedly, while climate science has been the subject of recent partisan attacks, the intelligence community's message on climate change has stayed steady, irrespective of the Oval Office occupant. As Professor Sarah Light of Wharton has already astutely argued, connecting climate

change to national security risks has the potential to change individual attitudes and beliefs concerning climate change. And this message is simply not going away. For example, the most recent threat assessment from the Office of Director of National Intelligence, released just a few months ago, addressed the national security implications of climate change in clear-eyed terms:

[G]lobal environmental and ecological degradation, as well as climate change, are likely to fuel competition for resources, economic distress, and social discontent through 2019 and beyond. Climate hazards such as extreme weather, higher temperatures, droughts, floods, wildfires, storms, sea level rise, soil degradation, and acidifying oceans are intensifying, threatening infrastructure, health, and water and food security.

Second, concerns over the national security implications of climate change are beginning to translate into legislative action. While the EPA is actively dismantling environmental and climate regulations, climate security remains "sticky." Indeed, forward-looking climate security provisions have made their way into the past two defense appropriations. More are in the works. For example, the 2018 National Defense Authorization Act prohibited military construction in the 100-year floodplain — an important climate adaptation measure that did not receive the attention it deserved. The 2019 defense spending bill required the Department of Defense to provide a report ranking the military installations most vulnerable to climate change. While this report ultimately fell short in detail and substance that many of us hoped for, it nevertheless kept climate change in the news and on the congressional radar. Since the Democrats took over the House in January, Congress has already held several hearings addressing climate change. And just last week, the House passed an initial defense spending bill that requires the military to develop a climate vulnerability and risk assessment tool.

Finally, the military is an enormous emitter of Greenhouse Gas emissions and is the world's largest institutional user of petroleum. A recent study released last month from Brown University's Cost of War project estimated that the Department of Defense emits more GHG emissions than many European nations. Indeed, if the military was ranked against all the nations of the world, it would rank as the #55th largest emitter of GHG emissions. So any future plans to reduce our reliance on fossil fuels and reduce GHG emissions must take into account emissions from the military and national security sector. The national security sector *must be* included in the broader climate mitigation discussion. It cannot be wished away.

In sum, what the future holds for the "big ticket" items on any future climate agenda — such as the future of the Paris Climate Accord and the future of domestic climate legislation — remains to be seen. In the interim, we should listen carefully to our national security professionals. Even better, we should continue to act on their advice as we prepare for the coming climate century.

Mark Nevitt is currently the Sharswood Fellow, Lecturer in Law at the University of Pennsylvania Law School. Prior to his appointment at Penn he served as a Commander in the U.S. Navy.

Idea #12

Insuring Ecosystems to Ensure Climate Resilience

by Sarah Light and Carolyn Kousky

The natural world and its ecosystems are valuable both for their own sake and for the value they provide to people. These benefits people derive from nature are often referred to as *ecosystem services*. An important class of benefits are those that help minimize the risks of natural disasters. Coastal mangroves and coral reefs act as natural barriers that can protect coastal properties from storm surges that are reaching further inland as the sea rises (e.g., here). Wetlands reduce flood risk to nearby property, a risk that is increasing from an upsurge in heavier precipitation events. Vegetation on sloping lands can reduce the risk of landslides. These risk reduction services are becoming ever more important as the climate warms. Yet the ecosystems that provide these services are themselves under threat as a result of extreme weather events like hurricanes and storms.

A first-of-its-kind insurance policy was purchased this past spring to insure these important natural assets. Off the coast of Quintana Roo, Mexico, a coral reef is both a tourist draw and an important coastal ecosystem that mitigates hurricane storm surges. In 2018, The Nature Conservancy signed an agreement with the Quintana Roo State Government in Mexico and the Cancun and Puerto Morales Hotel Owner's Association to develop a Coastal Zone Management Trust to build "resilience" along the coastline. In partnership with Swiss Re, a global reinsurance firm, they developed a parametric insurance policy to protect the reef. If a certain magnitude storm hits the coast, the policy would immediately pay funds to the Trust so they could begin restoration of the coral. Scientists have found that if divers go in very quickly post-storm they can reattach coral and restore the reef (for example, see the coral restoration effort after the 2017 hurricanes here). The insurance policy was purchased in June 2019 from a Mexican based insurer, Afirme Seguros Grupo Financiero SA de CV with a coverage limit of $3.8 million.

This novel example demonstrates the potential of innovative insurance policies to help in the restoration of natural systems that provide important risk reduction services. Insuring nature itself—by providing a specified payout to an entity with an insurance interest to restore a specific natural area such as a coral reef when it is damaged or degraded—can guarantee that the services nature provides are quickly restored in the event of damage from extreme weather events.

In the United States, some federal agencies will fund restoration of ecosystems if they are degraded or injured but this funding is tied to the whims of Congress and not guaranteed. Examples include dune restoration by the Bureau of Ocean Energy Management, the Emergency Forest Restoration Program in the U.S. Department of Agriculture, and select projects within the U.S. Army Corps of

Engineers. Given that most of the funding comes in off-budget disaster supplemental spending bills, it often takes months or years for funds to be spent and projects completed (for example, disaster supplemental funding following the 2017 hurricanes took months and years to be appropriated). For communities that need protection restored quickly, or for ecosystems, such as coral reefs, where successful restoration is dependent on quick response, parametric insurance is superior to waiting for government action.

That said, there are a number of challenges with this approach which we explore in a forthcoming paper. First, in order to harness insurance, an entity with an insurable interest willing and able to pay the premium must be identified. For many ecosystems, their benefits are public goods, which means that it is not possible to exclude anyone from enjoying the good and also that as one person enjoys it that does not diminish the good for others. For public goods, there is little financial incentive for a private company to supply them since they can't capture any profits. This could undermine the incentives for those with an insurable interest to pay the insurance premium.

Even those entities that would be financially impacted should the ecosystem be degraded may be unwilling to shoulder the cost of the premium alone. There are multiple examples of coordinating mechanisms and institutions that help overcome this challenge, including but not limited to government participation, and those would need to be used in this context, as well. Finally, insuring nature itself is not appropriate for all types of ecosystem protection. This method is ideal for systems in which there are restoration efforts that can be done to help the ecosystem recover. Further, to justify insurance, this restoration should require large sums, unlikely to be immediately available without insurance payouts, and should be cost-effective and add value beyond what the entity with an insured interest could do on its own.

So while not a silver bullet for ecosystem preservation in the face of climate change, insurance can be a powerful tool to fill a financing need not well addressed by other mechanisms. The state of California is beginning to explore these and other innovate insurance approaches with the passage of SB30, which directs the state insurance commissioner to "identify, assess, and recommend risk transfer market mechanisms that, among other things, promote investment in natural infrastructure…". California has many ecosystems that can be threatened by extreme events, from coastal systems at risk of storms to forests at risk of wildfires, making it a natural place to pilot and refine this concept.

To further develop the viability of this concept, a nationwide study could identify those places that meet our criteria for when insuring nature may a useful tool:

1. There is an ecosystem at risk of a natural disaster.
2. An entity or group of entities benefits from the continued provision of ecosystem services from that system.

3. Access to rapid funding post-disaster could finance restoration efforts, such as reattaching coral, reestablishing dunes, or planting samplings.
4. Quick restoration would be difficult to self-fund.
5. Beneficiaries can come together to overcome free-riding and collectively finance premium payments.

This post is based on a forthcoming article, Carolyn Kousky & Sarah E. Light, Insuring Nature, 69 Duke Law Journal (forthcoming Nov. 2019).

Sarah Light is Associate Professor of Legal Studies & Business Ethics at the Wharton School.

Carolyn Kousky is the Executive Director of the Wharton Risk Management and Decision Processes Center.

Idea #13

An Import Tax as a Border Adjustment for National Climate Policie

by Howard F. Chang

In a world in which nations adopt heterogeneous climate policies to reduce emissions of greenhouse gases, a nation that adopts a more stringent policy than its trading partners may place its producers at a competitive disadvantage when imports come from nations in which emissions are subject to relatively lax regulations. Proponents of a carbon tax or a cap-and-trade system as a national climate policy often advocate a "border adjustment" as an instrument to address this disadvantage. A border adjustment may take the form of a tax imposed on imports that is designed to offset the competitive disadvantage imposed on domestic producers by national climate policies. Such a border adjustment would help mitigate climate change through at least two channels:

First, by offsetting the competitive disadvantage imposed by relatively ambitious climate policies, this border adjustment would remove an incentive for consumers to shift their demand from domestic producers subject to strict regulations to foreign producers subject to more lax regulation. Without this border adjustment, domestic demand would shift toward imports, thereby expanding production in relatively unregulated economies and causing increased emissions abroad, which would undermine the effectiveness of the importing country's climate policies. One environmental purpose served by this border adjustment would be the prevention of this "carbon leakage."

Second, by restricting imports from relatively unregulated countries, border adjustments would reduce demand for the exports from those countries, and the threat of this economic harm may promote political support for more ambitious climate policies in exporting countries. More stringent regulations in an exporting country would reduce emissions in that country, which the importing country could reward with relief from the import tax imposed as a border adjustment. Border adjustment could thereby create incentives for exporting countries to adopt more stringent climate policies and reduce the incentives for these countries to enjoy a "free ride" on the more ambitious climate policies adopted by importing countries.

As these remarks suggest, an importing country would have to design its border adjustment carefully to serve these two environmental objectives effectively. To prevent carbon leakage and to create incentives for more stringent climate policies, a border adjustment must be sensitive to the climate policies adopted by the exporting country. If the exporting country has climate policies equivalent to those adopted by the importing country, for example, then the importing country has

no environmental rationale for a tax on imports from that exporting country. An import tax on this exporting country would only protect domestic producers from legitimate import competition and would represent the type of protectionist measure that the architects of the international trade regime sought to prevent through the adoption of the General Agreement on Tariffs and Trade (GATT) and the creation of the World Trade Organization (WTO).

The GATT imposes various legal restrictions on tariffs, including the Most Favored Nation (MFN) obligation in GATT Article I and the tariff commitments in GATT Article II. Some advocates of a carbon tax have suggested that GATT parties could justify border adjustments for carbon taxes as border tax adjustments authorized by an explicit exception to the Article II tariff commitment. This exception appears in GATT Article II:2(a) and allows parties to impose "on the importation of any product … a charge equivalent to an internal tax … in respect of the like domestic product or in respect of an article from which the imported product has been manufactured or produced in whole or in part." Proponents of this theory claim that energy may be "an article from which the imported product has been manufactured," so that a carbon tax on energy sources may be "an internal tax" that qualifies for a border tax adjustment.

This claim is questionable as a legal matter. Skeptics believe that an input like energy, which is consumed in the production process, is not "an article" that qualifies for the Article II:2(a) exception because it is not physically incorporated into the imported product. The French version of the GATT, which is as authoritative as the English version, seems to be more explicit in requiring physical incorporation of the taxed input into the imported product. Furthermore, the use of the Article II:2(a) exception would be even more dubious if national climate policy takes the form of a cap-and-trade system or command-and-control regulations rather than a carbon tax. It would be difficult to characterize these regulations as "an internal tax."

Moreover, the legal doctrines that apply to border tax adjustments, which the GATT parties designed for sales taxes and other taxes applied to products, are poorly suited to the policy objectives of border adjustments for national climate policies. In particular, nothing in the law of border tax adjustments under Article II:2(a) would require an importing country to consider the climate policies of the exporting country when imposing a charge on imports from that country. Indeed, discrimination based on the policies of the exporting country would violate the MFN obligation in GATT Article I. Thus, the use of the GATT Article II:2(a) exception for climate policies would be misguided as a normative matter, and the WTO should read this exception narrowly to require physical incorporation of "an article" to qualify for this exception.

The WTO should instead evaluate border adjustments for climate policies under the exception in GATT Article XX(g) for "conservation" measures, and importing countries should design border adjustments for climate policies with this exception in mind, not the exception in Article II:2(a). WTO case law indicates that in order to justify a trade restriction as a measure to protect

natural resources in the global commons under Article XX, the importing country must take into account "policies and measures that an exporting country may have adopted," so as not to discriminate against countries with environmental policies "comparable in effectiveness." Under this Article XX case law, the WTO should give its members broad leeway to impose import restrictions designed appropriately to promote reductions in greenhouse gas emissions in exporting countries.

Howard F. Chang is the Earle Hepburn Professor of Law at the University of Pennsylvania Law School.

Idea #14

Land Use, Labor, and Local Engagement: Transformation of Urban Sprawl

by William W. Braham

We face a civilization-defining transition whose challenges will not be met solely through technology. Building a renewable economy is not simply a matter of tools and resources: the greatest challenges are social and political.

A meaningful transition to renewables will radically change how we do and make virtually everything. I believe that transition is possible because we have been adapting to similar rates and scales of change for the last 200 years. However, three sociopolitical shifts are necessary for technology and design solutions to work. All of these changes are integral to the design solution I am proposing, which is the adaptive reuse of the suburban sprawl that emerged from the fossil fuel economy itself over the last 100 years.

Land use. As we move to replace the resources currently consumed by contemporary cities, we will be faced with stark land use choices—food, fuel, or electricity—and the question of who controls the land on which renewable resources are captured.

Whether we are considering solar, wind, water, or biomass, environmental energies are spatially more diffuse than fossil fuels. Vaclav Smil has spent his career determining just how much more land will be required to capture, concentrate, and deliver environmental energies, and it will require thousands of times more land than we have currently devoted to energy capture. So the first constraint on the transition will be the quantity of farm land, forest, rooftop, or parking lot that can be diverted for new purposes.

In earlier renewable, agricultural economies, most wealth was derived from control of the land or water where things grew, and cities or nations expanded by bringing more land under their control (militarily or by trade). The first sociopolitical challenge, therefore will be to manage the redistribution of land rights to and redirection of land use from energy consumption to energy production.

Related to the importance of land areas for capturing renewable resources are the structures and infrastructures that are already built on them. It is much harder, and slower, to change assets than to build on green fields, so the transition tends towards emptier land of lower economic value. The solution I am proposing is to reconceive the land use of low density urban sprawl, integrating renewable resource capture. Suburban development has been an opportunistic form of growth,

built on the availability of cheap power. The suburbs present tremendous opportunities to develop new urban arrangements combining food, power, housing, and work.

Labor. The second sociopolitical challenge is the assumption (or hope) that the arrangements of daily life formed in the last 100 years are the normal order of things, that driving to offices, sitting at desks, and processing specialized information are the natural activity of humans. Most of our real wealth—the ability to do, make, or have things—now derives from extracted fuels that captured sunlight over large areas in the distant past. It has been so easy to tap the stored potential of those fuels that most of our current occupations are highly specialized manipulations of the products and services they have made possible. The increased complexity and specialization of work is not only unprecedented, but as climate related costs increase, the marginal returns for that work continue to decrease.

