THE BROOKINGS INSTITUTION

THE RISING IMPACTS OF CLIMATE CHANGE: IMPLICATIONS FOR SCIENCE, LAW, CAPITAL MARKETS, AND POLICY

A Joint Event Between the Markets at Risk Initiative, the Environmental Defense Fund, and the Columbia Sabin Center for Climate Change Law

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P R O C E E D I N G S

MR. VICTOR: Well, good afternoon, everyone. I'm David Victor. I'm a professor at UC San Diego and also a nonresident senior fellow at the Brookings Institution where I lead a team of folks looking at interaction between climate change and the financial markets. And on behalf of us at Brookings, and also our terrific partners at the Sabin Center at Columbia Law School and Environment Defense Fund, EDF, I want to welcome you to this seminar this afternoon about advances in science and their understanding about climate impacts, advances in law, and similar implications and advances in understanding the capital markets, and the role of public finance in affecting how the nation is exposed to the physical risks of climate change.

This is a partnership between us and Columbia and EDF. And so I want to hand it over now to Michael Panfil who is going to introduce the first segment of our meeting. We have three segments this afternoon. The first segment, three terrific panelists, going to make a few comments. The second segment that's going to be looking at two papers from our partnerships that have appeared over the last six weeks or so, and then a final segment, which is a roundtable discussion.

If you have questions for the roundtable discussion, you can send them on Twitter to #ClimateRisk. If you're one of the six people on the planet who is not on Twitter, including me, you can also email those to events@Brookings.edu. We're going to collect those questions, organize them, get as many answered as possible. We have 30 already and rising, so please get your questions in early. And we look forward to that discussion, but that's after the first two segments.

And I'm going to hand the floor over now to Michael Panfil.

MR. PANFIL: Thank you so much, David. Thanks so much to everybody for joining us today. Incredibly excited to hear from our panelists. And a big thank you to Brookings and to the Sabin Center for co-hosting today.

The focus of our event today, climate change, presents grave and novel risk. The impacts are more visible with each passing year, in terms of hotter temperatures and rising seas, but also in terms of more extreme weather events. But these events, these impacts, are not some unknowable act of god, they are increasingly foreseeable with the degree of specificity and precision that is frankly

astounding, with the ability to measure and identify, down sometimes to the individual weather station. And what this means, this confluence of rising harm and increasing knowability, implicates the fabric of society, to our nation's legal system, to every economic sector, and to our financial health, and it is central to our conversation today.

And there is no better set of speakers to this topic on the rising impacts of climate change and its implications than our panel today. I am honored to introduce our speakers. First we will hear from Dr. Adam Sobel, a professor of applied physics and mathematics and of earth and environmental sciences at Columbia University, where he studies weather and climate with a focus on prediction and risk assessment. And his work focuses on the risk of rare but extremely damaging extreme weather events.

Next we'll hear from Tom Doe, who is the president of Municipal Market Analytics and a leading expert in municipal industry. Mr. Doe has appeared before Congress, financial regulators, and media, speaking and writing extensively to the dynamics, issues, and challenges in the municipal market and financing public infrastructure.

Last, but certainly not least, we'll hear from Dr. Susan Tierney, a senior advisor at the Analysis Group and expert on energy policy and economics, specializing in the electric and gas industries. She's a former assistant secretary for policy at the United States Department of Energy, a Cabinet officer for environmental affairs, and state public utility commissioner. Among her current appointments and work Dr. Tierney chairs the board of directors at Resources for the Future and at ClimateWorks Foundation, and serves on a number of other expert advisory boards.

Thank you all again for being. And, Adam, please do get us started.

MR. SOBEL: Thank you, Michael. Thanks to the organizers for inviting me and everybody who is present. It's an honor to be part of this discussion.

So what we see, and these reports are clear, evidence of it is a rapidly increasing recognition of the costs of climate change through all kinds of different ways and different sectors of society. And although global warming itself is not a good thing, this recognition is — it's — we have to know the problem is there and understand it in order to do anything about it. So this kind of attention hopefully should help us as a society not only increase resilience to climate change and disasters

generally, which is the clear goal, but also I think we might hope that it might also help motivate political action on mitigation — reducing emissions. Because part of that is understanding how serious the problem is might help increase some people's motivation to try to make it better in that more long-term sort of indirect way, which is ultimately terribly important, as I think we probably all know.

The science of doing this, the science of assessing the impacts of climate change and natural disaster is still in many ways primitive. That's changing quickly. In my own work with the insurance industry, I would say a couple of years ago there wasn't really much serious interest in assessing the change in disaster risk due to climate change. There was talk and study, but not really any serious move to incorporate into the business model. That is changing rapidly in the last couple of years, and I think that's true over the whole economy. So there's a lot we still don't know and that the science needs to advance rapidly. That is happening. It should happen faster. I hope that as it happens a big part of that will be open source solutions and participation from academia. That's my own personal little agenda. It's probably not the focus here, but I hope that we can do that to a greater degree than we have done in the past because some of these decisions have real consequences for people. And so it's important that they be made transparently, which means that the science that goes into them should be accessible and not proprietary, to whatever degree that's possible.

But, you know, the fact that we don't know how to do the science as well as we might like to, or to assess the damages — and you can see the recognition of those uncertainties in the two papers that we're talking about — shouldn't stop action. The uncertainties shouldn't be a reason not to act because, first of all, the uncertainties could make things worse than they think they are rather than better, but also because most — a lot of the actions that I think would be natural outgrowths of these two papers are no regrets actions. In other words, we aren't that well adapted to even historical climate, let alone — you know, the climate of the future is just making some kinds of events a little more extreme or a little more frequent, but — you know, for example, the Texas event that we just had where the power went down so badly over such a large region, my own view of the science is that that probably was not an event that was made more probably or worse by climate change, but it still happened. So that risk was there, even if the climate weren't getting warmer. So I think there's a lot that can be done that's in the no regrets category. And that plus the fact that uncertainty doesn't reduce risk but generally increases is,

means that while we should improve the science as fast as we can. To whatever state it's not good enough today, that shouldn't hold us back from doing the things that these kind of studies say we should do.

So I'll stop there. Thanks so much for having me.

MR. PANFIL: Fantastic. Let's turn now to Tom Doe.

MR. DOE: Thank you, Michael and David, and the Brookings and Columbia teams for including me today.

