PAST THE TIPPING POINT: HOW REGULATORS AND UTILITIES ARE AND WILL BE LOOKING AT WAYS TO MITIGATE THE INEVITABLE IMPACTS OF CLIMATE CHANGE

The following is a transcript of the Energy Law Journal/Energy Bar Association January 12, 2022 online symposium: "Past The Tipping Point: Looking at Ways to Mitigate the Inevitable Impacts of Climate Change." On August 7, 2021, the UN's Intergovernmental Panel on Climate Change released a report that produced an unnerving two-fold conclusion: The world has already passed the tipping point – no matter what we do we will face unavoidable and serious climate change impacts that we – humans – have already caused. Only if we act now, the report adds, will we have the hope to avoid a complete climate catastrophe. The panel of experts participating in the symposium examined what policy makers and utilities are already doing and can do to mitigate the various impacts of climate change on the reliability, resiliency and affordability of utility services, and discussed the analytic tools at utilities' disposal, the legal and practical limits on regulatory changes and the strategies utilities and policymakers may utilize as they decarbonize their power systems.

Moderator: Harvey Reiter
Panelists: Roshi Nateghi[1],
Judsen Bruzgul[2], Heather Payne[3], Michael Craig[4]

PANEL DISCUSSION

MS. BARTELL: Hello everyone. My name is Sylvia Bartell and I am the president of the Foundation of the Energy Law Journal. I'm pleased to welcome our distinguished panelists, our moderator, and all attendees to today's symposium titled Past the Tipping Point, Looking at Ways to Mitigate the Inevitable Impacts of Climate Change.

1. Michael Craig: Assistant Professor of Energy Systems at University of Michigan- School for Environment and Sustainability, PhD, Engineering and Public Policy, Carnegie Mellon University (2017) MS, Technology and Policy Program, Massachusetts Institute of Technology (2014) BA, Environmental Studies (Ecology), Washington University in St. Louis (2010).

2. Judsen Bruzgul: Senior Director, Climate Adaptation and Resilience + ICF Climate Center Senior Fellow, Ph.D., Stanford University, B.A., Middlebury College

3. Heather Payne: Associate Professor of Law, Seton Hall University School of Law, J.D.; University of North Carolina School of Law; BChE, Georgia Institute of Technology

4. Roshanak Nateghi: Associate Professor of Industrial Engineering, Purdue University School of Industrial Engineering, PhD, Geography and Environmental Engineering, Johns Hopkins University, 2012, MSE, Geography and Environmental Engineering, Johns Hopkins University, 2008, MEng, Mechanical Engineering, Imperial College London, 2006

This event marks the first time the Energy Law Journal has sponsored its own symposium.

In that regard, I would like to thank the Energy Law Journal's editor-in-chief, Harvey Reiter, who is also today's moderator, the executive editor, Caileen Gamache, our numerous article editors, the student editors of the Energy Law Journal at the University of Tulsa, College of Law, and finally, our panelists.

Throughout this event, please take a moment to read through the attendee list. You all make up a cross-cutting group of individuals, each with unique abilities and perspectives to contribute to the Herculean endeavor of fighting and mitigating the effects of climate change. Let this symposium be just one aspect of our engagement with this topic. We hope today's event inspires further discussion and, importantly, action.

As always, the Energy Law Journal welcomes submissions of original articles on this and any other topic of interest to the legal profession and energy professionals. Finally, this recording will be made available to attendees and the Energy Bar Association members.

With that, I will turn it over to our moderator, Harvey Reiter.

MR. REITER: Thanks so much, Sylvia, and thanks to all the attendees here and to our distinguished panelists. So, let me briefly introduce our panelists today. Hopefully, you'll be hearing a lot more from them in the coming hour and a half plus.

Roshi Nateghi is a professor of industrial engineering at Purdue University and director of its Laboratory for Advancing Sustainable Infrastructure. She's currently on leave from Purdue to work with the Department of Energy's Office of Energy Efficiency and Renewable Energy.

Judsen Bruzgul is the Senior Director of Climate Resilience at ICF and Judsen has advised clients on challenges of climate risk for 20 years.

Heather Payne is a former chemical engineer, but now a distinguished professor of law at Seton Hall, teaching and writing on the intersection of energy and environmental law.

And finally, Michael Craig is a Professor of Energy Systems at the University of Michigan School for Energy and Sustainability.

I want to welcome all of them here and I also want to talk a little bit about why we're here today. Probably one of the precipitating events was the August U.N. Panel on Climate Change Report announcing two unnerving conclusions: that we're already passed the tipping point on climate change and we can only keep things from getting worse.