In order to avoid a wholesale return to an agricultural economy, we will have to invent new forms of work based around environmental technologies for capturing wealth, and particularly for the control and administration of land areas. The opportunity presented by this transition is to reduce the anonymity and alienation that commonly exist in complex, highly specialized economies. In other words, reconnecting the economy to the management of land offers the opportunity to recover more interconnected and purposeful occupations.

Local Engagement. A common characteristic of proposals for the transition to renewables is their focus on avoiding the disruption of current patterns, treating the population as difficult customers rather than as citizens. That priority practically guarantees that the disruptions that do occur will be viewed as failures and the changes resisted. In the United States, our current form of retail politics promises people whatever they want, so the most challenging aspect of the transition to renewables will be to change the tenor of our politics. Part of the solution is to approach this transformation as a collective duty, with the emphasis on sharing the burden of change and the opportunities it will present.

As tempting as it is to focus first on the more concrete risks, like land-use planning, the third challenge is integral to the first two. In the US, we have had multiple examples of broad engagement with national challenges, from the military and industrial mobilizations during the world wars, to the many institutions established to reduce economic stress during the Depression, to the enthusiastic exploration of new ways of living in the post-war period. The risks of climate change cut across partisan political affiliations, and the changes required can offer something to people of every ideology. A reduction in the scale and complexity of social and political organization speaks to conservative concerns about government, while the reduction in wealth inequality and environmental consequences should resonate with liberal ambitions.

It may seem poetic to find solutions to the demands of climate change in the landscape that symbolizes the fuel-based economy that caused it, but I believe our future lies in new forms of urbanism that preserve the fruits of our current wealth—science, culture, health care—while learning from the inequalities of our past.

William W. Braham, FAIA is Professor of Architecture and Director of the Master of Environmental Building Design and of the Center for Environmental Building + Design at the University of Pennsylvania Stuart Weitzman School of Design.

Idea #15

Solving Climate Change Through a Grid Infrastructure Overhaul

by Daniel E. Walters

Many politicians want the United States to commit to a fully renewable energy transition, and with good reason—the price of renewable energy is plummeting, and it is possible for the first time to envision a zero-emissions electricity sector that actually *saves* money. The math seems simple, even for those who do not believe mitigating climate change is a moral imperative.

But grid managers and utilities are less sanguine about a wholesale transition to renewable energy than price signals alone would suggest. This is because, when consumers turn on their light switches at home, they expect the lights to turn on whether or not the wind is blowing or the sun is shining. It's not an unreasonable expectation, but it does present challenges for the transition to an electricity generation portfolio based on utility-scale renewable energy, like solar and wind. These resources are, indeed, renewable and increasingly cheap, but they are also intermittent in that the wind has to be blowing and the sun shining for these technologies to produce energy on demand, seemingly making them bad candidates to replace the regional baseload generation fleets—coal and nuclear power plants—that provide power whenever called upon. Grid managers and utilities worry about tilting the scale too far in the renewable energy direction, lest they create reliability problems on the grid. The result is that, at present, renewables are unable to meet their full potential.

The problem of intermittent electricity is not as intractable as it might seem. First, renewable technologies like solar and wind may be inherently intermittent, but they are not uniformly intermittent. Certain parts of the country—namely the Great Plains and the Mountain West—have meteorological conditions that allow more constant use of solar and wind installations, and they are ripe for massive-scale renewable energy development. Second, the United States is a big country, and while some renewable resources might be off line due to weather conditions at any given time, chances are that there are other resources in other regions that have excess capacity at the same time. Finally, it is increasingly cost-effective to couple renewable projects with energy storage installations that allow renewable generators to arbitrage operations to maximize efficiency and hold energy until there is demand somewhere. Together, these three factors give the United States the potential to make renewable electricity a more on-demand resource.

The intermittency problem is a relic of our historically parochial approach to grid architecture, not an indomitable physical limitation of the technology. Acting as a whole country, we have the capacity to move clean, renewable electricity from where and when it is available to where and

when it is needed. The challenges to this vision are political and legal ones: Can the country muster the political will and the legal authority to invest in an electricity infrastructure overhaul? It sounds like a tall order, but there are a number of concrete steps that could be taken that could start the process.

First, siting renewable installations where they can do the most good means we must overcome the fact that these locations tend to be isolated, meaning the existing web of low-voltage, congested, and regionalized transmission grids does not reach them. While entrepreneurial private companies like Clean Line Energy Partners have attempted to solve this problem by developing select high-voltage direct current (HVDC) transmission lines from the Great Plains to the heart of the Eastern Interconnection, progress was fatally slowed by regulatory permitting hurdles and inter jurisdictional conflicts. In this case,"pass over" states were all too willing to use their transmission siting authority to veto such projects and the federal government hesitated to use its limited existing statutory authority to override those vetoes and grant private companies eminent domain authority to secure land on which to build the lines. Congress has the authority to clear these regulatory barriers and end parochialism, clearing the way for private development of energy pipelines to the most reliable renewable resources at little cost to the public.

Hearkening back to the creation of the interstate highway system, the federal government itself could even develop a high-voltage public interstate transmission grid to relieve congestion and improve efficiency on the disjointed and archaic regional grids. One study from 2016 found that such an electricity superhighway could bring the United States to 80 percent of 1990 CO_2 emissions levels by 2030 by opening up markets for renewable energy all across the country. To be sure, such a project would likely cost over $5 trillion up front, although that's likely to cost out quickly as greater efficiencies push the price of energy lower. And compared to the costs of adapting to the climate change that the project could help avoid, the price tag is a pittance.

Finally, some of the costs of building out transmission lines to meet renewable resources where they are located could be eliminated by aggressive investment in energy storage technology. Storage allows grid managers to address the "Duck Curve" associated with renewables—i.e., the imbalances of demand and supply as renewables come online and go off line through peak hours—by smoothing production and supply. Moreover, the more energy storage capacity that is rolled out, the less need there will be to site renewable projects in remote areas. After all, the sun even shines in Seattle sometimes. Certain forms of energy storage, such as "pumped hydro" storage, are already deployed widely, but recent advances in battery technology suggest enormous growth potential for storage. Four-hour battery storage has recently become more cost-effective and a wave of grid-scale projects have been announced. To make a major impact, there would need to be longer-term storage capacity, but the technology seems to be increasingly within reach.

To help foster the development of long-term, grid-scale battery storage, the federal government should continue, but also bolster, its multi-faceted approach to encouraging storage innovation. The Federal Energy Regulatory Commission (FERC) took an important step by requiring grid managers to ensure that storage operators are able to bid stored energy into energy markets just like any other generator, and it must ensure that grid operators take this mandate seriously. Likewise, a raft of existing bipartisan legislative proposals to fund research and development of storage should be passed.

Most importantly, however, policymakers need to pursue all of these avenues at once. Private-sector investors and developers in renewables, transmission, and storage need credible commitments that markets will exist at the end of the road; otherwise they will not take the actions that are in their private interests and society's collective interests. There is a chicken-and-egg aspect to the factors most holding back an overhaul of the grid. The federal government needs to triangulate approaches and focus on generating an environment where investment and innovation in a renewable transition are encouraged and not stymied by fear of whether investment in other interlinked domains will continue.

Investing in infrastructure is politically popular, and Americans have rallied around that cause time and again over the last century. If we do it right in the energy context, the pieces are in place for a game-changing penetration of renewable electricity that could well avert climate disaster.

Daniel E. Walters is Assistant Professor of Law and Political Science at Pennsylvania State University and a Former Regulation Fellow at the University of Pennsylvania Law School.

Idea #16

To Modernize US Water Infrastructure, We Need New Financial Tools

by Allison Lassiter

Even though roads and bridges dominate federal infrastructure conversations, our most vulnerable and critical public infrastructure may be municipal water systems. We tend to take clean, reliable water for granted. Not only is a lot of water infrastructure reaching the end of its lifespan, however, it is particularly susceptible to climate change. Our built infrastructure of pipes, pumps, aqueducts, and dams all link to natural water infrastructure like rivers, lakes, and groundwater. In many locations, there has been or will be climate-related changes in natural infrastructure impacting the quantity and timing of water supplies that can be brought to drinking water standards. Altering source water locations, water storage, treatment methods, pipes and materials will require more money than most water agencies can currently access. Though many of the challenges of modernizing US water infrastructure must be addressed at local and regional levels of government, the federal government can help protect drinking water by dedicating funding and driving investment with new financial tools.

There is not enough federal money flowing into infrastructure, especially water infrastructure. At 1.6% of GDP, the US has among the lowest levels of national infrastructure investment in the world. If this trend continues, the World Economic Forum warns the US will have the largest shortfall of infrastructure investment of any country by 2040, with a projected gap of $3.8 trillion. Specifically with respect to water, the American Water Works Association says $1 trillion of investment is needed through 2035, which dwarfs current discussions of federal investment in water. To boot, these estimates are likely conservative, as many costs of climate-related impacts on water are not yet determined.

Water agencies bring in almost all their money through rate payers. Revenue from rate payers is often not enough but, despite shortfalls, it can be very difficult for public water agencies to garner the political support to change pricing structures and raise rates. Under tremendous pressure, public water agencies may avoid increasing rates for years. In the meantime, lack of funding can lead to deferred system maintenance. Then, when a large project is finally unavoidable, a public water agency may take on debt financed through a bond. Some agencies are either accumulating debt or under other financial risk, however, and are seeing a decline in their credit ratings. For these water agencies, new debt may only be accessible at high interest rates.

Without enough dispensable money, some public water systems have or are considering privatizing. This means a private company has either purchased or leased the infrastructure assets from the

water agency. There is a long history of private water systems in the US—about 12% of water systems are currently privately owned or managed, though there is massive variation by state. Privatization is likely appropriate in some cases, but also raises a number of issues. Some fear that privatization can lead to reduced water quality and diminished service reliability, alongside soaring water bills.

The largest problem with privatization may be that privately-owned water systems are less able to radically adapt water infrastructure, even though it is and will be necessary in some locations. Private investors in infrastructure are typically seeking low risk, stable investments. These investors (for example, pension funds) are often more interested in upgrading systems at the margin than planning for major capital outlays and system overhauls. But, the future of water will most likely require a suite of approaches beyond tweaking traditional infrastructure, including: investing in distributed green and blue infrastructure, investing in both water reuse and desalination facilities, consolidating and redistricting existing water systems, and developing new regional watershed-based flow management practices. To ensure adequate service delivery and all the necessary, major infrastructure adaptations, many municipal water systems will need to stay public and be supported with funding. *Funding*, not debt financing.

Part of this funding must come from federal government commitment, but to close the infrastructure investment gap we also need tools to responsibly leverage private money toward water projects. One way the US can do this by looking to Australia's infrastructure asset recycling initiative, which has skyrocketed infrastructure investment since its inception in 2014. This is how it works (more here and here):

1. At the federal level, devote money to infrastructure upgrades. Create a matching program with participating states. Australia matches 15% of proceeds from the sale of divested infrastructure that was reinvested into new infrastructure.

2. At the state level, create an overarching infrastructure agency. At a minimum, this could be by sector, but better to include multiple sectors, like transportation and water. This means that, for example, a bridge could be divested and funds brought into water delivery, thus keeping the water system public. At a maximum, the infrastructure agency could be built out to include social infrastructure, like housing or schools.

3. Divest from state infrastructure assets that match private sector investor preferences. Divestment can span different ownership and operation frameworks—whether leasing to private operators for a fixed term or fully selling the asset. In Australia, most assets have been leased for long, fixed terms to private operators, with the state retaining ownership rights and some management tasks, like quality enforcement.

4. Store money from the divested asset in a trust separate from other public money, where the finances are transparent and visible to the public.

5. Reinvest money into new infrastructure, as prioritized by the infrastructure agency.

Though there are many differences between the US and Australia, an infrastructure asset recycling program is possible. Already, we have structures in place at the state-level that could be expanded to integrate with an asset recycling approach, like the Clean Water State Revolving Fund.

Ensuring adequate funding for needed services like clean and reliable drinking water is going to require dramatically rethinking methods of infrastructure investment. The traditional public water agency tools of rate setting and bonding will not be sufficient to modernize public water systems, while privatizing may stymie adaptation. Though public infrastructure investment has been siloed by sector in the past, adaptation will likely require increased efficiency through cross-sector cooperation and multi-benefit projects. New financial tools, like infrastructure asset recycling, can help drive money into water infrastructure investments and secure clean, reliable water.

Allison Lassiter is an Assistant Professor at the Stuart Weitzman School of Design.

Idea #17

Reducing the Risks of Water Insecurity

by Trevor M. Penning and Marilyn Howarth

Our water security is in danger as a result of climate change; this contribution will focus on environmental health aspects of impending water shortages and contamination. Water security is defined as "the reliable availability of an acceptable quantity and quality of water for health, livelihoods and production."

With climate change we can expect unprecedented droughts in certain regions leading to scarce water resources. Adaptive responses to drought could include increased deep-well drilling for drinking water and irrigation. An increase in the use of agrochemicals would be necessary due to the expected increased population of invasive insects and weeds and warmer weather favoring thermophilic fungi especially those dependent on host stress. There will also be a need to house livestock in barns to protect animals from searing heat. These adaptive responses pose a threat to environmental health. These include increased contamination of drinking water by heavy metals and arsenic (prevalent in the geological formations in the mid-west) as a result of deep-well drilling, run-off of nutrients and agrochemicals into waterways used for drinking water sources, and the formation of toxic algae blooms from a combination of rising temperatures and nutrient pollution in waterways. Current wastewater and drinking water infrastructure are not configured to remove the increasing concentrations of these pollutants in water. Furthermore, increased exposure of workers to agrochemicals increases their risk for neurotoxic side effects, while the housing of livestock in close quarters will increase the prevalence of zoonotic disease.

Droughts resulting from climate change will also increase forest fires leading to the loss of lives and homes. The environmental health risks of these fires are substantial. Incomplete combustion of building materials increases particulate matter and volatile organic chemicals, affecting pulmonary function and exacerbating underlying respiratory disorders. The air plumes generated by large fires add contaminants to soil and surface water as they drift far from their place of origin. The use of flame retardants can lead to long term contamination of the soil, surface and ground water by these chemicals. Adaptive responses could include heightened enforcement of fire-codes, improved zoning of home developments, and the development of less toxic flame retardants.

With climate change, droughts in some areas will be counterbalanced by extreme flooding in others. Responses to floods can also generate environmental health challenges. Homes, if salvageable, will be contaminated by polluted water and upon drying, the infrastructure will develop mold creating environmental health hazards. Flood waters are contaminated by chemicals

and microbes that they encounter, leading to the re-distribution of contaminants into drinking water sources. Adaptive responses to flooding could include improving building codes for properties in floodplains and the engineering of levees.