I want to borrow a line from my friends at Breckinridge Capital up here in Boston who state that municipals are at the forefront of climate change. And the reason is, is because municipal securities are diverse and they're plentiful. There are a million securities in the municipal market, they're issued by 40,000 different entities. Many of them are state and city and local governments. And municipal finance carries about 75% of the annual infrastructure spend in the United States. And each of these securities, you know, essentially represent a loan in the form of a bond and the bond is issued with an offering document, which is to communicate or disclose the risk associated with the borrower's ability to repay the debt. And because of municipal's rep, they provide an opportunity to map climate risk across the United States. And since these securities often have maturities of 30 years or more, similar to a home mortgage, they're vulnerable to the risks associated with climate change.

So a couple of years ago our firm partnered with another firm up here in Boston called risQ, R-I-S-Q, to assist in the efforts to quantify the various climate risks for each of these million securities. And to make that data available to governments as well as other issuing entities, like schools, hospitals, power utilities, in order that they can not only disclose the risk but also can use the data to facilitate their adaptation plans and also to communicate their needs to their constituents.

And perhaps the most important — or the most challenging aspect of climate change in this sector to me is the migration and integration dynamics of the next 30 years. So, for example, it's somewhat ironic that the two states in the country right now with the greatest population growth are Texas and Florida, which arguably have the most substantial climate risk in the country. And on why is that population growing, well it's growing because both those states have reduced income tax exposure, and people are moving for today's monetary gains with little consideration for the vulnerability of their climate

risk and the climate forces at play. And of course that migration only exacerbates the challenges and risks associated with the climate in these areas.

But just as people are migrating to these high risk areas and ignoring the long-term risks, so too are municipal lenders and investors. And so despite the rhetoric of large investors such as Black Rock that is stated that climate change is a critical element of their investment policies, there's little to no evidence that a climate penalty has been applied to municipal borrowers or issuers who have measurably high climate risk.

And so, simply, investors are continuing to hold municipal securities with high climate exposure in order to provide tax exempt income to their clients and receive the management fees from the assets that they hold.

So now that this climate data, as Adam is pointing out, can be measured and is available, it is now really unconscionable that municipal issuers don't disclose the climate risk to investors and their constituents. And I am encouraged though that the issuer community, be it a government finance officers association, as taken a step to open a dialogue with investors and bankers and regulators regarding the disclosure of climate risk. In addition, because that climate data can also be utilized, again for the proper planning of projects for the public good, and certainly with the allocation of federal dollars to smaller governments as it trickles down to the local level.

And, again, what's kind of interesting to me is how migration is going to impact, you know, just the country and the world over the next 30 years or so, and that the municipal market is kind of in a position to kind of deal with these difficult decisions that are going to be — you know, how do we — you know, regarding the degree of stability required in those areas for those people who can't migrate away from climate's harm and still are provided essential services. And also then for those areas which possess the least amount of climate risk, and are the positioned to accommodate the needs of the influx of a population, either domestically migration or immigration from abroad.

So, you know, here we're addressing these big issues today. You know, I'm reminded of Nile Ferguson telling me once what the U.S. needs is to renew its commitment to posterity. And that's of course what climate change is all about, it's thinking beyond our lifetime. And hopefully we'll all kind of nudge the world to a better place. But specifically to the municipals, to the financial securities, municipals

in particular, is that the industry has a history of not responding or not addressing major problems without the push from a federal regulatory body. And I think that's what we're going to be looking for to really create the change that's necessary.

So thank you. I look forward to this discussion.

MR. PANFIL: Thank you so much.

Over to you, Dr. Tierney.

MS. TIERNEY: Thanks, Michael. I appreciate it. And it's so nice to be affiliated with all of the people who are participating in this seminar.

I was asked to talk about how the impacts of climate change might affect the electric industry and then to talk about what regulators are doing to address it, and to focus on state regulators.

I won't bury the lead. The answer to what are the impacts on the electric sector — huge. I'll come back to that in a sec. And what are regulators doing about it? It depends. It depends upon whether they have experienced a really bad set of events and what their authorities are.

So let me just give you some examples about that, which is all I'll have the time for today. And I'm sure we'll get into some of these issues as we talk later on. So moving from the most recent, I know that Adam said that the Texas climate events were not necessarily related to climate change. But they were extreme. And they affected the electric sector in very obvious ways. Virtually every kind of power plant and transmission line was affected in one way or another. You know, depending upon what partisan group you're in, you said it was either the gas industry supplies to the gas fired power plants, or the wind industry, but it all went down. And the planning had not been in place. And there are really, really adverse reactions going on in Texas, including extraordinary bills for some customers.

Then moving back from that, of course, are the examples in California associated with the wildfire events. And California has some pretty peculiar laws on liability for wildfire events that might be triggered intentionally or not by a spark from a transmission facility. And in fact we've seen time after time over the last three years there have been circumstances where there has been a triggering event, a quite benign one, that led to deaths, loss of property, and huge reaction amongst regulators and so forth.

I'll give you two more very quick examples. In 2019 there was 60 degree weather — minus 60 degree weather conditions in a polar vortex in Minnesota. If it weren't for the fact that

Minnesota was connected to extremely large electric grid, not only — like Texas — not only did many of its thermal power plants go down, but its wind turbines were not authorized under their OEM, the manufacturer's permit, to operate under such cold conditions. So there are changes in Texas, in Minnesota, a variety of different places.

Last example, when Hurricane Sandy hit the Northeast and Mid-Atlantic states, you know, New Jersey thought they were going to be well off by having a lot of solar panels and a variety of different things that were distributed generation. They had to turn because of the way that those are connected to the grid. So they weren't providing distributed generation in those times. One of the responses was a lot of people put in emergency generates that are fossil fuel.

So we find a lot of reactions to these conditions. And unless it's happened to you and unless you have authorities to really look aggressively forward, you may or may not be able to address these issues in a proactive way in the states.

Thank you.

MR. PANFIL: Wonderful. Thank you all for those introductory remarks.

I want to turn now to introduce a few folks to present work. First a relatively recent that we at EDF and Sabin have put out on intersections between climate change and physical risk, and another on the same theme put out by Brookings.

First I'm delighted to introduce my co-author, Romany Webb, the associate research scholar at Columbia Law School and senior fellow at the Sabin Center for Climate Change Law, where she focuses, among other things, on the impacts of climate change on energy infrastructure. She, I, and Sarah Ladin were the co-authors of this report and forms and informs our understanding here.

After we hear about that report we'll turn to Eric Gesick, a visiting scholar at the Institute on the Environment at the University of Minnesota and the former chief risk officer for Access Capital, a global reinsurance company.

Romany, do please take it away.

MS. WEBB: Thank you, Michael, and good afternoon everyone. It's great to be here.

I'm going to just introduce the work that Michael mentioned that the Sabin Center did in collaboration with the Environmental Defense Fund. And it really picks up on many of the points that Dr.