The U.N. Secretary General called the report Code Red for humanity. So, when we talk about climate change being past the tipping point, we're talking about certain irreversible changes no matter what we do. What are some of these things? We'll see more storms, more hurricanes, more heatwaves, more wildfires, flooding, and tornadoes, and their intensity will increase too. While no one weather event constitutes a trend, it's hard to ignore the numerous record-setting events we just saw over the last seven months. If you could just put up a chart, this will be a little bit of a reminder about what we've seen:

Extreme Weather Events June-December 2021

June 20, 2021- Temperature in Verkhoyansk, Siberia reaches 100° F. – a new temperature record for the Arctic.
June 29, 2021 -- Temperature in Lytton, British Columbia – a small town located eighty miles north of Vancouver -- reached 121° F, hotter than the highest temperature ever recorded in Las Vegas
August 11, 2021—190 wildfires spread across Siberia - covering an area larger than the fires in Greece, Turkey, Italy, the United States and Canada combined
August 11, 2021 – Temperatures in Sicily reached 120° F.-- the hottest day ever recorded in Europe
August 14, 2021- rain fell for the first time in recorded history at the highest point on the Greenland ice sheet
August 21, 2021 – 17 inches of rain fell in Waverly, Tennessee, followed by massive flash flooding
August 26, 2021 -- Hurricane (later Tropical Storm) Ida makes landfall, ultimately killing a hundred persons in the U.S. and causing massive destruction from Venezuela to Nova Scotia, into October.
September 7, 2021 – Death Valley reaches 122° F.-- "the hottest temperature ever recorded this late in the calendar year anywhere in the world."
December 10, 2021 – a deadly string of tornadoes hits Kentucky and seven other states, killing scores and virtually wiping out entire towns.
December 14, 2021 - Artic Global Report Card declares that Artic temperatures are rising twice as fast as the global average, scientists at American Geophysical Union conference predict that Antarctica's Thwaites Glacier could collapse within 3-5 years

Think about last June. On June 20th, the temperature in Siberia reached 100 degrees Fahrenheit. That was the highest temperature ever recorded north of the Arctic Circle. Later that month, the temperature in Lytton, British Columbia, a small town 80 miles northeast of Vancouver, reached a temperature of 121 degrees. That's hotter than the highest temperature ever recorded in balmy Las Vegas.

In August, early August, 190 wildfires spread across Siberia and covered an area larger than the wildfires that happened the same year in Greece, Turkey, Italy, the United States, and Canada combined. Later that same day in August, the temperatures in Sicily reached 120 degrees Fahrenheit. That's the highest temperature ever recorded in all of Europe.

Later that month, rain fell -- rain – for the first time at the highest point of the Greenland Ice Sheet. And again, in August, 17 inches fell in one day in Waverly, Tennessee, followed by massive flash flooding. Later that month, again, in August, Hurricane Ida struck and that was a hurricane that caused damage all the way from Venezuela in August to early October damage caused in Nova Scotia. In the meantime, as a hurricane, it killed 100 people -- some of them flooded in their basements – throughout the United States' east coast.

In September, we saw Death Valley reach a temperature of 122 degrees Fahrenheit, again, another record. This was the highest temperature ever record-

ed anywhere on Earth that late in the year. And December was another record month. We saw again a string of tornadoes hit Kentucky and in seven other states, wiping out entire towns.

And on the 14th of December, the Arctic Global Report declared that Artic temperatures are rising twice as fast as the global average. The scientists at the American Geophysical Union Conference predict that Antarctica's Thwaites Glacier could collapse in three to five years.

And after I'd prepared this chart, we had a couple of other events. First-time events like the first ever December tornado in Minnesota and the wildfires, December wildfires, in Colorado. And just yesterday, we had a report in the Guardian, the U.S. edition of the Guardian newspaper, that the highest ever reported ocean temperatures had occurred in 2021, breaking the record set in 2020, which in turn, broke the record set in 2019. So, what can we take from all of this and what is its relation to what we'll be talking about today?

Now, I imagine that none of the conclusions of the U.N. Report came as a surprise to any of our panelists. They've been looking at the impacts and the potential impacts of climate change on utility systems and how we respond for a number of years.

Let me talk a little bit about how we're going to structure our discussion today. First, I'm going to go around the virtual room and ask our panelists to talk about their current work and then we're going to divide our session into four segments. The first segment will focus on the types of climate risks we face and how they affect utility systems and the consumers who rely on them. Then, we'll talk about some of the analytical tools available at regulators and utilities' disposal to address these issues.

The third segment will focus on how different regulators and utilities around the United States, and to some extent around the world, are responding to climate risks. And the last segment session, and certainly not the least important, is the question of affordability to address resiliency and mitigation measures.

So, let me start first by going around our virtual room and we'll start with Roshi, if you could talk a little bit about your work.

MS. NATEGHI: Sure. So, in my research we assess the risk and resilience of energy systems under extreme events and climate change. For example, we've looked at the short, medium, and long-term impacts of hurricanes and extreme heat events on power distribution systems and I'm happy to talk about some of the highlights of the work later, but more recently, we are thinking about compound climate risks.

What I mean by compound climate risk is for example, droughts and heatwaves happening concurrently or when a heatwave follows shortly after a hurricane. And there's clear evidence that their likelihood and intensity are increasing under climate change and yet, there is very little understanding of how to model their amplified impacts on infrastructure and energy systems and communities, and that's the area that we are hoping to contribute to now.

MR. REITER: Yes, Judsen, if we could just turn to you now and you could talk a little, briefly, about some of the work that you're doing.

MR. BRUZGUL: Sure. Thank you, Harvey, and thanks to the Energy Bar Association and the Energy Law Journal for hosting this. I think it's a very timely panel and I'm delighted to be part of it.

I'm with ICF. We're a consulting firm. For those of you who aren't familiar, we're headquartered in Northern Virginia with about 7500 employees across the country and overseas. I work as a senior director for climate adaption and resilience and lead our work on climate resilience in the energy sector.

I'm also a senior fellow at our ICF Climate Center, which is a new platform that pulls together original data and insights on climate trends and brings together our more than 2,000 climate, energy and environmental experts across ICF. So, this is an area and a domain that we've been working in for a long time and I've spent my entire career working on climate impacts, understanding climate impacts to natural and human systems.