Many of these adaptive responses are woefully inadequate to be protective of human health. Water security needs to be more aggressively targeted by monitoring compliance with the Clean Water and Safe Drinking Water Acts. Maximum contaminant levels (MCLs) need to be enforced and new ones established for those for which MCLs do not exist (aldrin, dieldrin, endosulfans, to name but a few). Improvements in municipal waste water treatment plants could reduce contamination with toxicants so that water returned to source water is less polluted. Cost-effective desalination plants could increase the availability of water in general. Organic fertilizers could be used in place of agrochemicals to increase crop yield and reduce exposures to neurotoxicants.

Natural disasters such as large-scale drought, forest fires, or floods are to be expected and in anticipation of these events we should undertake research to better understand which preparedness and intervention strategies will be most effective in reducing disaster risk, including the subsequent environmental health impacts. This research must include planning for the emergency response as well as the recovery phase. Interagency disaster response preparedness (DR2) programs are being led by National Institute of Environmental Health Sciences.

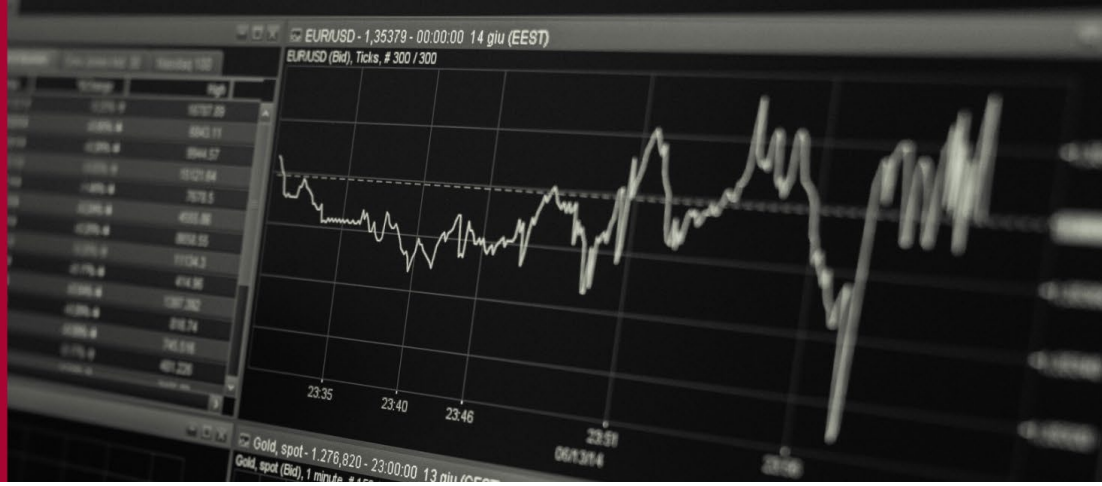
Trevor M. Penning, PhD is the Director of the Center of Excellence in Environmental Toxicology (CEET).

Marilyn Howarth, MD FACOEM is the Director of Community Engagement with CEET.

Idea #18

Redirecting Capital Flows of the Insurance Industry

by Alexander Braun



Current estimates show that the average temperature on earth has already increased by one degree centigrade since the industrial revolution. Anthropogenic emissions of greenhouse gases, such as carbon dioxide, are the major driver of this development, causing temperature anomalies that persist for millenia. Permafrost thawing, extreme weather patterns, ocean acidification, polar cap melting, and desertification are just a few of the irreversible consequences earth could be faced with if mankind fails to take quick and decided action.

Fortunately, during the most recent conference of the parties (COP) held 2018 in Katowice, Poland, nearly 200 nations approved obligatory rules for the measurement and reporting of their efforts to mitigate climate change.

Clearly, a substantial transformation of power generation and manufacturing infrastructures will be necessary to achieve the long-term temperature goal of 2°C. To accelerate this process, global capital flows should be redirected towards low-carbon technologies. The insurance industry could play a key role in this regard, as both an investor and an insurer. This is owed to the classical insurance business model, under which premiums collected from policyholders in exchange for coverage are not kept idle but are put to work in the capital market. This generates an additional source of income for the insurer and is possible, since payouts for insured losses typically occur with delays. Consequently, insurance balance sheets essentially consist of two portfolios: the investment portfolio, which forms the asset side, and the underwriting portfolio, which, together with the equity capital, represents the liability side.

Recognizing their responsibility, numerous insurers and reinsurers have already been proactive and started climate-related engagements such as financing mangrove reforestation, advancing loss prevention, and promoting disaster-resilient and energy-efficient building practices. Mills (2012), for example, discusses 1,148 initiatives from 378 insurance companies in 51 countries. Furthermore, 65 entities adhere to the Principles for Sustainable Insurance (PSI), a voluntary framework introduced in 2012.

Yet, it is unclear how effective these efforts really are. Some firms might simply be window dressing through small-scale investments in green technologies or climate-friendly funds, taking advantage of the positive reputation effects associated with sustainable business policies. A genuine impact, in contrast, will only be achievable if insurers strive for strict carbon-neutrality of their investment

portfolios. This means that they should refrain from investing in the stocks and bonds of companies which generate high levels of direct carbon emissions. The latter are typically from the power production, heavy manufacturing, and transportation industries. Anecdotal evidence indicates that such a change in investment philosophy would likely not be associated with a sacrifice in terms of expected returns. Recent empirical results even point to the possibility of a low-carbon premium.

The potential is huge: estimates for the for the global insurance sector range close to USD 25 trillion in assets under management, which is more than 15-fold the projected private sector gap that needs to be closed to achieve all 17 United Nations sustainable development goals (SDGs) by 2030. A mere partial redirection of this capital could be a substantial accelerator for the transition to a low-carbon economy. As extant sustainability principles are not mandatory and due diligence is associated with information costs for stakeholders, however, there are no strong incentives for insurance companies to free their balance sheets of carbon exposure. Barring a current study by Mielke (2018), the scholarly literature is surprisingly quiet on this matter.

In a forthcoming research article, my coauthors and I propose a new climate-change policy for the insurance industry, consisting of two main elements. First, we harness asset pricing theory to design a rapid test for carbon exposure in the investment portfolios of listed insurers. At the heart of the approach is the EU Emissions Trading System (EU ETS), which limits the total amount of emissions in the economy and requires polluters to purchase greenhouse gas (GHG) certificates, forcing them to internalize the external effects caused by their activities. Since this mechanism puts a price on CO_2 emissions and turns them into a scarce resource, it affects the operating costs of carbon-intensive businesses. Consequently, rises in the price of CO_2 should decrease the expected future profits of polluting companies and, in turn, the prices of their stocks. If this effect exists, it should also leave traces in the stock returns of insurance companies, who hold such assets in their investment portfolio.

To detect potential CO_2 price exposures hidden in insurance balance sheets, we thus suggest extending an existing factor model for insurance stocks by the excess returns on European emission allowances. Through an empirical estimation of the coefficient for this additional "carbon factor," it should be possible to objectively measure the carbon intensity of the constituents of the insurers' investment portfolios. This is important, since actual investment practices may diverge from proclaimed intentions, a problem known as style drift in asset management. In other words, a company might well announce a rebalancing of its asset base to low-carbon positions, but then not fully deliver on its promise. Based on a sample of 35 European insurers, we illustrate the implementation of the model and analyze the time-varying patterns of the carbon factor coefficients (betas). Due to the supposed negative relationship between the price of CO_2 and the stock prices of heavy emitters, higher betas imply less carbon exposure. Most firms exhibit an observable increase in the carbon betas throughout 2018, which is in line with explicit public declarations to decarbonize their balance sheets.

Second, we suggest a number of accompanying regulatory changes. One key aspect concerns the institutionalization of the suggested carbon test and the consequences for firms which exhibit a significant CO_2 coefficient. A straightforward way to tackle this question is an integration into Solvency II. Insurers could, for instance, be obliged to publish the carbon beta in their annual report and their Solvency and Financial Condition Report (SFCR). Stakeholders of the firm would thus have an easy and inexpensive way to evaluate the firms' climate compatibility. Moreover, the results of the suggested carbon test could be utilized for the introduction of an environmental, social, and governance (ESG) label for insurers akin to existing signals and rankings in the investment fund industry. Finally, as a measure of last resort, regulators could contemplate a rebate in the capital charges for insurers with green balance sheets and a markup for those with significant carbon exposures. While an adjustment of risk-based capital standards based on mere political considerations is certainly debatable, increasing carbon regulation and investor scrutiny could indeed change the risk profile of heavy emitters in the medium to long run. After all, empirical research has already documented a comparable effect for the stocks of companies in the tobacco, alcohol, and gambling businesses.

As this climate risk solution is still in an early stage, further research is needed to mature the concept. In particular, the suspected link between GHG emissions and stock returns needs to be better understood. Although equities constitute only a minor part of the typical insurer's investment portfolio (current estimates for the US amount to 12.5%), the potential to drive the shift to the low-carbon economy is still great: as mentioned above, total industry assets are estimated around 25 trillion worldwide. In addition, the relationship between CO_2 exposure and bond returns should be investigated. About 60% to 70% of the investment portfolios of insurance companies consist of government and corporate debt, implying a massive lever if one has a model that can detect bonds of polluters. Finally, the liability side of insurance balance sheets is not covered by the above-mentioned approach. This means that firms may appear to be climate friendly, since they run a low-carbon asset portfolio, although they still insure CO_2-intensive facilities, such as coal plants. Hence, to mobilize an even greater capacity for the mitigation of climate change, the capital flows of both the investment and the underwriting portfolios must be redirected. Although there are no straightforward solutions to these issues, considering the high stakes involved, their further consideration is well worth the effort.

This post is based on the article, Alexander Braun, Sebastian Utz & Jiahua Xu, "Are Insurance Balance Sheets Carbon Neutral? Harnessing Asset Pricing for Climate-Change Policy", forthcoming in the Geneva Papers on Risk and Insurance, which won the 2019 Shin Research Excellence Award of the Geneva Association and the International Insurance Society (IIS).

Alexander Braun is a Visiting Scholar at the Wharton Risk Management and Decision Processes Center.

Idea #19

From EJ (Environmental Justice) to CJ (Climate Justice): The Lessons of Iconic Katrina

by Regina Austin

Although attributing Hurricane Katrina fully to climate change may not be possible, the power of its imagery nonetheless suggests the need to include important considerations associated with environmental justice in the conceptualization of climate justice. Consider three "climate risk solutions" supported by lessons from Katrina the Icon:

- Expand the role of storytellers of all kinds, including not only ethnographers, sociologists, and philosophers, but also visual and literary artists, folklorists, documentary photographers and filmmakers, journalists and nonfiction writers. We need their creativity in conceptualizing climate risk problems that are local, national and global in origins and their experience in imagining and identifying solutions that build understanding and solidarity across races, ethnicities, classes and genders.

- Develop a mechanism and a terminology by which to assign human responsibility for climate harms. We know that those who are most likely to be negatively impacted by climate change and other environmental harms are the most vulnerable and marginalized people, such as racial and ethnic minorities, women, the poor, and persons with mental and physical disabilities. They are members of groups that are typically blamed for their own situations whatever the origin. Alternatively, they are treated like victims of ambush, perpetrators unknown. Confronting climate change requires an assessment of who is creating risks and how benefits are being distributed.

- Train those who, in justice, have a right to be fully involved in all aspects of the actual work of climate risk mitigation, adaptation and substitution and decision making related thereto. Means must be found to maximize the inclusion of disparately impacted groups that have been excluded from roles as "players" in development, climate science and high finance and that are likely to be ignored on account of their lack of "expertise and sophistication." Paternalism borne of conceit is not a substitute for real equitable participation, nor does it facilitate self-representation. Here again tools utilized by diverse reflexive humanistic multidisciplinary academics and artistic practitioners may be helpful.

These solutions draw on the iconic images associated with Hurricane Katrina as captured in documentaries like Spike Lee's *When the Levees Broke: A Requiem in Four Acts* (2006) and *Trouble the Water* (2008). Such films provide an enduring record of what transpired. In addition to

interviews, these films incorporate the visual documentation of the disaster by professional broadcast and print journalists, photographers and videographers, as well as their lay counterparts; the entire body of work had an enormous impact on audiences who were unaware of the extent of environmental injustice or racism in the United States.

The images of the devastation of Katrina spoke louder than words. There were black people trapped on rooftops and in attics, black people floating on makeshift rafts, black people wading in armpit-high water, black people lined up outside the Convention Center, black people begging for food and water with outstretched arms. The government's slow response left these residents of Louisiana, these citizens of the United States of America, to fend for themselves in a way that the federal government surely would not have allowed had they been white, middle-class, and Floridian. The images confirmed that America too can be a failed state if you are a person of color, poor, sick, uneducated and undereducated, or homeless and thus desperately in need of governmental assistance. Because the images made it nearly impossible to attribute the slow federal response solely to bureaucratic ineptitude and partisan cronyism, race, class and the sharp political divide could not be ignored as likely explanations for the tragedy that developed before our eyes.

As the coverage deepened, the audience learned more about the lives of people whose evident distress generated genuine empathy across a broad spectrum of the country. We came to understand that many of the poorest people had not evacuated New Orleans because they lacked private transportation and at the end of the month to pay for gas and other related evacuation expenses. Or they were too sick and infirm to be moved out or too conscientious and caring to leave the weak behind. Or, lacking insurance and other forms of protection against the risk of storms, they feared that their homes and their possessions would not survive the hurricane or the breakdown of social order that might follow if they left behind all they owned for higher ground. We also came to understand that many of the poor people seen on the screen or in photographs lived in the most geographically vulnerable and precarious parts of New Orleans and that what was happening before our very eyes was an environmental justice disaster.

The visual images, and accompanying commentary, of poor and minority people largely abandoned by their government in the wake of the disaster and grossly unprotected by the flood prevention infrastructure and disaster planning had an enormous impact because they captured what seemed to be the pure truth, unmediated by synthetic theories and ideologies. In addition, the media found a way to make the geography of Coastal Louisiana, the engineering of the levee system and the logistics of disaster preparedness and response explicable to a lay audience willing to assign blame.

The story told in the imagery was, of course, more complicated than it appeared. On the one hand, the imagery played into widely-held preexisting suppositions and predilections about the groups from which the victims came, as well as their entitlement to sympathy and tangible

assistance. Consider the heavy focus on poor blacks to the exclusion of poor whites, Latinos, and Asian-Americans and on New Orleanians to the exclusion of other Louisianans and Mississippians. On the other hand, the images confirmed that the storm and its aftermath literally obliterated the context, the causes and extent, of the victims' reduced social and economic circumstances along with the people themselves. They set the stage for the seeming "inevitability" of what followed: Thousands of black New Orleanians were permanently displaced, the city is richer and whiter than it was before, and the federal government has invested in an enhanced flood control infrastructure which many of those forced to weather Katrina will never enjoy.