Tierney made. That was perfect introduction for me. We know that, as Dr. Tierney mentioned, the electric system and the energy system more broadly, is especially impacted by climate change due to its reliance on long lived large place based infrastructure. And Dr. Tierney highlighted some of the ways that sort of event based climate impacts those more frequent and severe extreme weather events can impact electricity systems and energy systems. But I think it's important to also recognize the impact that nonevent based climate impacts could have. For example, the sort of increase in average air and water temperature studies have shown that that could impact the operating efficiency and therefore the output of certain thermoelectric generating plants. So there are multiple climate impacts that will stress the energy system in multiple ways.

And, of course, because all of our other economic sectors rely on energy, disruptions to the energy have much broader sort of social and economic consequences. The Fourth National Climate Assessment, which was released in 2018 warned of this, saying energy system disruptions are likely to have cascading impacts on other critical sectors and could affect U.S. economic and national security. And I think the recent events in Texas that many people have mentioned are a prime example of that, where we had this extreme weather event which led to widespread electricity outages, which in turn led to disruptions of other critical systems, like water and sewage, and also forced the closure of businesses and factories and had these broader economic impacts.

Initial estimates — some initial estimates that I've seen put the cost just in terms of lost wages and lost economic activity at over $200 billion. And that doesn't include the cost of property damage and loss of life due to the storms and associated outages.

So this event and other recent events, some of the events that Dr. Tierney mentioned, have really prompted a lot of discussion about ways to enhance the climate resilience of the energy system. And there's a number of ways to do that through hardening assets and redesigning systems. But a really important first step, before any of that can be done, is to engage in a process of what we describe as climate resilience planning, basically identifying where and under what conditions assets and operations are at risk from the impacts of climate change and then identifying different options for managing and mitigating those risks.

As part of our study, which Michael mentioned, we looked at the extent of climate

resilience planning specifically by electric utilities and we found, as Dr. Tierney alluded to, that it's really very limited. Very few electric utilities have prepared high quality comprehensive climate resilience plans. Some utilities do almost no climate resilience planning at all, others say they're doing climate resilience planning, but then focus very narrowly on a particular type or types of climate impacts or a particular part of their system, whereas what we need is a much broader approach that looks at the system as a whole.

So one of the questions that we really sought to answer with our work is how can the law be used to remedy this problem and to push utilities in particular to go further. One of the key functions of law is to of course allocate and mitigate risk. So how do existing legal principles around risk mitigation and risk allocation, how can they be used specifically to address climate risk in the electricity sector. And we concluded that as the science around climate impacts advances and the impacts become better understood and more foreseeable, those existing legal obligations take on new meaning and require action by utilities to deal with this climate risk.

So we argue that these existing legal principles can be used in both proactive and reactive ways. So some legal obligations can be relied upon to force utilities to proactively prepare for climate impacts, and others can be relied upon to hold utilities accountable when they fail to do that, and that results in some harm when climate impacts manifest.

So just to give one example on the proactive side, we looked at several principles of state utility law, the laws governing the operation of electric utilities that we argue require this sort of advance proactive planning. Among other things under public utility law, utilities have an obligation to act prudently when they're making investments or incurring expenses. And that prudent standard requires the utilities to act rationally and reasonably given what they knew or should have known at the time.

As climate science advances here with the more advanced downscale models that allow you to see or predict more accurately and with more specificity what climate impacts are likely to occur where, that really changes the nature of that prudence obligation for electric utilities. It's not reasonable or rational for them to ignore that climate related information when they're making decisions to invest in long lived assets that will remain in operation for decades into the future as climate change continues to accelerate. So they have this proactive obligation to prepare.

The law, as I said, can also be used in a more reactive way to respond after climate

impacts manifest. So, Michael, I'm going to turn back to you to talk about that briefly.

MR. PANFIL: Thank you so much, Romany.

So just to add here and sort of amplify what was just shared, I want to describe sort of the book end rights to the public utility law of a proactive approach. And that is using and considering tort law, which for the non-lawyers here has really tendrils in history that date back to earlier than the United States itself. It is everything to do with core conceptions of justice, of righting wrongdoing, of a real flexible legal framework. And core to that framework is what we call the duty of care. It obligates, very simply, entities to avoid foreseeable harm when performing acts that could injure others.

And so the work that we've conducted is not let's shape a new legal duty or obligation, it's a question of how do existing flexible longstanding legal obligations extend and encompass to consider the risks of climate change. So think about the operation in the electric grid. Are the impacts of climate change a foreseeable harm? Could the operation of the electric grid in a manner that does not consider those foreseeable impacts cause harm? The answer to those is yes. That on that and additional bases which we explore in the research, the conclusion to discharge the duty of care by planning for climate change impacts is simply an extension of long standing duty and obligation.

I really appreciate this time. And, Romany, unless you have anything to add, I'd love to hand this over now to Eric to share their important work on climate risk in the financial sector.

Hearing nothing, over to you, Eric.

MR. GESICK: Thank you.

So for the past year our research team through Brookings, and a collaboration with industry partners, has been looking broadly at how climate change might impact the financial markets. From the time of Mark Carney's defining speech "Tragedy of the Horizon," financial markets and policy makers have been focused on the transition risks of climate change, which has driven a huge and growing disclosure of information, public equities in particular. But what about the financial implications or the physical risk of climate change? We find it puzzling why physical risks have not gotten more attention. Just in the U.S. there are tens of trillions of dollars of real assets in local economies and financial assets whose values could be eroded or destroyed from those exposures. This raises all sorts of interesting questions from a disclosure, investment decision process, and public policy standpoint.

Our first paper "Flying Blind" looked at disclosure. We asked, what do investors know about climate change in the U.S. equity and municipal debt markets? We also looked at what influential market actors, such as credit rating agencies, are contributing to investor understanding of the physical impacts of climate change on those securities.

For equities, while we didn't focus heavily on quality of disclosure, we looked systematically at every 10K filing for the Russell 3000 firms over the last 12 years and found that overall disclosures did increase dramatically, both in number of firms disclosing, to something like 60% and the amount of language dedicated to climate disclosure increased as well. However, the focus is still on transition risk and not surprisingly concentrated on industry as related to fossil fuel, with only about one-quarter of mentions relating to physical risks, and those were more prominent for industries more likely to be impacted, such as insurance and agriculture. So that's the picture for equities.

The same study looked at municipals bonds, where the results are even more disturbing. They are far more exposed to climate risk than other financial instruments given they are in the front line of climate change, as Tom explained. While populations and industries can move, this then exposes municipalities to deterioration in tax bases necessary to support those bonds.

Looking at the best climate science about the impacts of climate change, what we found was shocking. There is essentially no statistical relationship between economies at risk, for example, coastal counties in Florida and Texas, and engagement of climate change through disclosure. And no relationship between duration of bond, climate risk, and disclosure.