I've been with ICF for the last eight years focused on this work. Specifically, I'm working directly and our teams are working directly with utilities, as well as with the Department of Energy and other state and federal agencies to help understand risks from climate change. That includes translating the science of climate change into actionable and decision-oriented information, really making it relevant to the work that they do and their ability to manage risks.

In terms of understanding and assessing risks, we provide a lot of support to understand vulnerabilities across their systems, as well as their operations and planning and workforce and other aspects of their business and then to build resilience plans to mitigate those risks, think about opportunities to advance their overall resilience across their organization and ultimately to better serve their customers.

So, that's the work we've been engaged in and continue to be. I'll stop there and look forward to the rest of the discussion.

MR. REITER: Thanks, Judsen. If we could turn now to Heather.

MS. PAYNE: Thanks, Harvey. So, I am from the Seton Hall University School of Law, as Harvey mentioned, I focus on energy and environmental law. And the last couple of years my work has really been from the basic assumption that climate change is happening and that we need to electrify everything to address that. And so, I focus on regulated utilities and the legal and policy changes that are necessary to make that happen.

And so, I found myself very frequently basically telling everybody that they aren't doing enough and they aren't doing it fast enough. And lot of that, I think, comes from the fact that we have policy layers that we are not aligning. So, for example, picking on my home state of New Jersey, we have fairly decent climate goals, especially if we take executive orders into account, but at the same time we're doing things that are anathema to that still.

So, for example, actually providing efficiency subsidies for natural gas appliances as opposed to try to move toward electrical. And while law doesn't necessarily tend to be, especially among these esteemed panelists, the most practical of applications, I do try to focus my work in a practical way. So, for example, one of my articles, Natural Gas Paradox, tried to give legislators regulators, and utilities menus of options when we were thinking about how to shut down

the natural gas distribution system as we electrify, especially, in terms of things like stranded assets, how we were going to deal with the financial implications of that.

I also recognize that some of our fundamental common law doctrines are going to need to change. The duty to serve, for example, is going to have to be modified as we deal with climate change and our increasingly extreme weather events. Most importantly, I think, and thanks to the Energy Law Journal for having this discussion, is we really need to be planning for and talking about the significant action that has to happen to get to that decarbonized future now.

And obviously, as we go through the conversation today, all opinions are my own and not necessarily those of my employer.

MR. REITER: Thanks Heather. I remember when I was working for the Federal Energy Regulatory Commission and I gave a talk, and one of the things I said was that my opinions are solely my own and not necessarily those of the Commission or the Commissioners, no matter how persuasive and logical I may be.

So, let me turn last to Michael Craig, Michael, to talk a little bit about your work.

MR. CRAIG: Thanks Harvey, and to Sylvia and the rest of the team for organizing this event. I'm looking forward to talking with the rest of the panelists and to thank all of you for attending.

My name is Michael Craig. I'm an assistant professor at the University of Michigan where I study energy systems in the School for Environment and Sustainability and I run the ASSET Lab. So, our research really is in two tracks on mitigation of climate change and adaptation to climate change. We're going to focus mostly on adaptation here. And my research is mostly in the power system, so we build large-scale models of regional power systems. You can think of multi-state regions where you can interconnect scales, like the eastern United States and the western United States.

And then we perturb those systems with future metrology under climate change instead of historic metrology to ask how bad could things get in the power system and what do we need to do to adapt to climate change and we do this work, partly, on long-term funded -- you know your typical academic projects like from the Department of Energy or the National Science Foundation, but we also do a lot of short-term projects on behalf of utilities or stakeholders because myself, and the rest of my students included, really do a lot of applied research where we're trying to answer practical, real-world problems.

So, I'll work in more of my research as we go through, but that's a high-level overview for now.

MR. REITER: We should have plenty of time to talk about some of that.

So, I mentioned before that we're going to break our program down into four different segments. So, we're going to start first with what climate change impacts are we talking about and at the end of each segment, just to the audience, I wanted to mention if you have questions, please put them in the chat box and we'll try to get to those at the end of each segment. And then, we'll also have an

opportunity for questions and answers toward the end of the program and we'll be able to open up the microphones then so you'll have a chance to ask some follow-up questions.

So, let me start with our first topic. What are some of the climate change-related events about which regulators and utility planners are now focusing on? And I know, Roshi, you mentioned the complicating factor of multiple climate events or weather events that have their own special impacts. So, I'll open up to the panel, whoever wants to start first.

MS. NATEGHI: I'm happy to chime in first and then I'm actually very curious to learn from the panelists, as well.

So, my impression is based on reading the literature and my interactions with utilities that on paper we are concerned about all hazards, ranging from cyber threats to malicious acts to climate hazards. Think about tornadoes, wildfires, hurricanes, and droughts. When you look at the bipartisan infrastructure bill, now there is the $27 billion budget to operate and modernize electrical grid to make it resilient to climate events and cyberattacks.

But if you look at the historical data from the Federal Emergency Management Agencies. I'm just going to refer to it as FEMA, easier to refer to the acronym. If you look at FEMA's disaster declarations, you'll see that the federal relief policies have been so responsive to rapid onset events like storms and hurricanes as opposed to slow-onset ones like heatwaves and droughts and sea level rise and that's not necessarily in line with the infrastructural and societal impacts.