Climate-related disasters are on the rise. Perhaps the stories told about the Trump Administration's response to Hurricane Maria in Puerto Rico and the Camp Fire's destruction of the working class town of Paradise, California will better grapple with the complexity of those situations and delve deeper and wider into the linkage between environmental justice and climate justice than was done in the case of Hurricane Katrina.

Regina Austin is the William A. Schnader Professor and Director of the Penn Program on Documentaries & the Law.

Idea #20

As We Adapt to Climate Change, Legal Doctrine Must Also Adapt

by Mark P. Nevitt

As climate change destabilizes the physical environment, longstanding legal doctrines are also ripe for destabilization. Today, federal, state, and local climate adaptation measures must be careful to not run afoul of the *Regulatory Takings* doctrine. This constitutional doctrine, designed for a more stable environment, should be looked at with fresh eyes in light of climate change's disruptive effects.

What, exactly, is a Regulatory Taking doctrine and how does it affect climate adaptation?

Under the U.S. Constitution, the Fifth Amendment's Takings Clause states that private property "shall not be *taken* for public use without just compensation." Since the nation's founding, this has prevented the government from *physically* taking private property for "public use." Today, the Takings Clause also encompasses governmental *regulation* of private property, potentially providing a chilling effect for future climate adaptation efforts.

Indeed, the scope of the Takings Clause greatly expanded in 1922 when the Supreme Court held that governmental *regulation*s may also run afoul of the Takings Clause. In the Court's reasoning, a governmental regulation that goes "too far" in diminishing a property's value by a "certain magnitude" will constitute a compensable taking. While climate change disrupts our environment, this vague legal standard has held relatively steady. It will come under closer scrutiny as federal, state, and local governments increasingly look to take forward-looking and innovative action to address climate change. Questions about its applicability arise. For example, does governmental regulation prohibiting the construction of large swaths of vulnerable coastal property exposed to climate change and extreme weather go "too far" in diminishing a property's value? Indeed, offshoots of the regulatory takings doctrine may already be thwarting proactive, well-intentioned, actions necessary to address climate change's future impacts on sea level rise, storm surge, and flooding.

Consider the long shadow of another seminal regulatory takings case, *Lucas v. South Carolina Coastal Commission*, decided in 1992. In *Lucas*, the Supreme Court struck down a South Carolina restriction on the building of property on a coastal barrier island, ruling that the regulation deprived the land of all beneficial use. Since *Lucas*, state and local governments have been fearful of takings lawsuits, particularly for construction limitations on land vulnerable to climate change. Indeed, many municipalities in coastal areas have been reluctant to tackle beach erosion issues exacerbated

by climate change-driven extreme weather. Yet recent advances in climate attribution science connects human activity, climate change, and extreme weather patterns. *Lucas*-stylized regulation will be needed now and in the foreseeable future as we confront sea level rise. But just the looming threat of litigation may be enough to dissuade such climate action, even if it ultimately passes constitutional muster. After all, passing and enforcing such regulations can drain municipalities with crushing litigation costs.

Further complicating matters, state and local governments may seek to withhold municipal services or gradually disinvest from access roads and places uniquely vulnerable to climate change. But this, too, may be subject to a regulatory takings claim as homeowners assert that governmental disinvestment cuts their homes off from the broader community, diminishing their property's value. So governments must walk a legal tightrope between action and inaction.

Where do we go from here?

Governmental action on climate may be able to avoid regulatory takings liability for reasons of emergency or actual necessity. Federal, state, and local legislators should be upfront about the costs imposed by climate change and should tie their actions to the public health, welfare and safety of its citizens. As Professor Cary Coglianese and I have previously argued, we are already paying a climate tax that is "hidden, unfair, and ever-increasing." Legislators should actively engage with advances in climate science and frame their climate adaptation measures as necessary to protect the health, safety and welfare of the community. While climate change is not (yet) a national emergency, legislative bodies should be upfront about the heavy costs imposed by climate change, leaving legislators with only a few options that are necessary to safeguard the welfare of their community.

We are nearly 100 years since the Supreme Court broadened the scope of the Takings Clause. Climate change is dramatically impacting our human environment in new and unimaginable ways, causing cities and states to take forward-looking adaptation measures to meet climate change's challenges. Absent a doctrinal change, the regulatory takings doctrine will increasingly have a chilling effect on bold climate adaptation measures, discouraging courageous climate action. We must fundamentally re-think and re-frame this doctrine to take into account our changing environment. Indeed, just as climate change will force communities to adapt, so, too, must the regulatory takings doctrine.

Mark Nevitt is the George Sharswood Fellow and a Lecturer-in-Law at the University of Pennsylvania Law School.

Idea #21

Incentivizing Local Governments to Manage Disaster Risk More Effectively

by Brett Lingle

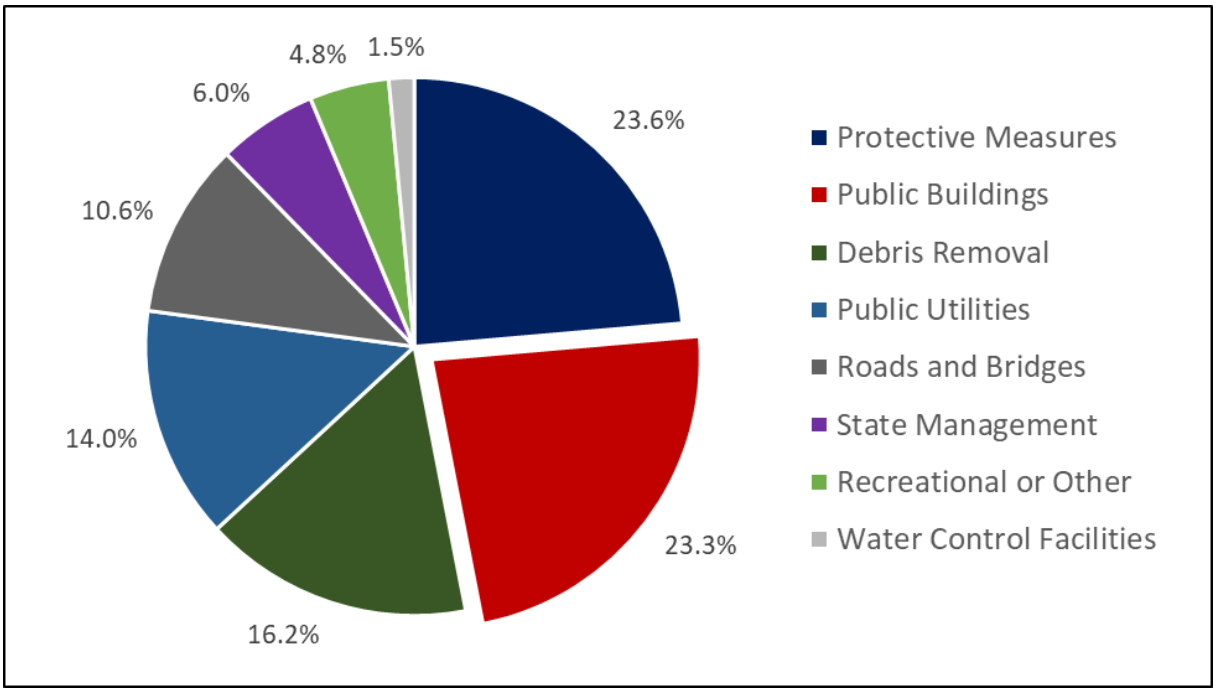
Given the decades-long trend in rising disaster costs and the increasing number of high-cost events, policymakers are increasingly looking for ways to reduce the financial impact on taxpayers. This is especially critical as climate change alters the frequency and severity of extreme events and as Congress increasingly relies on multi-billion dollar off-budget appropriations to cover disaster costs. FEMA has (unsuccessfully) tried to reduce federal costs by shifting more of the burden back to state and local governments through a "disaster deductible." That proposal was met with resistance from some stakeholders, with opponents arguing that it would be too confusing, expensive, and bureaucratic.

To effectively reduce federal exposure to disaster losses and simultaneously encourage local governments to better manage their risk and invest more in cost-effective risk reduction measures, FEMA should widely eliminate assistance for the repair and reconstruction of public buildings, exempting small and financially challenged communities that would not otherwise recover.

The vast majority of FEMA disaster assistance is directed to state and local governments through the agency's Public Assistance (PA) program. The PA program must be authorized by a presidential disaster declaration, after which point FEMA can begin disbursing funds to impacted communities. PA funds are used for two categories of expenditure: emergency and permanent work. Emergency work includes debris removal and emergency protective measures like flood fighting, slope stabilization, and search and rescue operations. It is carried out immediately prior to and after a disaster to protect lives, property, and public health. Permanent work, however, is focused on long term recovery and is used to help restore public facilities to their pre-disaster condition. Permanent work funds are used to repair or replace public buildings and equipment, roads and bridges, water control facilities, utility facilities and infrastructure, and parks and recreational facilities.

Among these various authorized expenditures, FEMA spends more on public buildings and emergency protective measures than other PA categories. From 2000 to 2018, FEMA spent roughly $95.5 billion (in 2018 dollars) on PA. Approximately $22.6 billion was dedicated to emergency protective measures and another $22.3 billion to public buildings. The table below shows the distribution of PA spending from 2000-2018.

FEMA Public Assistance Grants by Category of Work (2018 USD)



Source: Made by the author with publicly available FEMA data

Funding emergency work can be a critical federal role, helping save lives and minimize disruption, particularly in low- and moderate-income communities that may not have enough savings to pay such costs on their own. However, the rationale for federal dollars being use to repair public buildings – known as Category E Public Assistance – is less clear. Category E funds essentially provide free insurance coverage for state and local governments. Public buildings could have been insured instead and then not needed federal taxpayer dollars for repairs. Requiring insurance for public buildings would also send a price signal to local governments about where and how to build safely.

Federal assistance may be justified for roads, bridges, utility poles, and other types of public infrastructure that are difficult and/or expensive to insure. But public buildings *are* insurable. The private sector has insured commercial structures for decades and the commercial buildings currently covered by the private sector are often very similar to municipal buildings. Insurers (including the National Flood Insurance Program) are willing and able to take on these risks. Yet, many communities continue to rely on public funds and forego coverage. Who wouldn't want free insurance?

FEMA does have certain requirements in place to encourage communities to insure some of their assets. For example, as a condition of receiving aid for permanent work, PA recipients must purchase and maintain insurance for the type of hazard that damaged the building (for example,

flood insurance would be required for a flood damaged building). Also, for uninsured or underinsured properties in the FEMA-mapped 100-year floodplain, PA grants are reduced by the maximum insurance payment that would have been received if the building and contents were fully covered by an NFIP policy. These rules aim to make grantees bear a greater share, if not all, of the costs in the case of future events. But according to the Inspector General for the Department of Homeland Security, they have not been adequately implemented.

As another way to force local governments to have a financial stake in the decisions they make about development in hazard-prone areas, PA recipients are generally required to contribute 25% of PA project costs. This also creates some financial incentive to reduce risk pre-disaster. However, in the wake of major events, local cost-shares are often waived or paid by other federal dollars, thereby removing these incentives.

Thus, Category E assistance is likely creating a moral hazard among many state and local governments who, because of their belief that federal funds will be available post-disaster, fail to effectively manage their risk ex ante. The availability of assistance discourages them from taking proactive risk management steps like purchasing insurance or investing in hazard mitigation.

This is especially concerning because, in foregoing such measures, state and local governments may be putting themselves in an even more precarious financial situation since there is not an actual guarantee they will receive assistance—just political precedent. PA is only available when the president issues a major disaster declaration and even then, there is no guarantee that PA funds will be provided. If no Category E funds come through, the community may be left with a damaged building and have to divert local tax dollars or borrow funds for its reconstruction. Slow funding and repairs could also inhibit local provision of essential services such as medical care or emergency services that would be especially critical if another disaster were to strike. In contrast, with insurance in place, funding would be much more certain and the community would receive funds more quickly, allowing them to get critical facilities up and running as soon as possible.

FEMA recognizes the value of insurance and the incentive problems Category E funds create. In their 2018-2022 strategic plan, the agency states: “financial preparedness discipline requires communities to understand and appreciate the risks to public buildings and facilities and to secure insurance to cover the cost of replacement.” That will not happen if Category E funds remain as widely available as they are today.

For these incentives to work effectively, however, the repair and reconstruction of insurable public buildings and equipment must be ineligible for all types of federal disaster assistance. (HUD’s Community Development Block Grant – Disaster Recovery (CDBG-DR) program would also have to be examined for its impacts on local incentives as it has become an increasingly popular distribution channel for federal recovery funds.)

Eliminating Category E would have to be done slowly over time and proper notice must be given to states and communities far in advance so they can implement appropriate risk management schemes and effectively plan and budget for additional disaster costs. For communities or buildings where private insurance may be unaffordable, municipal insurance pools may be a viable alternative. Such pools already exist in every state to help cover uninsurable risks for local governments. These could be adapted so that local governments could mutually insure disaster damages to public buildings.

Eliminating Category E funds could help FEMA achieve many goals it had for the disaster deductible, including: encouraging state and local governments to better plan and budget for disasters; incentivizing hazard mitigation; reducing the costs of disasters and corresponding federal assistance; providing greater clarity on what assistance will be provided when; and make more effective use of taxpayer dollars.

Finally, this solution would not require Congressional action nor statutory changes. FEMA has the authority to implement it through the federal rulemaking process. They should do so thoughtfully and engage state and local governments, but make clear that the change is going to happen and that local decision-makers must do more to protect their communities from future disasters.

Brett Lingle is a Policy Analyst and Project Manager with the Wharton Risk Management and Decision Processes Center.

Idea #22

Rewarding Communities that Build for the Future: A Resilience Policy Score

by Carolyn Kousky

The costs of weather-related disasters have been growing in recent years. Over the past decade, the United States has spent over $200 billion in off-budget supplemental legislation to fund recovery from disasters such as hurricanes, storms, floods, and wildfires. While climate change is worsening many natural hazards, losses are also increasing from our building and land use decisions. Indeed, one of the most impactful policies to mitigate rising disaster costs are under state and local control: land use decisions and building codes.

While there are local governments that have been leaders in incorporating resilience into development decisions (see here for flood examples), many do very little. For flood, communities in the National Flood Insurance Program must adopt minimum requirements (see here and here) but exceeding these is the exception, not the rule. And despite increasing risks, particularly in coastal areas, several coastal states are actually weakening their building codes, despite demonstrated economic benefits (see here).