Another source for climate risk information that could be available to investors are the opinions of major credit rating agencies, given nearly all investors rely to some degree on the credit opinions for investment decisions. Using publicly available information from the major credit rating agencies, we found that they do consider climate risk, generally within their ESG frameworks, but the degree to which these considerations materially influence actual ratings today, were few and rare.

It was merely one of many factors that determine a rating. When climate risk was mentioned, it was usually event drive, for example, after Hurricanes Harvey and Irma and Maria and the California wildfires, rather than focusing on the longer-term consequences of climate change for credit worthiness of municipalities.

To put it bluntly, when it came to the physical risks of climate change, investors were flying mostly blind and investors in municipal debt were particularly to have much useful information about climate risk. We discovered two reasons for this striking finding. The first was that issuers have difficulty in estimating impacts of physical risk on assets and economies and translating those to damages functions and default risk. And, second, the reliance on the federal government through disaster relief policy to make whole communities after an event, greatly reducing or nearly eliminating municipal debt default risk. It's these two issues that drove the next phase of our research.

We believe the first reason is no longer true. The science has advanced a lot and so have the analytical tools for using that science. We show that in our work. We also wanted to demonstrate that it is possible to quantify the physical impacts of climate change, so we turned to a leading catastrophe modeling firm used widely in the insurance industry, AIR Worldwide, to model the impacts on hurricanes under a future greenhouse gas pathway, assuming little change in emission trajectory through 2050. And the AIR study found a projection of a sharp uptick in the number of category 4 and 5 hurricanes and an annual increase in damages. It also found significant increases and losses associated (inaudible) inland flooding for states not typically thought of being on the front line of hurricanes. They also found that sea level rise will compound storm surge losses in the major metropolitan areas of Houston, Miami-Dade, and New York Metro Area by up to a factor of two times, depending on the amount of sea level rise.

That's what we found working with AIR, but AIR is not alone. There are other firms also developing complementary capabilities, like risQ, as Tom mentioned, 427, and Jupiter Intelligence. And the credit rating agencies themselves are also building these capabilities and buying specialist companies.

While the science has advanced considerably, one important finding we did make is that there is no good inventory for national audit of infrastructure. Public and private investment into better understanding the nation's infrastructure will greatly advance our ability to understand and quantify the vulnerability and costs of climate change on our infrastructure. Everyone is struggling with the problem of estimated exposure. An inventory would help a lot.

People like to say, correctly, the science is in on climate change and now so have the

techniques of applying the science. The growing body of applicable data and analytics is quickly eroding the excuse for not explicitly considering the physical impacts of climate change for disclosure, standard setting, and opinions.

So what about the other reason for poor disclosure and management for physical risk of climate change? Is the federal government, through disaster insurance and infrastructure policy, inadvertently magnifying the harm of climate change? We examined the effects that needed government programs for disaster relief have on market signals and incentives by shielding investors from the consequences of investment and economic losses, such as building and buying properties in areas that have been or likely to be materially impacted from climate hazards and climate change. It has all the hallmarks of a moral hazard problem about to get much worse.

I do want to underscore something important here, there are important moral and public interest reasons for disaster, infrastructure, and federal insurance programs. The question shouldn't be should those programs exist, it's whether the design of the programs are fit for purpose, in particular in a world where disasters get a lot worse with climate change.

This issue is by no means new. And policy makers have been aware of the implications for decades and investors and others have relied upon these government mechanisms to make them whole in the event of a loss. All told, from 2005 to 2018 federal funding for disaster assistance across multiple agencies and programs was $430 billion, and about to get far worse with the effects of climate change coupled with demographic and wealth trends to exposed areas, such as the coasts, without rethinking our approach to policy.

What is new in our paper is a framework to looking at individual policies and government programs according to how they affect damages associated with climate related national disasters and how these programs provide incentives to mitigate physical impacts of climate change. This is a complex issue and the details matter. We outline those details in a major paper released last week from Brookings. To make that complex problem simpler, in effect we looked across the whole of the federal budget and asked a simple question, are those policies building back the same or building back better.

What we find is that the federal funding is heavily skewed toward recovery at a rate that is seven times greater than resilience. How bad could that get? We looked at future economic damages,

which by our estimates are up to 1,000 times FEMA payments currently, but keep in mind FEMA funds do not compensate for all economic damages. And it's worth pointing out that those future damages are concentrated in areas where FEMA money is currently being spent, a clear warning sign of the increase in damages to come.

The salient question is how do we fix this cycle of flatten, flood, scorch, and then rebuild and repeat? We look at reforms that have been proposed, what has been implemented, what has worked and not, and what conditions create success. We conceptually represent a tradeoff of real and contemplated reforms between political difficulty implementing reform and the value of that reform represented by residual moral hazard. The inspiration here is what is easy isn't necessary valuable, and what is useful isn't necessarily easy to implement.

So as we're considering reforms for the future, we offer several key learnings and recommendations in our paper, four of which are worth noting here.

First, we need to improve situational awareness. And one way to do so is leveraging the National Climate Assessment, done every four years, to include policy impacts on climate change, as well as from a science angle. The second is the window of opportunity to reform programs and fund resilience have generally been after large events when there is a focus on a larger tangible problem, such as what happened after Sandy, when recovery resilience, spending was more like three to one rather than seven to one, and also the brick program set up after Hurricanes Harvey, Irma, and Maria in 2017. The third is when the window of reform does open, we should have proposals ready to go and use a whole of government approach rather that piecemeal, such as the BRAC process used in closing military bases that focuses on a larger national interest. And, finally, it is important to disentangle the needed policy goals of disaster assistance, especially necessary for social justice goals of supporting communities and families less insulated from economic shocks and disaster, from the spending on resilience to mitigate future losses.

So in summary, the body of our research to date is pointing towards ways in which policy reform, in conjunction with the private market developments, can provide the incentives for moving capital with longer-term risks explicitly considered, while doing so in a human way by providing economic security for communities least able to manage the damages caused by climate change.

Thank you.

MR. VICTOR: Excellent. Well, thank you very much, Eric, and thank you, Romany and Michael, and also to our three panelists.

So we're going to have a fireside chat now. And I want to cluster some questions together and have some discussions around a handful of very focused topics. And what I'll do is I'll talk first about the science, where we are, then I'll talk about infrastructure, ask some questions about in infrastructure, then go on to law and regulation and some other topics from there and weave in some of the questions we have already on line.

But let's begin with the science and with you, Adam.

Several of the speakers mentioned that the science is not only in but it's getting better in the sense of downscaling, implying that it's now possible to link these probablistically potential impacts of climate change down to the asset level. Is that your sense of where the science is headed? How quickly is this happening, and what concerns you about that?