For example, droughts and heatwaves are amongst the most costly and lethal events in the U.S. Just one example is the Chicago heatwave back in 1995 where 50,000 customers lost power, over 700 people died, and yet, when you go back to the disaster relief database, you'll see very disproportionately less amount of investment and responses.

And based on my group's sort of shallow survey of some other countries -- some government documents from European countries, my sense is that this is not necessarily unique to the U.S. Somehow rapid onset hazards appear to catch most of our attention and just my experience has been that there's not uniform attention spent to various types of hazards. And yes, I'm curious to hear about what the experience of other panelists have been in this area.

MR. BRUZGUL: Okay, Roshi, I think that's a really interesting perspective and I'm glad you brought it up and I'm looking forward to learning more about your research on the compounding events. I think that's a really important dimension here.

MS. NATEGHI: I would say we see broadly that folks are interested in the hazards that they're experiencing already and how those may be exacerbated. That tends to be the starting point. I think for hazards that maybe are emergent for them, either sea level rise, for example, and flooding maybe along the coast that they haven't experienced or are just beginning to experience at, let's say, a king tide event, is newer ground for folks to understand what that means for their

operations and their planning, but we do see a lot of interest, of course, in sea levelrise and flooding.

I think, in general, there's a recognition, just as you say, of gradual change, as well as the low probability, high-impact events however those manifests, either fast or slow. I think a low probability extended drought can have a high impact and I would put it into that category. And I think it's those things that push the conversation beyond the traditional reliability discussion and that's an important element to our work. Utilities and the power sector has dealt with storms all along and there are a lot of good approaches to managing risks from storms and other kinds of climate-driven events.

I think what we see as different is the frequency and intensity, the compounding nature. As you point out, things like consecutive winter storms, such as the Reilly-Quinn back-to-back storms in the Northeast that caused massive, long duration outages that significantly impacted customers just a couple of years ago. So, I think those are really important and the notion that these events can be longer duration, more widespread, and really need a different or at least complementary approach to reliability planning and investment I think is really significant and ties with the kinds of hazards that we see already and anticipate based on the science.

MS. PAYNE: And to pick up, Roshi, on what you said about FEMA and the longer-term hazards not being addressed, I think the Village of Kivalina really is the poster child for that, right? We have an Alaskan native village that has been pounded and is really seeing the impacts of climate change, needs money to go ahead and relocate and yet, has been denied that multiple times by FEMA because they don't view, essentially, the impacts from climate change as within their discretion.

To Judsen's point, I think that we, especially for legal reasons, are starting to see utilities take action based on climate change that they haven't before that are having a significant impact on customers, right? All of the public safety power shutoffs that we've seen in California over the last couple of years to address wildfire risk, which is primarily there because of an historic five-year drought and the fact that we had, perhaps, other reliability issues that were not addressed by the utilities as they should've been are having a massive impact on people's ability to be resilient through these different issues.

And I think that the pandemic really puts both of these different facets of it into an entirely different perspective that I don't think that we would've had before for something like public safety power shutoffs or addressing things like Hurricane Ida where traditionally what we would have done was evacuate people to things like convention centers where we would've had backups where we could have provided services now we have the potential that those are super spreader events and so the pandemic just adds another layer of an impact where we're not able to see traditional reliability and resiliency really act in the same way.

MR. CRAIG: So, I love panels where I learn on the panel, which has been great. So, I just want to add a perspective on why we care about these events. And I agree with all the other panelists in terms of the types of events and we're

doing a review right now of different utilities and how they're planning for it and we see heat come up all the time, extreme heat. California of Summer 2020 had rolling blackout there. They pointed to climate change contributing to this, what they call a heat storm, which was not unique because of how bad it was, but was also bad in terms of the length of it and the special scope of it, so it's new in that way.

But they talk about extreme heat, wildfires, drought, sea overrise, but we can think about different parts of the power system and then think about where the vulnerabilities are there to understand why these events are of concern. And the major impact that we see from climate change or one of the most clear ones that are robust across studies is increasing electricity demand. As things get warmer, people run their air conditioning more and so you have increasing demand. And if you're not planning for that in your planning procedure, then you are at the risk of outages. At the same time that that is being driven by high temperatures, you also have risk at your thermal powerplants. You might have droughts contributing to low hydropower output. You might have impacts on your transmission system in terms of acute impacts like we see with a lot of safety power shutoffs or just that you have lower carrying capacity.

And so, there are these different events and they impact the power system in different ways and I think one of the challenges that we're a little behind on at this point is to think about across those different parts of the power system. How are they all going to interact or compound one another and to drive these sorts of events that we dramatically want to avoid, like outages or like turning people's power off because they're in wildfire-prone areas.

MR. REITER: So, I had a question. You've talked about how these events are not individually unique and we've had storms before. We've had droughts. We've had wildfires and some of them have even intersected in time, so those aren't themselves unique. How do you look at these events where their intensity and frequency increases and how do you approach solutions to those issues as opposed to just saying, okay, I know that we're going to have an occasional wildfire? We can harden our systems. We can underground them or something like that.

MR. BRUZGUL: Michael, did you want to respond.

MR. CRAIG: No, I'll go after you. Go ahead.