In part, this is because there is very little financial incentive to regulate development and building: local governments usually claim all the tax revenues from allowing hazardous development, but pay few of the costs when disasters strike. Those costs often fall on the property owner, who may not have adequate information or understanding of the risks, on insurers, if the damage was covered by a policy, or on the federal taxpayer through disaster assistance. Many broader costs to the community from disasters are reimbursed by FEMA's Public Assistance Program and, for large disasters that receive additional Congressional appropriations, through disaster block grants from the Department of Housing and Urban Development or appropriations to other agencies (see here and here).

This misalignment of costs and benefits can distort decision-making. One step to start encouraging local governments to pay more attention to disaster costs is a community *resilience policy score*. This could be used by insurers to offer more competitive rates in higher scoring areas, by rating agencies in assessing bond ratings for hazard-prone locations (as they are starting to do – for example, see here), or by FEMA in allocating disaster aid (such as in the now abandoned public assistance disaster deductible concept). It could likely spur other uses, as well, since, as the saying goes, "what gets measured gets managed."

This would not be a resilience index or set of indicators, as explored in many efforts (see here). Such efforts have raised thorny questions about objectives, measurement, comparability, and subjectivity. Instead, this would be a resilience policy score based on actual public policy, on-the-ground implementation and enforcement, and regulatory decisions made by the local government. For instance, it could include whether model codes for different perils had been adopted, what zoning requirements were put in place in high risk areas, and whether regulations for new development and citing of infrastructure incorporated state-of-the art estimates of increasing risk.

This concept is not without precedent. One example is the Firewise Program. Firewise is a community-level program run by the National Fire Protection Association, a non-profit focused on reducing fire losses. Participants undertake a range of activities to reduce wildfire risk in their jurisdiction; these can be tailored to each community. This program is currently being used by the insurer USAA, which provides discounts to policyholders residing in communities that participate in the Firewise program to reflect their lower risk of losses.

Another program that is similar in concept is the Community Rating System (CRS) of the National Flood Insurance Program (NFIP). The CRS rewards communities with points as they adopt flood risk management measures (different activities receive different point levels), and as they accrue a certain number of points, they reach a new level in the program. Each improvement in level is rewarded by discounts on NFIP policies purchased by community members. One challenge with the CRS, however, is that the premium reductions are not actually reflective of lower claims—instead the NFIP has in place a cross-subsidy from other policyholders to those getting CRS discounts. Also, some communities find participation costly and burdensome.

The resilience rating envisioned here would only be rewarded with lower insurance costs when insurers find they are justified, such as USAA and the Firewise program. That means that the adoption of such a metric would need to be accompanied by studies to document the benefits to insurers, as well as impacts on total losses, disaster assistance, and recovery more broadly, for other users. This could help with the concerns voiced by Breckinridge, for example, that current approaches by rating agencies to incorporate climate risk are not transparent, that their metrics are not necessarily material, and that they fail to fully appreciate the full impact of natural disasters.

Essentially, any resilience policy score, to be influential, would need to be seen as credible, salient, and legitimate (see Cash et al. 2003). For example, the public policies included in the score card and the methodology for calculating and adapting them across a country where areas are differentially exposed to various hazards would need to be seen as technically sound. To be viewed as salient, the score must also reflect achievable policies at a local level and linked, through causal studies, to measurable improvements in recovery. And finally, it would need to be calculated by an independent third-party to be seen as legitimate and unbiased and not able to be manipulated.

There are a number of questions that must be answered before a resilient policy score could be created. For instance, should the scores should vary by region or state to reflect variations in hazards and state level policy that influences building and development? Could it work with systems already in place, such as CRS and Firewise? A team of interdisciplinary scholars could tackle the challenges in collaboration with potential user groups to create a useful measure of community policy that could help align incentives for cost-effective investments in risk reduction.

Carolyn Kousky is Executive Director of the Wharton Risk Management and Decision Processes Center.

Idea #23

Climate Change as a Political Problem

by Michael Jones Correa

The science of climate change points overwhelmingly in a single direction: the data show that the Earth is gradually, inexorably warming, with unpredictable consequences for humans (see here and here). Though we might expect some disagreement about possible responses, that there should be *some* kind of coordinated policy response seems clear from the data. However, agreeing on a response has been difficult, certainly across nations and particularly in the United States, where agreement on the scale of the problem or even the existence of human-led climate change remains unresolved, at least politically. So why is climate change such a difficult *political* problem?

In liberal democracies the politics of climate change are exacerbated in two ways. The first has to do with the democratic political system, which operates on the short time horizon of elections, complicating policy decisions regarding social and natural processes with much longer time horizons (say decades rather than years), and for which the policy consequences may be quite serious, not to say catastrophic, but far removed from the political timeframe. The second is the increasing fractionalization of politics, with representatives and voters sorting themselves into mutually exclusive ideological camps, and seeing their partisanship as an important part of their identities.

Election cycles in liberal democracies— every two years in the US House of Representatives—mean that elected officials, who can be characterized as "single-minded seekers of re-election," pay attention to the near future rather than the longer-term time horizon of issues such as climate change, whose full effects may not be felt for decades. In theory, short election cycles make representatives sensitive to public opinion, however, the public's stance on issues seems increasingly driven by voters' partisan identities. There is quite a lot of evidence indicating that in the United States the public takes positions 1) that follow the positions adopted by elected officials of their own party, 2) that express their alignment with their party (see, here, here, here, and here); and 3) that are the contrary of positions taken by partisans of the opposing party (see here, here, and here).

Partisan polarization shapes debates around policy issues ranging from gun control to immigration to climate change. In particular, partisanship as a social identity contributes significantly to motivated reasoning: when individuals are confronted with information that accords with their preexisting beliefs they easily accept them, but when new information cuts against existing beliefs, it is subjected to intense scrutiny (see here, here, and here). Motivated reasoning makes

persuasion through the provision of new information or reasoned debate exponentially more difficult (see here, here, and here).

There is some indication, however, that politically fraught topics such as climate change can be fruitfully addressed. One avenue is to remove the topic from a partisan framework, with impartial actors providing information, and providing spaces for participants to listen to and engage with the views of others in ways that do not denigrate their sense of self-worth. In addition, people may be persuaded to re-examine their positions on issues through the introduction of external shocks or focusing events (see here and here). As the effects of climate change become more evident in people's daily lives, this may well lead to a re-evaluation of their views, and an increased willingness to consider policies to address these changes. Broader shifts in public opinion may be accelerated if spurred by congruent shifts in elite opinion. As public opinion changes, so will politics. Finally, in many liberal democracies, even if policy change is blocked in one venue, change can be pursued in others. For example, even as national level institutions in the United States have been resistant to addressing climate change, states and localities have been more successful in implementing a range of strategies.

In sum, climate change is as much a political problem as it is a scientific or technical one. The short time horizons of democratic politics and the partisan polarization of public opinion have stymied climate policy debate and implementation. Finding ways around these obstacles is key to working toward any climate solution.

Michael Jones-Correa is the President's Distinguished Professor of Political Science and Director of the Center for the Study of Ethnicity, Race and Immigration (CSERI) at the University of Pennsylvania.

Idea #24

Design and Planning for Multi-Use Renewable Energy Infrastructures

by Nicholas Pevzner

A major challenge of the renewable energy transition is renewable energy's much larger spatial footprint on the landscape compared to fossil fuel energy sources. Renewable energy has less energy density compared to coal, oil, and gas, raising questions about the extent of physical space required to deploy the amount of renewable energy generation that is needed to achieve deep decarbonization. Theoretically, this kind of buildout of U.S. renewable energy generation infrastructure is physically possible — the constraints are social, economic, and political. In practical terms, the scaling up of renewable energy generation will create substantial conflicts over land use, which could potentially slow down the energy transition at a time when it in fact needs acceleration. In some states, renewable energy has already come into conflict with forestland or prime farmland as those states pursue aggressive targets for renewable energy development, raising public concerns and preventative policy changes.

Such conflicts can be reduced through careful design and planning, in which renewable energy is deployed across the landscape in a manner that co-exists with other land uses, and enhances rather than competes with them. Numerous examples of wind energy coexisting with agriculture and rangeland (in Texas, for example) point to the potential for beneficial coexistence of this spatially intensive energy technology with farmland. Photovoltaic solar arrays can similarly complement, rather than compete with, agricultural and grazing land. Seven states have adopted pollinator-friendly solar standards that promote the planting of bee and pollinator habitat under and around PV panels; other solar co-location projects have proven the benefit of combining solar photovoltaic with ranching and grazing of sheep or cattle, or with other kinds of agricultural production. But combining energy development with other productive land uses, whether for agriculture or pubic space, is a task that needs careful design and planning, so that both functions can benefit and conflicts can be avoided.

Another strategy for reducing land use pressures and avoiding land use conflicts is renewable energy development on brownfields, including landfills, mine sites, and other contaminated lands. With the addition of renewable energy generation, many of these sites have gained new productive uses, but with careful participatory design and planning some of these sites could be pushed even further in providing community amenities after comprehensive cleanup and decontamination.

The strategy of design and planning for multiple uses carries over to the design of related infrastructure — most importantly, energy transmission infrastructure. Meeting national carbon

targets in the U.S. will rely on a sizeable expansion of new long-distance high voltage transmission capacity, as my colleagues here have noted. Currently there is strong social opposition to new power line construction from landowners and municipalities along the route; a potential avenue for increasing social acceptance of transmission lines can be found through the creation of high-quality public landscapes in the rights-of-way of these power line projects. Multi-purpose infrastructural transmission corridors already provide well-used outdoor recreation in Seattle, for example, where the municipally owned utility co-developed the transmission line with a light rail project and with hiking and bike trail infrastructure. If designed well, these new multifunctional trail networks could connect the American public to their nearby wild lands, be an amenity for recreation and economic development, while supporting the push for a cleaner energy grid.

Public participation in the infrastructure planning process has the potential to reduce public opposition and potential litigation, but all too often, the public is confronted with energy infrastructure projects once virtually all design decisions have been settled, with little public consultation. The public participation early in the planning and development of the Middelgrunden wind farm just off the coast of Copenhagen, along with public investment and cooperative ownership, offers a classic case study in how careful project design can win widespread public support for energy infrastructure development, despite the proximity and visibility of the energy project to some of the most culturally important sites in Copenhagen.

The state of California has deployed spatial planning in its attempt to limit land use conflicts over renewable energy development by issuing its Desert Renewable Energy Conservation Plan (DRECP), which streamlines renewable energy project permitting while steering energy development away from sensitive wildlife conservation areas, using a multi-stakeholder process. In the Netherlands and Denmark, municipalities have gone further, developing detailed spatial plans for proactively accommodating wind turbines as a visual layer of the rural cultural landscape, alongside agriculture and urban development.

Of course, transforming the energy sector on its own is not enough to reduce emissions as deeply as is necessary for full decarbonization by midcentury, but it is a necessary component of the larger strategy known as "electrify everything," in which other sectors like transportation, heating, and industry switch as much load as possible from combustible liquid fuels to electricity, in order to be ready to take advantage of the rising share of carbon-free electricity on the grid. The second step in the electrify everything strategy is actually deploying the renewable energy generation and storage capacity to decarbonize the electricity supply.

As more energy infrastructure gets planned close to the places where more Americans live, work, and play — both renewable energy generation infrastructure and transmission infrastructure — careful design for co-location and mutually beneficial multiple uses will be key to avoiding land use

conflict, reducing NIMBY opposition, and winning public support for these necessary pieces of infrastructure.

Nicholas Pevzner is a full-time lecturer in the Department of Landscape Architecture at the University of Pennsylvania Stuart Weitzman School of Design, and is Co-Editor-in-Chief of Scenario Journal.

Idea #25

Mandating Disclosure of Material Climate Risks and Mitigation Strategies

by Witold Henisz

According to the most recent National Climate Assessment of the United States government, the material impact on the US economy alone of inaction on climate change is over $500 billion, but this could be reduced to $220 billion if appropriate policies are implemented. Firms facing such a range of material risks from climate change and potential remediating policies should have to disclose those risks and their mitigation strategies in their publicly audited financial statements. Investors and creditors should incorporate that information in their analysis of future cash flows. While support for the recommendations of the Task Force for Climate-related Financial Disclosures (TCFD) continues to grow, voluntary compliance is leading to only partial and selective reporting. Without more data transparency, investors and creditors lack the information needed to assess laggards from leaders in their response to climate change risks.

To date, only France has codified disclosure of climate change risks into law with the European Union, actively assessing an update of its non-financial reporting directive to include the recommendations of the TCFD. An important policy-relevant and solution-oriented idea that could alter the current trajectory of emissions and improve our collective ability to adapt to that trajectory would be for the United States Securities and Exchange Commission and/or the New York Stock Exchange to mandate additional data disclosure for publicly traded companies on their sensitivity to climate change risks.

From 2012 to 2018, there has been a dramatic increase in the share of global assets under management that actively weight Environmental, Social and Governance (ESG) issues, with investment surging from $13.5 Trillion (21% of total global Assets Under Management) to $30.7 Trillion (39% of AUM). The share of executives, board-members and investment managers who perceive ESG issues to be material has doubled over the same time period (see here, here, here, and here). Numerous high profile convenings of business, financial, and public sector leaders[1] have also highlighted the need to take a longer-term perspective on corporate performance that recognizes the medium- to long-term risks generated by imposing environmental (and social) externalities on society as well as the long-term opportunity for business and society offered if business were to devote greater attention and resources to large societal challenges such as climate change. (Examples of such convenings include Focusing Capital on the Long Term, the Embankment Project of the Coalition for Inclusive Capitalism, the Sustainable and Responsible Investor Forum, the Bloomberg Sustainable Business Summit, and the Global Responsible Investing Forum.)

Numerous triggers and stimuli have fueled these trends. ESG issues—which have long motivated values-based investors, managers and employees—are increasingly perceived as impacting value (i.e., being material). Interest in ESG issues by asset owners and managers continues to climb, spurred on by high profile letters to investees by Black Rock, State Street and Vanguard as well as the rise of activist ESG hedge funds such as Jana Partners, Blue Harbour Group, Impactive and Apache Capital Management. Millennial investors, customers, and employees are also placing greater emphasis on ESG issues, as compared to preceding generations. Approximately half of millennials expect CEOs to speak out on issues such as air and water quality, renewable energy, climate change, sustainability, land conservation, among others. Millennials also say that they would reward such companies with greater loyalty as employees, greater purchasing as customers, and a greater share of their investment portfolios. More generally, the growing effects of climate change have triggered a reappraisal of corporate purpose and the role of business in society.