And then after that I want to go to Tom and Sue for some related questions. But first to you, Adam.

MR. SOBEL: Yeah, it is happening. Just to set the stage, I mean since AIR and some other firms were mentioned, I mean the reinsurance industry and insurance industry have for a long time been calculating disaster risk using what's called catastrophe models. I think that term was mentioned at least once. And the limitation of those is that they haven't historically considered climate change explicitly. The hazard, the risk of a given physical event occurring, is based on historical data, which is back — you only have it in the past and not the future, and so it doesn't represent even the present really risk necessarily right because the present risk — the climate change signal is hard to disentangle from the natural variability. And so that's one of the limitations of those models. Another is that they are proprietary, generally speaking. And so there can only be so much robust debate about what's in them.

In academic climate science, we understand climate change we think reasonably well, although not at the granular level of detail that's needed for looking at the risk from extreme events. So there's sort of a gap in the middle that I think is starting to be filled now, but I still think there is a lot of work to be done there.

I think the information that we have is good enough to draw the kinds of conclusions that our speakers are making. But that's not to say we wouldn't like it to be better. And I think — I'll just make a pitch again that I think it's good for these solutions to be open source and peer reviewed as much as possible so we can have a robust debate because these things really do matter.

I mean in terms of how well we can say how much a given type of event is being — how much and in what ways any climate change is changing extreme risk, it depends very much on the type of events we're talking about. So we know a great deal about heat waves, we know a fair amount about extreme rainfall events. Those are both increasing. You know, the severity and frequency of those are both increasing fairly strongly and clearly. We know a bit less about hurricanes. And when you get down to tornadoes and cold events, and events like that that are related to mid-latitude weather, those are particularly uncertain.

I think if we frame — it's important to say that the uncertainties don't make the risk — or not an excuse for inaction, they — I framed as a risk problem, the uncertainties just generally increase the risk I think if viewed properly, but it's nonetheless important to recognize them.

The other thing I want to say is about attribution. I think Susan said unless it's happened to you, the electric utilities don't take the necessary actions. I think that's important. We focus on attribution, which means assigning — an event that's happened, you know, the causes to an event that's happened, but a proper view of the risk involves thinking of the events that haven't happened too. And so I think it's fair to recognize — it's right to recognize that the window for action may be after a big event when everybody is concerned about it, but it's important at the same time to understand that risk isn't properly — the full spectrum of risk isn't well represented by the events that have just happened recently. So when that window is open, we should have ready a broader view of what the risks are that's based on a full view of the science and not just what happens to have just occurred in whatever given state in the last year or so.

MR. VICTOR: So I'm going to come to Sue in just a moment on exactly that issue, but first I want to go to you, Tom Doe.

Adam has just underscored that this is, you know, a risk problem, the tools are improving. Are we on the cusp of a major transformation in the industry that is most exposed, as you said in your

remarks, which is the municipal debt market, where investors are going to know a lot more in a granular way and be able to look at this ultimately through the lens of the credit rating agencies, in terms of default risk? Is everything about to change because the science is improving, or is something getting in the way.

MR. DOE: Well, I think that with the exciting aspect of it is that all this data is now being put in front of investors for the first time in a very public way. The firm that we're working with is also working with the intercontinental exchange to take those climate risk scores — these are not ESG scores, these are climate risk scores that will be associated, will be adjacent to every security that's transacted and so that an investor will now have that information directly in front of them. And now it can't be denied.

Still, there has to be that motivation to act on that and to believe that it's important to make a financial decision around it. And I'm always reminded of the great hockey player, Wayne Gretzky, who always said, well, you need to look to where the puck is going, not where it is. And that's what is really an inhibiting factor for a lot of the action taken in the financial industry, which is everyone is reacting or they're doing what's just right in front of them now or to the next quarter, or satisfying the client that's right in front of them.

But the good news is that this data is now coming out. And not only the people we're working with, but, as already mentioned, you know, Moody's is with 427, and some of the other rating agencies are mobilizing. I think one of the challenges will be is that everyone — they're looking at climate risk, but it's also climate risk is getting blended in with ESG efforts and then some of the urgency is getting lost or the data is being slowed down by trying to get metrics for E and S and G. And some of these are very elusive when you get to the social and to the government side of it.

So that may be the inhibiting factor, David, but I think the good news is that the data is out there. And, as I mentioned, the Government Finance Officers Association is now recognizing that and starting to put best practices together in a very nascent way. And I think the regulators too, in conversations that we've had, are now starting to think about it. But it will be — as I mentioned in my remarks, the history of financial industry has been it responds to federal regulation or the federal hand in terms of really having movement and in seeing change.

MR. VICTOR: So then we have a question from Woodwell Climate Research Center about this issue of standardization and transparency. It sounds like that's your answer to that question,

which is some sense this might be actually easier than the ESG agenda, which seems like a sprawling mess and there's a full employment program for people who are interested in standardization.

So I am curious, Sue, in your remarks you talked about where we are with utilities doing this kind of climate resiliency assessment. This paper, this terrific paper that Romany and Michael presented laid that very clearly, that most utilities aren't — there are some good examples, Con Ed, under a settlement agreement. And, as you said, in places where it's already happened, in some sense there's a cognitive problem here, which is people don't recognize the gravity of the problem until their houses burn down and then they work on the problem.

So how do we move beyond looking backwards as a method of doing climate resilience assessment when what Adam said is looking backwards is a bad guy. Are we just kind of doomed to keep driving by looking in the rear vision mirror, or is there a way to do better by looking forward?

MS. TIERNEY: Well, there's a way to do better by looking forward for sure. But there are systemic regulatory structure — whoops — maybe it would be good if I didn't turn down the volume while I was talking — there are some systemic structural approaches in traditional regulation that make it hard to look forward. For example, if you're setting rates for utilities, you look mainly at the historical test year. Has it happened before? If you are projecting demand for electricity and air conditioning loads, it's based on regression analyses from the past, for the most part. I mean I'm generalizing of course. It's really hard for people in the regulatory industry, including the actual decision makers themselves, to deal with low probability, high impact events, and things where it's hard to quantify impacts, including quantify benefits relative to cost. And yet I think we are in a world where we need to use the climate science that Adam talked about and risk assessments that are there to change a number of things.

For example, you can think that the engineering — can I call that science? Engineering science? Or technical stuff in engineering.

MR. VICTOR: Definitely you can call it technical stuff.

MS. TIERNEY: Technical, okay. So you could begin to use climate science and probabilities of heat or coldness to look at availability of power plants, how well transmission lines can carry juice in a really hot condition.