MR. BRUZGUL: Okay. Well, I'll just make a comment or two on that question. I would say two things. One is a sense of there's a threshold that exists to how we want to respond in the frequency or intensity, and I think Heather made a great point about, so traditionally, we would gather people and send them to the Super Dome or other places or evacuate people. If you're doing that every other week, it also starts to be something that you want to rethink as a strategy and so I think as we think about the frequency of these outages that's important.

The other element, you mentioned the pandemic, the thing that comes to my mind there is not only those gathering issues, but more people having a different relationship with their power, depending on it from home, for work, for liveli-

hoods in a different way. We're much more dependent on it for connectivity, increasing for transportation and other services. And so, as that dynamic changes, I think the acceptance of outages is also changing and I guess that gets to my second point which is around the view of risk and the risk tolerance. And I think one of the most important conversations that we see is both lacking, in general, but is necessary is understanding the risk tolerance. What is acceptable in terms of power system performance, in terms of the level of risks that you can maintain or manage as you're delivering power for the utility because ultimately you've got to make tradeoffs about the level of investment you want to make and the resilience that will provide based on how risk tolerant or adverse you are.

I'll just give one quick example. You think of the FEMA one in a hundred-year flood plain and we tend to -- or the 1 percent annual chance flood plain. That's something we think of often. We probably don't want to build there. Everyone has the sense that it's a riskier area. We don't have that same shared view of other risks. Whether that one is right, we can debate about, but we don't have that same view on a heatwave, for example, or other kinds of challenges and those, I think, are really important to this broader conversation about what are we going to do about it and why is it different.

MR. CRAIG: Yes. And I might take the answer in a slightly different direction, which is if we think about how we have traditionally planned power systems -- and most of my research is on large scale power systems. We take a large planning model and we give it metrological data to understand what demand and supply will look like and this has been becoming increasingly important as you put more wind and solar into the system, but let's set that aside.

So, where did we get metrological data before? Well, we can go to the historic record. Utilities have long periods of reliable operations. They have these reanalysis datasets that have satellite-derived data going back 40 years and so you can go 40 years full historic record. And if you wanted to, understand how your system would withstand 40 years of historic meteorology.

Now, we're faced with a situation where we have nonstationary, meaning that prior 40 years is not representative of what we'll see in the future and so the utility picks up its head and says, okay, so where do I get my meteorology data now? And the unsatisfactory answer is you get it from climate models, but the climate models were not built to give that data to utilities. They don't capture these extreme events. Well, they're not at the resolution that they want them at and so how are things different?

The process needs to change somewhat, but the process needs to change because the data that has been driving our decisions thus far is not as useful anymore and there are limitations in the new data they want to use and so you can't just take a pipeline where you used to shove data in and take this new data and shove in instead. That has a limit to it because the data itself has issues with is and so that's where we need to think about where the processes at the planner level needs to change to account for the fact that the data is not quite what you expected it to be.

MR. REITER: Are you seeing conversations between utilities and the government on the way they aggregate sample data so it'll be more useful?

MR. CRAIG: So, yes, that's a great question. So, we actually ran a workshop for utilities -- well, we ran a couple in association with NARUC -- and other organizations, trying to talk to utilities and provide them with better data and understand what their needs are. I think there has been an increasing understanding that the past is not going to be particularly useful anymore. California has a very large RFP out now for research on climate resilience.

New York is engaging in similar research. You saw Texas using a five-year historic record for cold weather events and they found out that that was not a good idea and so I do think that there are conversations along these lines. I just think that things have changed so quickly that we are a little behind the eight ball right now and really coming to terms with not just what the new data needs to look like, but what those processes need to do.

And actually, I would say Con Ed in New York is one of the leading examples that I believe ICF contributed in their planning, thinking about how they need to use new data and working with climate scientists in that regard, but then also working to improve their planning processes and resiliency analyses.

MR. REITER: Roshi, I see you're nodding your head. Did you want to add something?

MS. NATEGHI: No, I'm in agreement of what Michael is saying and I think the nature of some of our modeling work are aligned, so yes, I was just nodding in agreement.

MR. REITER: So, let me ask you all, generally, do you think that the U.N. climate report has elevated the urgency of the issue for utilities and regulators? Has it sunk into their consciousness yet?

MR. CRAIG: I'll go first, very quickly, not based on any conversations, but I would just assume that having events happening in your backyard will bring the message home much quicker than a U.N. report will. And wildfires, heatwaves, Super Storm Sandy, I have seen a lot of actions that are in response to extreme events, not so much actions in response to the U.N. climate report. I'm sure it helps them understand the problem they face at scale and scope, but I think a lot of these extreme events that you, yourself, have just listed there, as well as others, have really also incentivized a lot of action.

MS. PAYNE: I would say the fact that we had 20 billion dollar disasters in 2021 in the United States, together with an economic toll of those 20 disasters of $145 billion, I think that is probably driving much more than the U.N. report would.

Now, I certainly think in some states, right, the U.N. report -- for the states that are already paying attention, then those states are going to see additional urgency, but of course, that's not all of them.

MR. REITER: Roshi, go ahead.

MS. NATEGHI: I just wanted to agree with what was just said and that based on my conversations with a few utilities, I feel like many have already started trying to be proactive just because they've been very challenged by many different events. And if you just look at the major outage data collected by the Department of Energy, Office of Electricity since early 2000s, you see that extreme weather and climate events since early 2000s have been the main culprit behind major outages. By major outages, I mean more than 50,000 customers being affected or more than 300-megawatt load loss. So, the intensity of weather-related outages has increased by almost 70 percent since early 2000s, so I think the utilities are very much aware of this data. They report this data to the Department of Energy, so my sense is also that they felt the urgency based on the experience, perhaps not necessarily just based on the report, though it varies in different parts of the country.