Yet, at the same time that financial and human capital turn their attention to ESG issues, executives, board-members and investment managers are growing less confident in the data that they have to evaluate such issues (see here and here). The weaknesses of scoring companies' voluntary unaudited sustainability reports or their responses to exhaustive surveys are increasingly apparent (see here and here). ESG scores across proprietary data providers exhibit low inter-rater reliability and frequently omit, or incorporate with a lag, material environmental, social and governance factors. Academic and corporate research seeking evidence of the materiality of ESG factors using this data has been inconclusive.

Recent innovations in data and analytics have the promise to help demonstrate the materiality of ESG issues and the efficacy of management strategies to identify and mitigate risks as well as seize opportunities. ESG data providers are turning from voluntarily released corporate reports to myriad new sources of real-time information on stakeholder actions and statements in their efforts to rate companies and provide valuable signals on their idiosyncratic risks and opportunities to both active and passive investors. Data sources include media and social media monitoring; text analysis of speeches, press releases, and other public documents; corporate and individual political contributions; regulatory, administrative, and legal records; satellite photography; customer reviews of products; and employee reviews of employers. While academic research using these new data sources is generating promising evidence of an investor case for addressing ESG issues, data limitations remain the greatest impediment to amassing an evidentiary base that could contribute to a shift in behavior.

Were the US and EU to mandate such disclosure, investors and creditors would have comparable information on firms' exposure and mitigation strategies to the material risks of climate change. Greater transparency in the magnitude of risks and opportunities would lead to improved allocation of financial and human capital seeking only financial returns as well as the growing pools of such capital seeking to contribute to climate risk mitigation and adaptation.

Witold (Vit) Henisz is the Deloitte & Touche Professor of Management in Honor of Russell E. Palmer, former Managing Director at The Wharton School, The University of Pennsylvania.

Idea #26

Consider Project Risks When Designing Adaptation and Mitigation Projects

by Matthijs Bouw

Although the magnitude and precise impacts of climate change remain uncertain, it is clear that urban environments play a critical role in climate change mitigation and will necessarily be at the forefront of adapting to climate-related risks. Urban areas, home to more than 50% of the world's population, account for more than 70% of CO2 emissions. Improvements in building design, land use and transportation planning, as well as the transition of urban energy systems, should all contribute greatly to the reduction of CO2 emissions.

Mitigating and adapting to climate change demands a fundamental transformation of our urban environments. As we have learned in the wake of Superstorm Sandy, the design and engineering of major climate adaptation projects such as the Big U and its follow-up projects impact much more than the coastal infrastructure that serves as their original motivation. These projects provide opportunities for rethinking drainage and wastewater infrastructure, transportation networks, open space, and ecological systems – and their integration with neighboring communities and their priorities. We have also come to understand that each project is part of a suite of projects that must work together, laying the groundwork for further growth and adaptation as the pace of climate impacts increase and become more evident.

As we have learned in the U.S., but also in the Netherlands, planning, implementing, and designing such projects is not easy. After a major flood in 1953 that inundated much of the Southwestern Rhine/Meuse/Scheldt delta and killed approximately 2,000 people, the Netherlands built a massive flood measure to reduce the risk of inundation to an 1/10,000 annual probability. Devised by the engineers of Rijkswaterstaat, the Dutch Department of Waterways and Public Works, the Delta Works were originally envisioned as a series of dams which would close off all the estuaries with the exception of the Nieuwe Maas, and the Oosterscheldt, such that the ports of Rotterdam and Antwerp would remain accessible.

After most of the dams were constructed, it became clear that the original plans needed to be ameliorated. The closed-off estuaries suffered from ecological degradation. At the same time, scientists and the public increasingly recognized the ecological value of the delta. As a response, the final dam, at the Oosterscheldt, was designed to be partly closed, with operable panels that could open to allow tidal flows. The Delta Works exemplifies how a large-scale project with a singular goal (flood protection), conceived and executed by a single expert group without community participation led to adverse large-scale effects in other realms.

Subsequent generations of Dutch flood protection projects have moved beyond the singular focus on damage mitigation, **toward a value system with multiple goals**, including ecological value and spatial quality. Programs such as 'Ruimte voor de Rivier' (Room for the River) also allow for a more flexible approach to flood protection standards, ultimately resulting in a series of smaller, more adaptive solutions. Integrated programs such Room for the River take time. Originally conceived as a landscape design competition proposal in the mid-Eighties, it took about 25 years of planning and 10 years of implementation to achieve its recent completion, despite occurring in a country with governance and funding in place.

Given the speed with which we see our climate changing, the necessity to mitigate and adapt does not provide the luxury of time. The margins of safety for building in flood-prone areas, established in the relative stability of the 20th century shorelines and sea levels, are rapidly becoming obsolete. At the same time, it is also clear that mono-functional projects do not work. The design of climate mitigation and adaptation projects must account for long time-horizons, allow flexibility to address uncertainty, work across systems, and seek out opportunities for expedient implementation – while elevating the diversity of stakeholder voices and concerns and seeking to create equitable benefits for the communities they aim to protect.

This is why at the Stuart Weitzman School of Design we have introduced the concept of 'Project Risk' to complement the concept of 'Global Risk' when designing climate mitigation and adaptation projects. In one class, author and Penn IUR scholar Peter Hendee Brown listed some common 'project risks', such as funding risk, approval risk and political risk but also economic cycle risk and failure risk. Taken together, project risks are those risks that can keep a project or a program from being implemented, or from performing well. The urgency of the climate crisis requires an understanding that strategies to mitigate 'project risk' are equally important as developing tools to mitigate 'global risks', especially because we operate in a market-based society, where considerations of 'project risk' weigh heavily on our ability to adapt and mitigate.

In our 'Design with Risk' class, we explored the agency of design in mitigating, or building resilience to, 'project risks'. Such an approach to risk reduction 'by design' begins with considering several straightforward examples. Elevated coastlines that protect from coastal flooding can be designed as parks that also function as social infrastructure, reduce urban heat, and act as stormwater filters. Designing for multiple benefits reduces political risk and funding risk, and can serve as a good example of how to be integrated and resourceful.

Such projects, which attempt to integrate multiple functions in a new solution for a new set of (climate) challenges, bring with them new risks. Not only construction risk and failure risk, as we have seen with the Dutch examples, but also governance risks. Implementing and operating agencies are often not yet equipped to manage, and therefore accept, such integrated projects. Using pilot projects, projects designed to be broken into smaller, manageable pieces, makes it

possible to learn from the first pilots or phases and improves flexibility. Designing projects such that they have the possibility for phased implementation, or the re-assessment of the components, reduces market and economic cycle risks, and make projects more robust, with better use of resources.

Students in the course learned that design must encompass both the physical and the social, to operate as a tool not only for connecting different systems, but also for improving the enabling environment: the institutional arrangements and rules that govern climate adaptation. Part of that is normative, by designing exemplary solutions to climate adaptation and mitigation that can influence the arrangements and rules, but part is also practical, from the design of a certain software to the design of projects such that stakeholders are better able to take them up, run with them and learn from them, and as such reducing, for instance, approval risk, procurement risk and political risk.

Design's capacity for communication is an important element in all this. This does not start with the communication during the project development itself, where models, renderings and diagrams can help stakeholders and communities weigh in with their expertise and concerns. Visual tools are also extremely helpful in effective risk communication, and critical to help stakeholders overcome the daily concerns and behavioral biases that so often make collective action and long-term stewardship difficult. The development of apps, games and other tools for inclusive risk communication and engagement in class can help reduce the political risk that often stands in the way of implementation,

Linking strategy to implementation is a critical step in addressing the climate crisis. Our research in class allows us to build and expand our design toolset for mitigating project risks and developing project resilience, and thus foster the ability to implement climate adaptation and mitigation strategies.

Matthijs Bouw directs the Urban Resilience Certificate program at the Stuart Weitzman School of Design, where he is an associate professor of practice. He is the founder of One Architecture & Urbanism, an award-winning Amsterdam and New York-based design practice that is involved with flagship climate adaptation projects in the US, Latin America and South East Asia.

Idea #27

Business Must Get Political - For Climate Sustainabilty

by Eric Orts

Most business firms don't like to "get political" unless they are threatened with an adverse law or regulation. As Richard Epstein noted when predicting that the Supreme Court's holding in *Citizens United* would not spawn unprecedented amounts of political spending by business corporations, it's rational for most firms to stay neutral in order not to provoke consumers, employees, investors, or other key stakeholders who are likely divided on various political issues.

With respect to climate policy, we have, therefore, seen business interests active mostly on only one side of the debate. Large oil, gas, and coal firms whose business models and future profits depend on the continued acquisition and burning of fossil fuels have been highly incentivized to act politically – though partisan campaign contributions and lobbying – to prevent policies for climate sustainability. Most notorious are the Koch brothers, who have piled huge amounts of "dark money" into a political agenda designed to forestall climate regulation in order to protect profits for their oil-based business. They have followed a strategy of putting "democracy in chains" and been a principal early sponsor of climate science denial. Infamously also, ExxonMobil has also been caught using a similar strategy of denying climate risks even though its own scientists had many years ago identified the climate problem as real and dangerous.

At the same time, most business firms and business leaders have not engaged politically on climate issues – or at least not with sufficient weight to overcome the influence of the deep pockets of the fossil fuel industry. Under these circumstances, it is imperative not only for businesses who may profit from recognition of the climate problem, such as firms focused on renewable energy, energy efficiency, or insurance, to "get political." It is necessary also for business in general to get involved.

The reason is that the climate crisis imperils the very foundation of global civilization. Business must therefore become part of the solution rather than only part of the problem on a political as well as an economic level. An analogy might be drawn to World War II. In a global crisis, business must choose sides: fascism or democracy, climate sustainability or climate catastrophe. And it's clear that time is running out. As climate scientists have now warned authoritatively, we have only about a decade in which to reverse the current trajectory that we are following toward "an uninhabitable earth."

There are positive signs that business is beginning to get it. The Business Roundtable of CEOs of many of the largest companies in the world have just released a statement that promises to

"protect the environment by embracing sustainable practices across our businesses." The devil will be in the details, but this new statement of business purpose at least opens the door to political engagement for climate sustainability. Several large automobile companies have also recently taken the laudatory and unusual step of rejecting the current U.S. administration's offer to reduce fuel efficiency standards, and agreeing instead to "do the right thing" (as I was one to advocate) and to comply with California's stricter, more climate-friendly fuel efficiency standards.

Business must do more. When faced with a potentially civilization-ending challenge, it is not sufficient for business leaders to shrug their shoulders and say something like: "Climate is an externality that government should regulate. We will of course follow the law, focus on our own operations, and try to reduce our carbon footprint. But it is not our job to engage more broadly on the policy issues. That's the role of government not business." Instead, on some issues of greatest importance at least, business must adopt an approach of what one prominent group of business professors has called "corporate political responsibility."

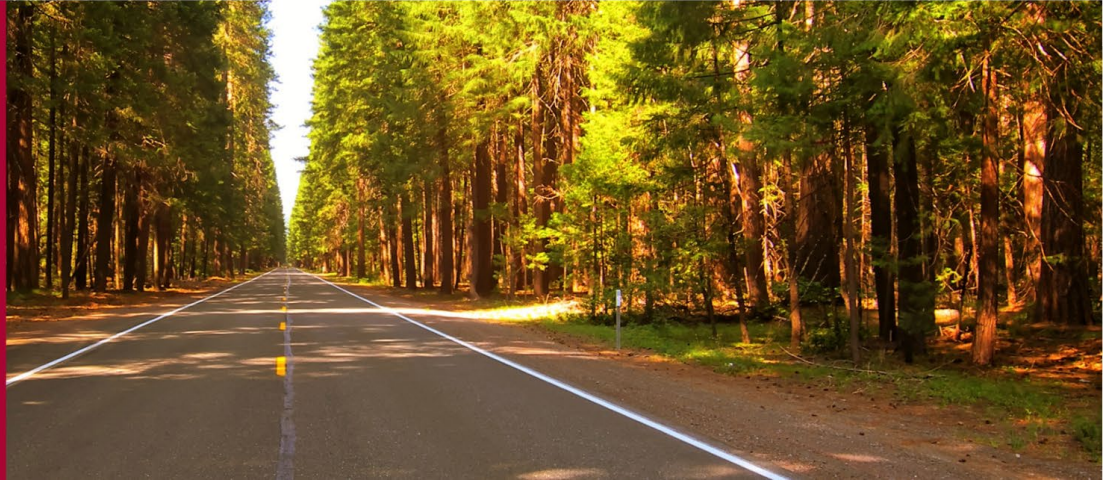
Business leaders and investors of all stripes need now to consider the interests of our children and grandchildren. They need to come together to counter the influence of reactionary business forces that have captured political positions of power and retarded the development and adoption of effective climate policies. Business must get political to help save our civilization from climatic self-destruction.

Eric W. Orts is the Guardsmark Professor of Legal Studies and Business Ethics at Wharton and faculty director of the Initiative for Global Environmental Leadership.

Idea #28

Design and the Spatial Politics of Climate Change

by Billy Fleming



We are living through a period of once-unfathomable hope on climate change. It can be hard to notice at times, as we watch the Amazon burn and we careen from disaster-to-disaster in the United States—including Hurricanes Maria, Harvey, and Irma, as well as the recent California wildfires and Midwestern flooding—without a response to match the scale, scope, and pace of the devastation.

But beneath the surface of these devastating global events, grassroots movements—led by organizers in the Sunrise Movement and newly-elected Members of Congress like Rep. Alexandria Ocasio-Cortez—are shifting the parameters of what's possible in a national mobilization around climate change. They rightly recognize that the greatest risk to the future of this country is that we'll continue searching for small, technocratic fixes to a system in need of complete transformation.

This isn't to say that those technocratic fixes aren't important—indeed, amending the National Flood Insurance Program, instituting a carbon tax, and creating new financial instruments to catalyze clean energy investments are all vital components of a national response to the risks posed by climate change. But on their own, they are no longer a sufficient means of dealing with the climate crisis. They must be paired with big, structural reforms to how and where we live. Put another way, we have to redesign the planet for a new, novel climate that we've helped create.

The greatest risk to the future of the United States is that we'll continue tweaking the system that produced climate change rather than transforming it.

How might we mobilize and expand the organs of government to accomplish something like this? Whether through the framework of a Green New Deal or some other yet-to-be defined national response that is scaled to the challenges of climate change, there are a number of ways the federal government can lead on the dual tenets of decarbonization and adaptation. And because I tend to see the world through the buildings, landscapes, infrastructures, and public works that national-scale investments create, that's also where I see tremendous opportunity for government to lead on climate. Though this work could unfold across a number of agencies in a variety of ways, four particular ways of dealing with climate risk can be tied to the Departments of Transportation, Housing and Urban Development, Interior, and the Environmental Protection Agency.