So those are things where you should begin to start adjusting things on a going forward

basis. A lot of interest around the country in electrification and installing heat pumps for the future. Well, there's questions from the science and engineering about whether heat pumps in buildings will actually operate under really extreme cold conditions.

Additionally, in the social science part of it, David, we could, rather than use historical regression analyses to look at air conditioning loads, we could begin to look at some probabilities of new events and conditions in the future. And also in the social sciences we could begin to look at testing. If you put in place an anticipatory policy, which is shutting off the wires in the event of real heat waves and wind conditions, you would want to know how people are going to react based on how often it happens, what is the length and duration of outages, what people think were the causes. So there's a lot of social science that could be applied looking forward as well.

I'll stop there.

MR. VICTOR: I want to come to Romany now and pick up exactly where you left off, Sue, which is one can think about what a good program looks like and you can figure out what the science might be and the risk approaches and so on, that the DOE indeed has guidance around this. There are a few high water mark examples — I guess maybe high water mark is not an appropriate metaphor in this business — but there are a few good examples like Con Ed, some of what's going on in California right now. And yet we don't see it happening in the real world.

And so, Romany, from your perspective having done all this research, what's needed here? Is this the utilities commissions and maybe organize through NARUC, which is the association of all the utilities commissioners, need to kind of compare best practices, there need to be more lawyers suing them? Like what's needed to actually change things here?

MS. WEBB: Yeah, I'll start off. Michael might have thoughts on this as well.

I think it's a combination of things are really needed. Part of the reason — when we looked at why utilities aren't doing this sort of comprehensive climate resilience planning, we saw a number of different reasons. One is that they say they don't have the science they need, there's too much uncertainty, it's too speculative, these future impacts. So advances in the science and better communication of the science I think is really key. More close work between the scientific community and the utility community because, you know, there are a couple of mentions to the work Con Ed has done

here in New York City, that was done — you know, there work was done in very close collaboration with scientists at Columbia, and that really strengthened that report. So, more clearly, sort of injecting the science in I think is vital. But also this does, to some of the points that Sue made, this does really require changes at the utility commission level. One of the big barriers here is the reliance by utility commissions on cost-benefit analysis when they're evaluating how you deal with these risks. A lot these risks, if they're sort of low probability, high impact events, the benefits are somewhat unclear, they're difficult to quantify, and so it really makes the use of that cost-benefit analysis metric really difficult.

But even without those sorts of what I would class as sort of big picture changes, there are certainly ways in which utility commissions and the advocates who participate in utility commission proceedings can adjust their approach to get more attention paid to this issue in terms of how utility investments that aren't related to resilience, but are just investments in just sort of ongoing system upgrades and so forth are evaluated in light of climate change. Things like that which I think are really important as well.

MR. VICTOR: So I wanted to see whether Michael wanted to comment briefly on this and then I wanted to just talk briefly about the science and the incentives in the science community before coming to infrastructure.

But, Michael, did you want to say something further?

MR. PANFIL: So I just want to highlight something that Romany referenced here, because I think it's a really important aspect, which is that it is the advances in climate science, it is the risk posed by climate change that is the novel thing. The foundation of law itself is to account for risk. It is a core function of law.

The electric sector has always been built upon ensuring safe, reliable, adequate service. And so the question is how do we ensure those foundational conceptions of how we built our sector in ways that does account for and recognize the impacts of climate change.

MR. VICTOR: Adam, help us understand a little bit about the incentive structure in science. You talked about the wish, having this be all open sourced. Some of what's been referenced here is the granularity that one needs from companies that are ultimately trying to make a profit. And so they can't be fully open sourced, or at least they've got to figure out how to make money as well. And the

science community has its own set of incentives, which is mainly to push the scientific frontier, and not necessarily to collaborate with utilities that want to do a better job keeping the lights on, which is great for people who use electricity, but not necessarily a scientific advance.

So help us understand whether the incentives are changing in science in this area or whether everyone is just kind of trying to do good for the world.

MR. SOBEL: Yeah, that's a great question. Thank you, David.

First of all, I wouldn't say everything has to be open sourced, but I think it would be good if more was. I mean what happened in reinsurance in the catastrophe modeling, you had sort of cottage industry that grew up in response to a real need from the private sector. And of course the people came out of academia and built that up in a way that was more or less independent of the rest of the science as it's practiced in academia and government. I mean it's not independent, but the information goes one way. I mean we in universities train graduates and some of them go and work in the private sector, but not a lot of the information comes back. In part that's our fault, I'm not blaming the private sector for this. It's also a lack of interest on the part of academics, and to some extent government scientists too, who are responding to the incentives, just as you said. Most of us are working on government grants. And I would say the federal agencies have not been that interested, in my experience, in funding this type of work, maybe perceiving that it's the private sector's problem. I'm not sure of that's the problem.

At any rate, I do think there's a gap where the academic scientists are, very broadly speaking, with many exceptions, not — and it's changing quickly, but maybe not quickly enough — are not that focused on these kind of very specific problems that have dimensions that are outside any single discipline. I study weather and climate, but understanding what's going to happen to electric utilities requires extra expertise.

So I think there is a gap and it's sort of a Wild West situation now where because there's such a need from the private sector you have, you know, more — a bigger industry springing up very quickly. And it's not disrespect to those companies. I'm glad there's a — you know, the private sector wants our science, it's jobs for our students. It's good to have a robust private sector and some of it has to be proprietary. But I think the basic problem is that what we need here is a public good. I mean it's not just — you know, it shouldn't just be — there's a lot of reasons to do this science that might not

necessarily be in the narrow financial interest of any particular company, or even sector, but it's a value to society. So it's a basic problem of supporting a public good. And we have to someone change the incentives. I think it would be great to get the federal agencies interested in supporting kind of work so that it would —– and that would hopefully benefit the private sector too because they would have a bunch of stuff they could use for free and it would no doubt still need to be adapted and value added and there would be plenty of work there to do that.

So I don't have a real like policy map for how to do it, but I think there is a gap. It's going to be filled one way or the other, but it would be good to have it filled in a way that's best in the public interest.

MR. VICTOR: And we'll have a chance to talk a little bit more about potential investments in this area, including in the new infrastructure bill. And I know we're going to lose you at the top of the hour, Adam, or a dissertation defense. The machinery of academia continues on.

But I want to now switch gears and talk about that infrastructure bill. Today is infrastructure day, the President is announcing $2.2 trillion infrastructure plan. I guess a trillion dollars is not what it used to be. And I'm curious —– maybe we can start with you, Tom Doe, and then to Eric —– help us understand —– you said in your opening remarks, that municipal finance accounts for 75% of the infrastructure spend in the country. So that's the dog. In some sense the federal programs are the tail, although the tail is getting bigger. But I'm curious as to what you, as someone who studies the municipal market, what are you looking for in the infrastructure bill that would help address the kinds of problems that we're talking about here today?