MR. REITER: So, I'm going to direct this question to Judsen, but I think others may have something to say on this as well.

Based on your interactions with utilities and regulators, do you think they look at climate change impacts differently, the distinction between those that are inevitable and those that may be avoidable, over the long term, by climate change mitigation, like decarbonization measures?

MR. BRUZGUL: That's a good question, Harvey. I think a question that a lot of people are wrestling with is, first, how big an impact is this to my system, right? Just getting a baseline on that is important to understanding, well, what am I doing about it and what are the costs of doing something about it, and then, which of those costs is it prudent to incur right away because I've got a gap against the risk and the risk tolerance that I have set and therefore those are the things I need to take care of no matter what and which are the ones that I might to create some flexibility or optionality to invest in later at a lower cost by making an upfront investment, but there is a lot of uncertainty about the future and that uncertainty is climate related, right, the pace and change of certain climate hazards.

There's uncertainty because we don't have a forecast of the future. As we think about uncertainty, there's a lot of other uncertainty in the energy sector right now. That's part of what makes it so exciting, I think, to work in the spaces. You have massive transformations in the way that we produce and distribute energy, along with the way that we use it in electrification, beneficial application across the sector. So, anything that you are doing to your system to be responsive to adapting to climate needs to be done in the context of those other investments and I think all of that poses major challenges to folks, to utilities, as they think about where to make investments and when.

And I think very few have established frameworks for thinking about that problem rigorously and I'm not aware of -- I think there's only been initial regulatory encouragement to do that. And in the absence of that, much of what's happening, I think, is still at a preliminary level. I'd love to hear others on the issue.

MS. PAYNE: Well, Harvey, I would say that your question assumes that we're going to solve a very wicked, collective action problem and that some of what we're actually thinking may happen is still avoidable, right, and I think that that is probably why, you know, to Judsen's point, we're seeing not necessarily a lot of the conversations framed that way.

I mean I still have environmental law colleagues, very well-respected ones, who just put out an article about how we need to actually plan on a 4 degree C world because of the fact that based on everything they're seeing they don't think that we're actually going to solve the collective action problem that would avoid that, right? So, I think that part of the challenge inherent in your question is how much utilities and regulators can assume that four degree C world is not what they're actually planning for.

MR. CRAIG: And just to do one last bit of level setting. So, the Paris Agreement is either 1.5- or 2-degree Celsius target. I forget which. I think it's a 2 degree C, but 1.5, for instance, is this very extreme, great world in which we could possibly get to that's going to require a huge effort, 2 degrees is still a huge lift. So, if somebody said I want to aggressively mitigate climate change, that would be like a 2 degree C world. It gets worse from there.

Even if we meet a 1.5-2-degree Celsius world, climate change will still intensify over the coming decades. So, a lot of these impacts are coming whether we want them to or not. There's a certain amount of climate change baked in and then it's really almost in the latter half of the century where we can hopefully avoid some of these very extreme outcomes.

MR. REITER: So, that sounds pretty pessimistic. I mean I think part of what we're talking about today is mitigating the inevitable effects of climate change. The question is how much of it is inevitable. I mean we know a fair amount of it is, but in terms of the collective action that you mentioned, Heather, where is there room for optimism on this?

Let me pose a slightly different question. Not only where is there room for optimism, but what do you see as the role of the utilities and utility regulators in addressing this issue of collective responsibility? Do they have the obligation to lobby for changes in law? I mean how far does their obligation, the utilities' obligation, for example, to provide reliable and affordable service tie into their greater responsibility to the community-at-large or even beyond that?

MS. PAYNE: I mean I take a fairly expansive view of what utilities and regulators can and should be doing, right? So, I mean, obviously, I think the first thing is that they need to not be making the problem worse, right? So, you should not be putting any fossil fuel infrastructure into your system at this point, right? I mean if you want to be part of the solution, I actually do view that it's that simple.

In terms of things like lobbying, I mean, listen, we, I'm sure, are all very familiar with the Exxon knew everything that's coming out about the climate disinformation campaign. I think what's not as well known is that EEI actually knew and did lots of studies around carbon as well, right? So, the fact that cli-

mate change and utility infrastructure actually being part of the climate change problem is something that has been well known for decades, especially, within the utilities and their regulators and so I think that to be part of the solution does mean that, yes, you need to admit that fossil fuels cause climate change. Its human caused at this point and so you do need to be bringing to your legislators, to your regulators, that you want to be part of the solution. I think that that is something that we should expect of our utilities and their regulators just as being – I wouldn't even say like good global citizens, but just being a global citizen that's where you need to get to, but I'm very interested in hearing what others think about that.

MR. REITER: (pause) Not everyone at once. Well, I imagine we'll come back to this, at least in part, when we talk about affordability during the last segment of our discussion today.

I did want to ask a more practical question about the different types of climate impacts and if you could just briefly discuss your own work on how utilities and regulators prepare differently for some of the events that may be more likely in areas whether it's wildfires or even flooding or sea level change or the impact of heat waves and the like.