This work can begin with a 10-year moratorium on new highway construction—a $200 billion program (nearly $1 trillion when leveraged). Not only are the materials involved in the construction themselves massive sources of carbon emission, but nearly 20 years of transportation engineering research has shown that building these new roadways does not alleviate congestion—it increases it, through induced demand, leading to more vehicle miles traveled and more carbon emissions in the transportation sector (already our biggest emitter). This moratorium would give the Department of Transportation the opportunity to maintain the massive highway system we already have, to deconstruct more of the urban freeways that destroyed neighborhoods during the urban renewal era, and to invest the bulk of the savings in new low or no-carbon transport systems, including Bus Rapid Transit, light rail, commuter rail, and high-speed rail.

As part of a broader, green industrial policy initiative, the Department of Housing and Urban Development could also begin to condition its funds—including, but not limited to its Community Development Block Grants program—on a new set of carrots to reshape land use patterns in communities throughout the U.S. This could include requirements that municipalities eliminate carbon-intensive parking minimums, invest at least 10% of their total budget in building new low-carbon public housing and retrofitting their existing public housing stock for maximal low-carbon outcomes, and abolishing single-family zoning districts in their comprehensive plans.

As Senator Elizabeth Warren first proposed, the U.S. Department of Interior (DOI) could also fundamentally reshape the management of public land towards new goals that de-prioritize the extractive goals of oil and gas exploration and instead invest in decarbonization and biodiversity aims. This could include a rolling moratorium on oil and gas exploration on all public lands, as Warren has proposed. But it should also be tied to a drastic rollback in timber operations across these landscapes—a practice tied to the concept of sustainable yield, in which forests are mined at the highest level possible without triggering an ecosystem collapse. Instead, DOI could reorganize their land management goals around maximizing carbon sequestration *and* biodiversity—both of which would require an end to the pine plantation forests of the Southeast and a new investment in more complex, multi-species forests and landscapes. DOI could even tie the new management of these public lands to a jobs guarantee—a form of transition assistance for whatever timber and oil/gas industry jobs are lost due to their managerial reforms.

Finally, the Environmental Protection Agency (EPA) could dramatically expand its brownfield and Superfund (CERCLA) remediation programs around a central goal of the Green New Deal: to clean-up every single toxic site in the United States. Not only would this open up new land for other social goals like public housing and parks, but it could serve as a 21st century equivalent to the Civilian Conservation Corps—in this case, a jobs guarantee program tied to the clean-up of polluted sites that could take a generation or more to complete.

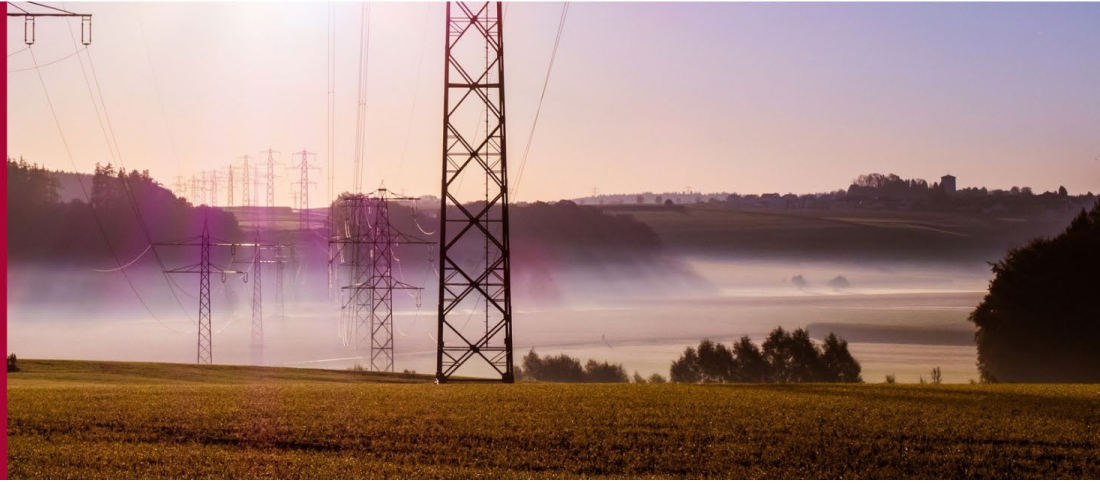
When it comes to mobilizing a national response to the risks posed by climate change, there's no time to spare.

Billy Fleming is the Wilks Family Director for The Ian L. McHarg Center at the University of Pennsylvania Stuart Weitzman School of Design.

Idea #29

Addressing Climate Change at the Edge of the Grid

by Charles Howard



That buzz you're hearing from your utility's nearby pole transformer is coming from something more than its high use in the late summer heat. In the Northeast, the Midwest, and increasingly across the country, climate change is being addressed by transformational changes happening at the grid's edge, part of a fundamental shift in how electricity is generated, transmitted, and sold, which collectively is helping to decarbonize the entire system.

However, potentially impeding this particular energy transition in the U.S. are ambiguities in certain provisions of the 1935 Federal Power Act (FPA) which dictate who controls the economic terms of various transactions on the grid: the Federal Energy Regulatory Commission (FERC), or the various state public utility commissions (PUCs). This uncertainty is further amplified in FERC's and some PUCs decisions to assert (or decline to assert) authorities that might arguably be in the other's exclusive province under the FPA. Finally, this is playing out in the political context of the stark difference between the aggressive steps that some states are taking to lower the carbon footprint of the grid, while those currently at the top of the federal government and some other states nominally deny any connection between human activities and climate change that requires immediate action, a viewpoint they are pushing with all seemingly available levers.

Under our constitutional system (including the Supremacy Clause and principles of preemption), state action is typically trumped by any conflicting federal law (including regulations and FERC orders); thus any uncertainty over which government agency has jurisdiction over a particular decarbonization measure at the edge of the grid may discourage any business model that might implement it.

Following is a brief review of some of these measures at the 'edge of the grid;' and the regulatory impediments to these developments created by the jurisdictional ambiguities in the FPA. It then joins the call of some commentators that FERC (which, after all, is supposedly independent from the Executive branch) should explicitly, prudentially, recognize that the FPA does not mandate its jurisdiction over the various economic relationships that are developing at the grid's edge, much as it did for transmission rates that are bundled into PUC-regulated retail sales in its groundbreaking, market opening (and Supreme Court upheld) 1996 Order 888.

Where Is, And What's Happening At, The 'Edge Of The Grid'?

From the early 20th Century through its last several decades, typically one local utility (often an "investor owned utility," or "IOU") provided all your electricity needs, from generation (including frequency regulation, 'black start' capabilities and other ancillary services, as well as energy) (G) through transmission (T) and distribution (D) to final delivery at your meter for consumption (C). It was a one-way flow which ended up at your meter, the "grid's edge," where historically, regulation stopped and your individual use of the electricity began.

Today, consumers (residential as well as commercial and industrial), equipment providers, private investors, and regulators are bringing together new technologies, financing structures, and legal relationships (regulatory and contractual) to build new facilities and set new relationships close to, and on either side of, the grid's edge. Examples of these new facilities and relationships include:

- Distributed G, including relatively small solar, wind, and biomass generation facilities), interconnected on the D system, as well as consumer owned/controlled 'behind the meter' G (e.g. net metered facilities which set off a customer's G against its C, at the retail rate), nominally off the edge of the grid,

- Battery storage, also on either side of the grid's edge, capable of providing G for at least short time periods, including utility sale storage facilities and (at some point in the future), aggregated, parked and plugged-in electric vehicles,

- Microgrids, combining multiple, adjacent small generation units and consumers, often joined with a small central power plant (often combined heat and power), which can decouple from the grid and remain operational in the event of grid disruptions,

- Voluntary, aggregated, legally binding limits on C that are verifiably beyond what that C otherwise would have been (demand response), which can be bid into the wholesale market as G (since a MWHr not consumed (a "negawatt") is as valuable to the grid as having to procure a MWHr), and are often cheaper to obtain,

- Similar aggregation of G ownership 'in front of the meter' facilities (e.g. community solar), and

- A more dynamic D system overall, in part resting on widespread deployment of "smart meters" able to respond to complex changes in local G and C behavior in real time, necessary to enable much of the above.

With respect to climate change, collectively these developments can provide:

- Mitigation, by reducing the grid's carbon footprint through lessened peak demand (which typically require the dispatch of the most expensive, and typically dirtiest G units (e.g. oil and diesel "peakers"), and increased deployment of renewables, and

- Adaptation, by increasing resiliency against grid disruption (G, T, and C) from storm events and other new weather patterns.

Additionally, this diversification of G and D (and potentially lessened need for new T) allows each of us to provide both G and C, thus becoming a "prosumer," a growing trend in the U.S. and across the globe. Finally, it also improves the grid's ability to survive other challenges, including natural ("Carrington event" solar flares) and manmade insults (cyberattacks and worse).

Regulatory Challenges, or "Is the 'Edge of the Grid' Anywhere Near The 'Attleboro Gap'?"

In the earliest years of the grid's development, the typical IOU owned all of G, T, and D, all of which was all confined to one state, and its rates were supervised by that state's PUC. Over time IOUs began buying and selling power from neighboring IOUs to fill temporary gaps in their generation needs. In the seminal 1927 decision *Pub. Util. Comm. of Rhode Island v. Attleboro Steam & Electric Co.* the Supreme Court held that the Rhode Island PUC's assertion of ratemaking authority over an interstate sale of power to a Massachusetts utility violated the Dormant Commerce Clause of the Constitution, and that "such regulation . . . can only be attained by the exercise of the power vested in Congress," which had not yet occurred.

In 1935 Congress filled the revealed *Attleboro* gap with the FPA, which set out a federal/state division of ratemaking authority that made sense for the grid of siloed, vertically integrated IOUs that existed over 80 years ago:

- Federal: The FPA granted FERC (then known as the Federal Power Commission) exclusive jurisdiction over "the transmission of electric energy in interstate commerce" and "the sale of electric energy at wholesale in interstate commerce," including the power to ensure that rates "for or in connection with the transmission or sale" of electricity at wholesale are "just and reasonable" and must be "not unduly discriminatory or preferential." 16 U.S.C. §§ 824(b), 824d(a), 824e.

- State: Section 201(b) provided that FERC "shall not have jurisdiction [except as specifically otherwise excepted] over facilities used for the generation of electric energy or over facilities used in local distribution or only for the transmission of electric energy in intrastate commerce, or over facilities for the transmission of electric energy consumed wholly by the transmitter." §824(b)(1). Additionally, Section 201(a) of the FPA reserves to the states jurisdiction over all grid matters not specifically given to FERC, understood by various Supreme Court decisions and FERC orders to include retail sales and intrastate wholesale sales (see here).

The problem today is that many of the grid edge innovations discussed above can arguably be viewed under the FPA as falling in to one or the other of these two categories, and thus subject either to federal or state jurisdiction.

- Should the formula by which a particular state values excess G from a net metering project – retail or wholesale rate – determine whether it is subject to FERC or PUC jurisdiction?

- Should aggregated demand resources (which reduce retail load) which are bid into the federally regulated wholesale markets be subject to PUC or FERC jurisdiction?

- Should a D-connected solar project which sells its output to the local D utility, or to an in-state reseller in a deregulated market, be subject to FERC or PUC jurisdiction?

- Do state renewable portfolio standards (RPSs) (which typically require retail sellers of electricity to obtain a certain percentage of their wholesale supply from renewable resources), or the analogous state Zero Emission Credit programs (ZECs) (which similarly give wholesale price support to nuclear generation) unduly impinge on FERC's authority to set wholesale rates?

To be sure, some of these questions have been answered by some courts (including some by the Supreme Court, albeit in factually limited contexts which turned on FERC's discretionary decision to exercise its federal authorities), and all have been discussed in detail in recent articles from the Kleinman Center and elsewhere (see here, here, and here).

The broader point is that regulatory uncertainty impedes the deployment of current and future technologies and business models at the grid's edge that could play a significant role in helping to decarbonize the grid overall. Indeed, in its recent Interim Report on its "Pathways for Regional Energy Transition" project, the Kleinman Center found from its discussions with key local energy stakeholders that "uncertainty" over applicable policy (as well as technology and climate impacts) "rather than deadlock, is what limits decision making on Philadelphia's energy future."

In sum, while the "Edge of the Grid" is both historically and functionally far removed from the "Attleboro Gap," both reflect a moment of regulatory uncertainty that was/is counter-productive, and which was and should be, respectively, eliminated.

A Modest Proposal: FERC Should Formally Recognize That The FPA Does Not Require It To Exercise Jurisdiction Over Certain Developments At The Grid's Edge

In 1996 FERC issued Order 888, which opened up the wholesale electricity markets to new participants by forcing utilities to provide all with generators non-discriminatory access to their transmission systems. Significantly, while finding that the FPA's authority to assure that rates are

"not unduly discriminatory or preferential" authorized it to separate wholesale transmission and generation services, and to set the rates and other terms for "unbundled" (i.e. deregulated) retail as well as wholesale transmission, it decided not to exercise this authority over "bundled" rates, i.e. in states which had decided to retain the vertically integrated IOU model, out of concern that this would be too disruptive to state regulation of retail rates. The Supreme Court upheld FERC's decision as being within the scope of its authority under the FPA.

Similarly, FERC could draw a box around some of the grid-edge relationships and technologies described above, declaring them to be sufficiently intrastate in nature so as to leave them beyond the scope of its authority under the FPA. Moreover, such a decision would accord with the stated goal of those in the federal government today who urge a return of regulatory authority from the federal government to the states, while allowing those states which want to address their mitigation and adaptation climate goals to so more confidently.

Charles Howland teaches Navigating the Regulatory State: Law, Science and Policy in the Law School's Master of Law Program, and heads the Environmental Law group at Curtis, Mallet-Prevost, Colt & Mosle, LLP.

Idea #30

Mitigate Housing and Climate Risk through a Green New Deal for Housing

by Daniel Aldana Cohen

The risks of social inequality and climate change are converging in American homes—for those lucky enough to have them. By one estimate, the country has a shortage of almost 7.5 million homes for extremely low-income households. Meanwhile, roughly 20 million American households spend half their income on rent or mortgage payments; another 20 million spend a third. It gets worse.

Fully one third of Americans face major challenges paying their utility bills—that is, they have recently received a shut-off notice, sacrificed in other areas (like food) to cover utility bills, or kept their home at an unsafe temperature. This pattern is racialized. In the mid-Atlantic, fully half of Black households are energy insecure. According to one study, the main reason Americans take out pay-day loans is to pay utility bills—followed by everyday expenses, followed by rent.

What does all this housing injustice have to do with climate change? Everything. Could anything *but* a Green New Deal for Housing address all the intersecting housing and climate crises in a way that improves people's lives, accelerates decarbonization, and increases resiliency?