MR. SOBEL: Well, I think like with anything, when there's a lot of money flowing, there needs to be some guardrails that are set up in order to ensure that it ends up in the right place. You know, it's a bill that's come out, and I honestly haven't gone through all of it because I tend to be a bit cynical with just how long it's going to take before it all gets hammered out. You know, probably not until fall when we really kind of see what it looks like. So, you know, what I would like to see is utilizing the data that's out there and —– either if it was from academia or from private companies that are starting to use the data to make decisions. And as you pointed out in your paper with regards to an infrastructure audit in order to identify where are the areas that are at risk so when dollars are flowing to the states and

to the local levels and to the cities, is that those dollars are allocated in areas that face the least amount of risk from a climate perspective, or at least if the investment is being made for the essentiality of it, is that it's known just how viable or how — and the longevity of any type of project that's done in that area.

And so what we're talking about on the municipal side is — why I've been drawn to this area is that yes, it's the financial community, but it's also — it's essential services. I mean we're talking about treatment of water, clean water, water and sewer. We're talking about hospitals, we're talking about transportation, we're talking about the grid. All of these elements are just so essential. And I think what needs to be done with all this money that is flowing, this is the opportunity to really do the accounting before these dollars are just cut loose and flow without guidance.

So I'd like to see some element of incorporation of the data into the direction of where these dollars flow.

MR. VICTOR: I want to ask the same question to Eric in particular in light of the whole history, many efforts at reform of the infrastructure incentives. And one of the key points in your remarks was that some aspects of the public finance story here are actually maybe making climate dangers worse.

And so what should we look at in this infrastructure bill that we would think of as a success in terms of getting the incentive structure right around investment?

And then I'll go to Sue on the electric power side in particular.

MR. GESICK: Yeah, David, so I think probably one of the major things to think about here is when we're looking at this, like I mentioned, is the whole government approach. I think that's going to be really important, because if you start picking and choosing various areas, for lack of a better word, the local politics is going to get in the way. And so I think when you're looking at this I think the issue around the military base closings is going to be really instructive of how to think about this in a broader sense.

And then some of the other things is that probably need to look at — one of the major ones is the insurance piece of it, the national federal flood program. I think that's going to be another thing to look at in conjunction with this bill as well because there's going to be an interaction between the local building and resilience and how some of the other things are going to respond. And so that's why it

is so important to have this whole government approach, because you don't want to go one area and have unintended consequence in another part of the government. And so I think that's probably going to be the most instructive thing as they set this up, is to really, really look at it that way.

MR. VICTOR: Let me put that same question to you, Sue, and in particular focus it in on the electric power side. There's $100 billion, more or less, that's earmarked — earmarked is not quite the right word yet, but is tagged to electric infrastructure. There's a lot of words around resilience, yet the experience that we've just had over the last 10-20 years is what Romany and Michael document in their paper.

So what looks like success to you in terms of the electric part of the infrastructure spend in terms of getting serious about these physical risks?

MS. TIERNEY: Before I answer your question, I want to say how wonderful those two papers are. They are very, very thorough and represent a deep understanding of the dynamics in these areas.

For the infrastructure bill, I would look first at that principle that –– was it Tom who said that there are a lot of public good issues here. You know, you cannot internalize a lot of the value of some of these investments, or not enough. So in an infrastructure bill, there are various things that make the whole system more robust and investment in them, not only job creation, but they could be down payments for becoming more resilient. Advanced meters sound like they're kind of crazy things just to know how much use of electricity is going on in a house, but it actually signals where there's an outage. And that's how Southern Company demonstrated to its regulators that they should put in place advanced meters everywhere, so that you could get back to operations really fast.

Additionally, I love the idea of the climate resilience planning that you two, Michael and Romany, described because that's not only jobs, but it's also figuring out where the risks are so that people could plan. And jobs — when I say planning and analysis jobs are also jobs, not just construction jobs. So there's a lot of different kinds of jobs here. But it could again be a down payment.

David and I just participated in a National Academy study on the future of the grid and one of the things we talked about was that there is a public good in building models that can do stress testing of the operations of the grid. And those are public goods. The private sector is not going to do

those, the states cannot do them, there has to be work on that. You could imagine not only hardware investments attached to the grid, but these other kind of analytic tools and other pieces. And I argued to the science committee recently that they ought to be looking at those things as part of infrastructure.

MR. VICTOR: Just quickly on this, and then I want to switch to a different topic, which is about the future of the financial markets. A lot of questions about that. But quickly on this, a little hard to figure out exactly what the infrastructure plan is with regard to research spending and the creation of these public goods — Adam talked about that. It looks like at least $35 billion is carved out for that, so that's 1.6% or so. Is that a big number, a small number, about the right number? How would we know the answer to that question?

MS. TIERNEY: David, I think that you said, as a member of the future of the grid committee, that we need to do at least double the spending. And $35 billion I'm not sure gets us double, especially in the applied investment area for R&D. So I think it is a nice step. And perhaps in all the tradeoffs it had to be made for a multi-trillion dollar plan, but there's a lot more that could be usefully done there.

MR. VICTOR: Yeah, okay. Let me ask you — I want to switch gears and talk about the financial market because we have a lot of questions about the role of climate in the financial markets. A small topic, easy to address. So I'll tick that one off in just a moment, but we have questions from Public Citizen about this, from the SEC about this, but maybe I'll sharpen this around a question that came in from someone at Freddie Mac, which is — and I'll start with you, Eric Gesick — do you see the concerns about climate change expanding or contracting the risk markets? How should we think about this question? It seems like if there are a lot of new risks and the incentives are right, that that whole market gets bigger, but with new incentives. Or is that the wrong way to think about it?

MR. GESICK: So I'd like to go back to some of the comments that were made that as the information starts expanding, I would say that the fiduciary responsibility include that into a whole host of investment decision making processes will increase. And so I think you're going to see tendrils of this climate, the physical impacts of climate risk broadening somewhat.

You know, municipal bonds is a clear test case right now, but it's going to expand as the data expands. And I just would see the direction of this, yes, David, expanding to other securities and

other forums just because — either through ESG lens or because there's going to be more of a causal link between physical risk of climate damageability to some sort of asset and then the derivative value of a financial asset on a physical exposure. That causal link, once it gets established, is going to be important.

And the other thing is that it's plausible that market actors who have more information, or who have studied this more than say sophisticated investors, could move early and you could have a situation where, you know, there's — I'll call it a little bit of an analytical arms race around this to figure out where it's going to impact first. And so you could potentially see movements before the physical impacts have actually materialized.