MR. CRAIG: Sure. So, I'll start out on this and then I'll turn it over to others. So, actually, I think the EU had some guidance that came out last year, climate-proving guidance. When we think about these different types of events, I don't, as a power system person, care about the event, in and of itself. I care about how it will affect my power system and how it will affect citizens in the United States.

So, for each individual part of your power system, each individual transmission line, each individual power plant, you can go through and catalog the vulnerability of that asset to climate change and that is what the climate-proving guidance in the EU provides a nice framework for vulnerability as a function of what is your exposure to climate change. Are you on the coast and so you're exposed to sea level rise or not? Are you in area where wildfires might be increasing or not? If you're exposed to it, what is your sensitivity to it and what is the risk that you face of something happening in terms of a climate-change related event?

So, you can go through and you can catalog each individual part of your power system to understand what the vulnerability is and that is to be the first guiding part of your understanding of how should I respond to different types of climate impacts. Heatwaves or heat storms, as California called it, are bad, in part, because they can occur over very large spatial scales and climate change, at least out West, will make it over larger and larger footprints.

So, Roshi, earlier on, mentioned compounding events. Heatwaves have this spatially compounded part of them where they can occur over California and neighboring states, so all of their power systems are getting hammered at the same time and it's affecting your demand and your supply in your transmission systems. And so, once you catalog vulnerability at the asset level, you can think about how are those vulnerabilities related to one another, will they all occur at the same time or not, and then, ultimately, think about how will this affect my

power system.

And so, once you've gone through that process, once you understand here's the risk that I'm at, then you can start thinking about adaptation measures. You can think about, okay, where can I harden my grid and does it make sense. One thing about wildfires, one of the tricky parts is you've got hundreds, thousands of miles of transmission lines that could be causing wildfires to be affected by them and that's part of the reason why that has been such a challenging problem to deal with out West.

But if you think about a thermal powerplant like in Texas, they've got 100, 200, 300 powerplants in their system and really probably 50 are incredibly important for reliability. And so there Texas has the opportunity to go out to this finite number of powerplants and make hardening investments there, basically weatherproofing them and that can help them avoid bad outcomes under extreme cold events in the future, for instance. And I saw they just sent inspectors out to look at all those powerplants. It's very hard to do that for all miles of transmission lines out West. And so, once you understand the vulnerability, once you understand the joint vulnerability of your system to different effects on your assets, then you can ask a question of how can I adapt and make some hardening decisions and that's really going to vary by types of events and asset-to-asset.

MS. NATEGHI: Maybe I can add. I like it, Michael, how you were approaching it from the adaptation side and maybe I can add a few points on the response side.

So, I worked with a few utilities to develop power outage forecast models for a couple of days before a hurricane arrives, so they can get a map of what areas will be more highly impacted, how long the outage would be, and so on, and that allows them to be more proactive and efficient in response and recovery.

And from that perspective, if you're operating on a shorter time scale, the difference is your ability to predict these events with reasonable degree of accuracy. So, for example, it's much easier to predict hurricane activity compared to wildfires or ice storms and that the nature of your inability to predict the impacted area or the speed at which it happens or ice accumulation on your power lines that really challenges the utilities in their ability to rapidly respond.

And the other part, actually, as Michael was mentioning as well, it's different events have varying degrees of impact on different parts of your power system. So, for example, after most hurricanes -- I mean not the very intense ones – or floods the majority of their impact is on the power distribution system that have maybe a less lengthy/complicated recovery process compared to the transmission system. And I haven't done a whole lot of work on wildfires, but I was reading how, Michael, you were mentioning as well, a transmission system's expsoure to wildfires is particularly increasing under climate change and those aspects of what parts of your assets are more vulnerable to different types of disasters also affects your ability to respond in a reasonable timeline, but yes, coming at it from a shorter time scale.

MR. REITER: So, I -- I'm sorry. Judsen, were you going to say something?

MR. CRAIG: Go ahead, Judsen.

MR. BRUZGUL: Go ahead, Michael. I'll let you respond.

MR. CRAIG: I was just going to quickly say actually on our lab website, assetlab.org, we have a handbook that we put together as part of those workshops to try to walk through the vulnerability assessment and talk about the different climate impacts. So, before I forgot, I just wanted to flag that in case people want to learn more. It's in the Students Accomplishments tab.

MR. BRUZGUL: I'll just say I wanted to add -- I agree with everything that was said and Michael did a great job of laying out that perspective on assessing vulnerabilities and I think alluded to -- both Michael and Roshi alluded to the customer and differential customer consequences, if you will, and I think that plays into the kinds of prioritization of investments, as well as the types of investments that are possible. As you think about differential vulnerabilities, we saw a lot of this play out in the Texas freeze. For example, through the headlines you saw disadvantaged communities be significantly impacted for a variety of reasons. You see it in heatwaves. You see it during major outage events. And I think moving beyond just understanding which customers are dependent for medical device reasons and which ones are fire stations and police stations to a more sophisticated understanding of vulnerability of the customers they serve is an important direction to add to the conversation around understanding vulnerabilities and what to do about it.

MR. REITER: So, we're going to turn in the next segment to talking about some of the analytical tools and touching on, at least, some of what Michael was talking about, but I do have a couple of questions --before we close out this segment --from the audience.

My first question is from Michael Kessler. And he asked if the panelists could discuss how markets and specifically RTO markets may or may not be able to effectively address climate change by including, for example, carbon pricing and market clearing prices.