After all, no climate policy can dispense with housing; it's hard to imagine a successful housing policy that neither meets desperate Americans' needs, nor slashes carbon emissions. Already, American homes cause a sixth of US greenhouse gas emissions, just a bit more than all commercial buildings combined. And transportation by private car, mostly to and from homes, causes another sixth of emissions. Added up, that's one third of emissions, from living at home and traveling back and forth.

To zero out carbon emissions as quickly as humanly possible will mean transforming home energy systems, stripping heating oil and natural gas out of very home in the space of a decade or two, and enabling far less energy-intensive modes of transportation.

We'll also need new homes. Tens of millions of them. For one thing, climate change will move people around. By one estimate, up to 13 million people could be displaced by sea-level rise alone by 2100; 6 million from South Florida. But there will also be cities like Phoenix where by the middle of the century, it will be over 95F for *152 days*, even with extreme cuts to carbon emissions. Alongside sea-level rise, extreme heat, drought, inland flooding, and fire patterns will also doubtless push people to move. And people will keep being born. And unless the country turns into a nativist

hell-hole, tens of millions of immigrants will arrive by the end of the century, many fleeing even worse climactic conditions.

So we must not only retrofit the homes we have; we must build new homes—indeed, new communities—that emit no carbon, that facilitate walking, biking, and other no-carbon transport, and that remediate inequalities of class and race.

Underlying and uniting all the risks of climate change and inequality is political risk. How ugly would politics get if only the affluent and geographically fortunate get access to low-cost clean energy, greenery, and safety from climate disasters? This trend to eco-apartheid, facilitated by private service providers who are not utterly focused on equity, is hardly a far-fetched prospect.

Just this past summer, on July 21st, New York electricity utility Con-Edison cut off power to at least 30,000 customers in the mostly Black Canarsie neighborhood to avoid broader outages. Canarsie's Black population has grown significantly since the year 2000 while the Black population plummeted in gentrifying neighborhoods in more central parts of Brooklyn—whose power services Con-Edison prioritized.

In California, we are witnessing a slow trend toward grid defection, where communities unplug from the electricity grid if they can afford enough solar panels, batteries, and generators. Just as Con-Edison failed to actually prepare for climate change's heat extremes, in California, the investor-owned utility PG&E failed to inspect power lines that sparked massive forest fires; PG&E's regulations were such that savings from maintenance could be passed on to investors as dividends.

In a more mundane sense, the high costs of housing in the US right now mean that moving—for work, for family, or to escape climate risk—will seem traumatic, if not impossible. What are the conditions under which a new Great Migration could be good for the environment and bearable—even life-improving—for the migrants?

A Green New Deal for Housing represents a vision of massive investment in millions of units of new, beautiful, no-carbon social housing every decade; such a vision makes most sense as part of a broader "Homes Guarantee." The new social housing would displace much of the wasteful, inefficient private-market construction with dense, transit-connected, sustainable homes. Already, in New York, affordable housing is leading the technological development of sustainable living environments.

A Green New Deal for Housing would also make investments into saving and upgrading the public housing that already exists. And it would channel green investment into low-income communities to weatherize homes, remediate lead and mold, and create jobs and community wealth. Wherever appropriate, such funds could facilitate the establishment of community land-trusts, as in poor neighborhoods in Philadelphia and Baltimore where there are crumbling row homes in desperate

need of rehabilitation; taking them off the market and upgrading them would make them permanent community assets.

Inspired by California's Affordable Housing in Sustainable Communities program, a Green New Deal for Housing would also ensure that housing investments are always tied to transit investments that enable easy, no-carbon mobility from home to work, social service, and public recreation amenities.

Finally, a Green New Deal for Housing could only work as part of a broader system. For one thing, all this implies a dramatic reform of federal agencies, and likely of federalism itself. For another, as discussed above, these policies could never be separate from energy policies. Indeed, one of the principal upshots of all this green investment should be reducing energy demand and improving the affordability and quality of home living at the same time.

This is a big dream. But do we have another choice? Bad housing policy, in the form of red-lining, turned the emancipatory promises of the first Great Migration and the New Deal into cruel and enduring segregation, creating a massive racial wealth gap and feeding mass incarceration. Meanwhile, the abandonment of public housing and the modest War on Poverty has little to show for it. The housing policies of recent decades have created wealth for millions—and a way of living utterly at odds with sustainability and equity.

The safer path is social and environmental ambition—mitigating risk by mobilizing wealth to build affordable and sustainable homes for all.

Daniel Aldana Cohen is an Assistant Professor of Sociology at the University of Pennsylvania, where he directs the Socio-Spatial Climate Collaborative, or (SC)².

Coda

Solving Climate Risk Requires Normative Change

by Cary Coglianese

Finding solutions to climate risk is really easy. At least it is *conceptually* easy. With climate risks increasing due to the accumulation of greenhouse gases in the atmosphere, risks can be addressed by reducing the accumulation of gases. That can occur either by reducing new emissions or by pulling gases out of the atmosphere, such as by preserving existing forests or planting new ones to absorb carbon.

Of course, if it is so easy to identify the necessary solutions, why has humanity made so little progress in mitigating climate risks? At one point in time, delayed responsiveness might have been said to stem from uncertainties in the science or from a lack of clarity in how to design public policies. But by now, neither of these explanations holds real weight. Although scientists can always learn more, the parameters of the problem and its causes have been more than adequately studied to justify swift, major action. And, as evidenced by this series of essays organized by the Wharton Risk Center, the world hardly lacks concrete policy ideas about how to respond.

What is lacking is neither information nor imagination, but the necessary *impetus*. Any solution, after all, will be costly. Solving climate risks—heat, droughts, floods, storms, agricultural losses, and so on—will require reducing consumption, investing in new energy sources, changing lifestyles, or making other transitions with important associated costs. As a result, any current industries and individuals with a stake in the status quo—and thus presumably holding political and economic advantage in their countries and around the world—can be expected to resist the necessary changes. This is because, one way or the other, climate risk solutions will demand those who are contributing to the problem to "internalize their externalities." That is, they must start paying costs to reduce the spillover harms they impose on others, namely those who suffer the ravages of climate change.

Of course, spillovers are neither novel nor irremediable from the standpoint of public policy. For decades, environmental regulation has imposed standards on industrial firms, compelling them to assume the costs for spillovers from other types of pollutants and to work to reduce them. This is not to say that enforcing environmental regulation has been easy or always successful. But it is to say that the policy tools exist to require the internalization of externalities. The methods for internalizing externalities are not rocket science. Yet with respect to climate change, the challenges associated with using the methods seem profound. Climate change has been

properly characterized as a "wicked" policy problem because it exhibits at least three qualitative differences from other environmental problems.

First, the scope of contributors to climate change vastly exceeds the scope for any other environmental problem. Climate change is a collective action problem on steroids. It not only is a global environmental problem requiring cooperation across many nations, but it is a deeply individually sourced problem to which virtually everyone contributes. In fundamental ways, the problem stems from actions each of us takes to secure shelter, provide food, and satisfy transportation needs. Even if the contribution of any one person is *de minimus* in its own right, each individual's impact adds up. Solving the climate problem requires coordinating behavioral change across the vast majority of the world's population. Each nation, as with each individual, will have an incentive to free ride on the efforts of others. Or they will at least ask themselves why they should accept the burden of reducing greenhouse gases when doing so will not yield substantial benefits until everyone else does the same.

Second, the kind of institutions most readily equipped to solve collective action problems like climate change simply do not exist at the international level. If climate risks were just regional or national in scope, it might still not be a piece of cake to solve them. But at least once political support developed to address these problems, there would exist necessary legal and regulatory institutions at the domestic level of government that could be used to make a collective choice stick. Such institutions would provide the incentives and assurance needed to convince most businesses and other actors to take costly steps. But such institutions do not exist on the international stage, which is why climate policies adopted in recent years have appeared at the national, regional, state, and even local levels. This is also why the Paris Agreement was structured to depend on each country to follow through on its own commitments to reduce greenhouse gas emissions. Yet, despite the existence of the Paris Agreement and numerous local and national climate policies, the steroidal nature of climate change's collective action problem means that these current bottom-up efforts are still neither substantial nor widespread enough to address climate risks adequately.

Finally, although the manifestations of climate risks in storms, floods, and fires are all palpable, the connection between those risks and climate change is facially invisible to publics around the world. Even "climate" is not visible. It is an abstraction; no one can look outside the window of their house and observe a global mean temperature. As a result, building the kind of public support needed to adopt meaningful policies has been more difficult for climate change than for other pollution problems that can be tangibly seen or smelled. Greenhouse gases are not noxious fumes; humans even exhale carbon dioxide. Moreover, these gases also do not cause harm by directly affecting humans or the air they breathe. Rather, it is only by their accumulation in the upper atmosphere and a subsequent complex chain of interactions that they ultimately change climatic conditions in ways that increase the likelihood or severity of droughts, floods, fires, diseases, and the like.

In short, climate risks have proven especially difficult to address because they stem from a deep and pervasive collective action predicament, one in which relatively few people have an incentive to bear substantial mitigation costs alone. That predicament also arises in a setting that lacks necessary institutional capacity and makes it harder to build public support for policy action. Climate change is truly a "wicked" problem.

What, then, is the path forward? The fundamental solution must address the "wicked" structure of the climate problem and find a way to overcome the structural barriers to policy action. This will not be a solution at the level of, say, a choice between carbon taxes or cap-and-trade systems. Or one at the level of many of the excellent ideas assembled by the Wharton Risk Center. These are all important policy options, to be sure, but sufficiently strong policy measures ultimately demand a public drive for climate action that overcomes self-interested resistance.

Political scientist Michael Jones-Correa is exactly right when he writes that "climate change is as much a political problem as it is a scientific or technical one." What is fundamentally needed is change in how people perceive climate risks and society's responsibility for addressing them. In other words, the solution to *climate* change lies with *normative* change. It must become viewed as normatively unacceptable for nations and their leaders to overlook the suffering, mortality, disease, and property damage that climate change exacerbates. Just as societies invest in crime control, the provision of social services, and other public measures that today seem unthinkable for government not to provide, so too must societies demand, as a moral necessity, strong climate policies that include investments in modifying energy systems, agricultural practices, and other facets of society that contribute to climate change.

Normative change will hardly be easy to bring about. There exists no definitive checklist or formula. In other contexts, some value changes can be sudden, while others are long in coming. Some normative change requires bold efforts at public mobilization, even at the cost of violent struggle, while other change occurs relatively subtly or gradually, such as with changing social acceptability of public smoking in the 1980s in the United States.

With respect to climate change, normative change might be helped by visible rallies, protests, or strikes, such as those organized by young people around the world in recent years. It may be helped by media coverage of other symbolic efforts, such as Greta Thunberg's recent trip across the Atlantic Ocean in a sailboat instead of an airplane. It may be helped by increased media attention to natural disasters and their plausible linkage to climate change. It may be helped by linguistic choices made by elites, such as the decision made by some media outlets to begin using terms such as "climate crisis" instead of "climate change." It may be helped by the messages of corporate and political leaders, especially highly publicized "conversions" by those who previously had been climate skeptics or who rise above their or their firms' seeming self-interest.

We cannot be certain what exact actions—or, more precisely, what combination of actions—it will take to reach a tipping point where norms become deeply embedded and sufficiently widespread. One difficulty in reaching that tipping point is that normative commitments to climate action appear to be associated with deeply engrained worldviews and ideological predispositions. The cultural and political polarization evident in many countries around the world means that protests and other efforts to build norms in support of climate responsibility are met with countervailing efforts to resist normative change. This dialectic nature of the battle over norms is exemplified in the fact that President Obama's leadership achievement with the Paris Agreement was soon followed by the election of President Trump, who then announced that the United States would be pulling out of the Paris Agreement. Getting people to change their hearts and minds is especially tough when ideology, culture, and self-interest stands in the way.

Normative change also takes time. Consider the shift in public attitudes about LGBTQ rights. That shift is often said to exemplify one of the most rapid changes in public norms ever to have occurred. As recently as 2004, public opinion polls in the United States showed that Americans opposed same-sex marriage by a two-to-one margin. But now, fifteen years later, public opinion has flipped, with Americans supporting same-sex marriage by a two-to-one margin. Yet, as fast as that change has occurred, the struggle for LGBTQ rights hardly began in 2004. Almost fifty years passed between the uprising at the Stonewall Inn in New York and the U.S. Supreme Court's decision recognizing a right of same-sex couples to marry.

Waiting another fifty years may seem like waiting an eternity with respect to climate action. Yet sufficient normative change could plausibly take even longer than fifty years. As long as addressing climate change requires shifting energy systems or changing consumption patterns, normative change will need to overcome self-interested resistance to change. Furthermore, normative change with respect to climate issues must take hold around the world for it to have a meaningful effect. By contrast, recognition of same-sex marriage rights never imposed any costs on those whose attitudes needed to change.

The need to combat self-interest on a global basis might suggest that the trajectory of normative change related to climate could take as long as other norm changes—perhaps even centuries. After all, when it came to changing norms about slavery, a process that started robustly in the early 19th century, global action was also needed to abolish an international slave trade, and opponents of slavery needed to overcome opposition by slaveholders and anyone who relied on their cheap products. Today, despite the passage of a century and a half since the conclusion of the U.S. Civil War and the abolition of slavery, illegal human trafficking tragically still persists. Of course, so does the racism that supported slavery. Will norm change with respect to climate be doomed to a similar drawn-out struggle?"

Climate change does have one difference that may make normative change occur more rapidly: its risks are not unchanging. The longer it takes to solve climate risks, the more costly they will become. Sooner or later, the public will start to realize that the costs of the status quo exceed the costs of shifting to new energy systems and undertaking other climate mitigation efforts. With luck, this realization will occur sooner rather than later. Otherwise, by the time the pressures for normative change align with a broader public understanding of its real self-interested stake in mitigating climate change, it may be too late, even if this confluence of values and interests occurs in the next decade or two. Already forecasts portend catastrophic climatic risks in little more than a decade. Even if all new emissions of greenhouse gases could somehow be halted tomorrow, the gases already in the atmosphere will not dissipate for some time to come.

In the end, the solution to climate risks may come down to a matter of timing. Normative change—the only solution that can fundamentally overcome the structural edifice underlying climate change as a collective action problem on steroids—might not occur quickly enough to forestall significant climatic change and the ravages it will bring. If that is true, then the best hope may rest not with politics or morality but with some heretofore unknown technological cure-all: a breakthrough that either delivers cheap, climate-friendly energy, or, better still, could extract greenhouse gases from the atmosphere or counteract their warming effects—all without creating other harmful effects. But identifying *that* solution is really hard.

Cary Coglianese is the Edward B. Shils Professor of Law and professor of political science at the University of Pennsylvania Law School, where he is also director of the Penn Program on Regulation.