MR. VICTOR: Mm-hmm. Similar question to you, Tom Doe, and then I want to come back to some legal issues if we have time before we finish.

The FSOC started a meeting seven minutes ago. Climate change is number one on their agenda, thanks to Janet Yellen. Are you seeing — as someone in the financial markets, are you seeing this big — basically a big rise in attention to the physical risks of climate change? There's been all this attention to transition risk, but the thesis in both these papers is that physical risk is actually a bigger concern and been a harder one to get our heads around because the analytics haven't been there. Are you seeing this now as a big shift, and frankly a big rise, the way Eric described it?

MR. DOE: I think we're going to see a change over the next 12-18 months where there's tremendous momentum that gets behind us. One is because the — and, again, in the municipal space, remember most people are chasing the tax exemption and most of those people by definition are high net worth individuals who are making a lot of money. And these people have the luxury and the privilege of being able to spend time on these issues, which is what their leadership role is. And as a result, they're going to start pressing their — the people who are managing their money about these questions. And that's going to start to force change.

And, again, as the data becomes more readily available through the different provides, that no one can say I don't know because there will be data to discuss and to address. And so I think it is going to gain momentum for a lot of the comments that Eric's made and that you made in the paper. And it's coming. And I think it's great. Right now, the opportunity is that the regulators and the leadership in

the administration, as you point out, have made this a priority. And so now as the discussion has been evolving the last few years in the municipal industry, began a little bit below the surface because it hasn't been a headline yet, but it's going to gain some prominence. And so I'm encouraged.

Rarely is the municipal industry in a position of leadership. And I'm excited personally as someone who has spent their career to be in a position where we're leading in a very positive way and contributing just beyond the financial marketplace.

MR. VICTOR: Can I just quickly ask a follow up on that? We have a question from someone at CoreLogic around climate risk stress tests. A bunch going on in Europe. Looks like we're getting ready to do more of that here in the United States. Are we going to learn really useful things from those for how individual risks get managed? Or is that something that people like to talk a lot about, but doesn't have generally a lot of useful information?

MR. DOE: You're asking me?

MR. VICTOR: Yeah.

MR. DOE: I think a lot of people are talking about it and it's just too long for it to unfold. I think you made a really good point earlier when we were talking in the discussion is that is climate going to get in the financial sector, is it going to get buried under the effort of trying to define ESG, because the ESG has been so popular in the equity and corporate space, and that's where so much more of the revenue is derived from. And it's going to be — my concern is that climate gets lost in the shuffle. And I think some of the efforts in Europe just aren't going to get applied.

MR. VICTOR: Yeah. We have a few minutes left, I want to put a question to Romany, and then if we have more time bring in Sue and Michael.

But I'm curious as to what you see as the balance of effort in getting utilities to do more of this climate resilience planning, between law actions, anticipatory and responsive — very helpful distinction you made there — versus just the utilities commissions figuring out how to apply existing tools, as you say, more effectively. Is it mostly the latter, or is it the former is actually doing most of the work?

MS. WEBB: It's definitely a combination. There are certainly things that utility commissions can do now. We just saw last year the California Public Utility Commission ordered all the major utilities in the state to submit these sorts of climate vulnerability assessments with their rate cases

that they submit every four or five years.

You know, we could see other commissions do that as well in other places around the country and the world. That would be an important first step. But ultimately the utilities have to engage on this topic in a meaningful way. You know, we've seen some examples of the way utilities have said they're doing these sorts of assessments, but they rely entirely — to Sue's point, they rely entirely on historic weather patterns that take no account for future climate impacts.

And so having that sort of utility engagement and participation in a larger sort of stakeholder process I think is really important to make sure that utilities aren't just kind of paying lip service to this obligation and are actually doing it in a meaningful way that can inform their decision making so that we're not spending money on things that we don't need, but we are spending money where we need it.

MR. VICTOR: And let me just ask you, Michael, you in particular called out tort actions. Do you see this as a growing area of action in the law that's really going to transform the utility business?

MR. PANFIL: I think that regulatory action, and legal action more generally, help to provide the connective tissue between what law requires and what evidence suggests is necessary to react to. And I think that what an electric regulator, what a financial regulator can and should be doing is evaluating their mission and mandate, holding it up against the context of climate risk, and asking what can be done proactively. But that doesn't mean that the action and activities of a court in reviewing in a reactive way isn't also incredibly important, not only as a gap filler, but as a way to ensure that we have consistency of legal design framework.

MR. VICTOR: Let me just give you a minute, Sue.

Supportive of what Michael and Romany just said, how should we think about whether some parts of the country are actually going too far? We have some rather interesting liability rules in California that maybe are leading to an overreaction, or there can't be an overreaction for a problem like this?

MS. TIERNEY: Well, that's a good question. I think California's model — I'm not a lawyer, you guys know that — but I think California's law with regard to liability is one that doesn't look at the public good nature of this risk. And it seems to me that if we're talking about it being a public good,

that ought to be underwritten by tax revenues as opposed to utility revenues. So perhaps it can go too far.

I actually would think that, as Romany and Michael just said, we haven't gone far enough in most places and the California law is pretty much of an outlier in terms of that construct. I think a lot more needs to be done. And I would just say, hear, hear to what Romany and Michael said.

MR. VICTOR: Well, I want to say hear, hear to our panelists and presenters. What an extraordinary discussion.

I wanted to say two things to close here. One is that there has been a big shift in analytical capabilities. It's really extraordinary and it's not visible, I would say, for the most part, but the visibility is rising very, very quickly. And the second is that the financial markets in particular, and I think public finance to a greater degree, should be hungry for information about this type.

In some sense the noise level has gone up a lot. The signal has gone up as well, but the noise level has also gone up. And I think in of trying to find signal and noise in the whole ESG debate, and so on, has been very, very trick indeed. But what's exciting to me about this is that the physical risks of climate change in some sense I think are the sleeper issue around climate change for the financial markets and there's now all this evidence that it's possible to do a whole lot better, and, frankly, without heroic changes in statute and so on, with existing concepts applied intelligently.

A terrific collaboration between Brookings and the Environmental Defense Fund and the Sabin Center at Columbia Law School. I want to thank all of you for joining us this afternoon and have a safe day.

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I, Carleton J. Anderson, III do hereby certify that the forgoing electronic file when originally transmitted was reduced to text at my direction; that said transcript is a true record of the proceedings therein referenced; that I am neither counsel for, related to, nor employed by any of the parties to the action in which these proceedings were taken; and, furthermore, that I am neither a relative or employee of any attorney or counsel employed by the parties hereto, nor financially or otherwise interested in the outcome of this action.

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