MS. PAYNE: So, I'll start on that one. And FERC did a technical conference last year around carbon pricing and I think that there's still healthy debates on whether it would come in under a Section 205 or 206 filing, but I think that most likely what we will see is we will see an RTO like PJM, probably, or New York ISO and New England ISO actually put forward a filing where they would include carbon pricing in their clearing price and then, I think, that that's when we'll actually see whether that is accepted. I do think that that is something that FERC could allow, but based on what we're seeing today, obviously, it hasn't happened yet.

MR. REITER: So, the next question I have is from Jorge Roman-Romero. And he asks -- actually, asks two questions. What policies or laws will aid utilities to respond to climate risks from the state and federal level? And for purpos-

es of decarbonization, is it legally and economically feasible and practical to adopt a carbon credit system for electric power at the household level, that is, for consumers?

MR. CRAIG: So, I'm going to give a high-level response, nothing concrete, so you will not get anything useful out of this, but I do just want to flag that right now we're talking mostly about adapting to climate change. Of course, mitigation is this other big theme that is ongoing in the power system and one thing that I do not think we have any sort of handle on is how much these two can align or not.

We did a study last year for the southeast United States and we were looking at adaptation and thinking about, okay, if I build more wind and solar in my system does it help me with adaptation or not because these other new technologies that we're building, renewables, nuclear powerplants, carbon-capturing sequestration powerplants, they all are not invulnerable to climate change. They have their own vulnerabilities. Solar panels, for instance, are affected by wildfire smoke, so they had huge generation penalties last year during wildfire season and they are less efficient at extreme heat.

So, I think when we're thinking about how we should be mitigating climate change there can be co-benefits in your adaptation, but these are things that we need to think of together rather than separately. These are long in advance. That's 20, 30, 40 years, so they're going to be around as climate change intensifies. And so, in general, I would say we need to think about these together. And a carbon price, for instance, that pushes investment toward low carbon technologies, does not necessarily make you more adaptive to climate change. You could be putting nuclear powerplants or carbon-capturing sequestration powerplants in places on the sea or on rivers that in 10 or 20 years are not going to be good for cooling that are going to be affected by sea level rise. And so, I just want to flag that mitigation/adaptation, adaptation does not naturally lead to mitigation. They need to be done hand-in-hand and so whatever mitigation policies you put in place are not necessarily going to help you adapt.

MR. REITER: And what you just said, Michael, for example, if you're talking about decarbonization and you're talking about adding more solar, for example, large-scale solar probably has a significantly lower unit cost than rooftop solar, but in terms of restoration of services and the like there may be some advantages to local fuel cells or rooftop solar or the like that would be less vulnerable to changes in the climate. Is that part of what you're saying?

MR. CRAIG: Partly. I mean I think I would frame the distributive versus centralized more as Judsen spoke about, which is there are certain communities that are going to be more vulnerable than others and so can we think about distributive energy not as like mitigate first, adapt second, but as an adapt first, mitigate second tool. And so, thinking about where we need to put rooftop solar, along with grid, other storage, maybe even a diesel genset in order to provide adaptive capacities to communities that lack them, to me, would be more important than thinking about rooftop solar versus centralizes solar or mitigation potential.

MR. REITER: Any other responses to the last question before we turn to our next segment?

MS. PAYNE: I'm not sure that I quite get the question, whether is it legally and economically feasible and practical to adopt a carbon credit system for electric power at the household level? I mean I think the one thing that I would say is that, for example, California has a cap and trade system that's based on carbon for power as well as additional industrial segments. And basically, every single person in California twice a year gets a credit on their electric bill that's tied to that cap and trade system. So, if that's what it goes to, then yes, at least at the state level.

MR. REITER: So, with that, Heather, we're going to turn next to our discussion of some of the analytical tools. And Michael, I think, touched briefly on some of those. So, let me just open up, generally, the question of what are some of the analytical tools that utilities and regulators are utilizing right now in system planning to help them plan for climate change and related events?

MS. NATEGHI: So, I can chime in briefly. As I mentioned, I worked with a few different utilities to develop predictive models of power outages ahead of some extreme events. And based on my conversations, it seems like at least most of the utilities that I've talked to, they have a meteorologist on the team, so they have access to some type of weather forecasting capability at various scales.

What I often find missing is a model that translates the climate impact to infrastructure impact. A lot of times I think that translation happens based on expert's knowledge, which would've been fine if our climate system was stationary, but that translation based on gut feeling as opposed to a data-driven way which is guided by the physics of the infrastructure is not always helpful. And I'm curious to learn from other panelists and others.

MR. REITER: So, let me turn to Michael. So, what are some of the analytical tools that you have used or working with regulators, governments to utilize in this area?

MR. CRAIG: Sure. So, I talked about the vulnerability assessment already. I do think that utilities are increasingly adopting that. Con Ed in New York, for instance, has their climate resilience or adaptation plan that does a vulnerability assessment. The EU has their climate-proving guidance so that you're engaging in this as well. So, I think that's the first step. I've already talked about that.

I think, otherwise, a lot of the approaches are taking existing tools that utilities have typically used to plan and putting new data into it. I have not seen any utilities radically revising their planning processes and so when I talk about planning processes I'm thinking of, for instance, a utility releases an Integrated Resource Plan or an IRP. And for that, they had this long-term power system model where they look out 5, 10, 15, 20 years into the future and say what assets do I build, where do I build them, when do I build them? And all of that is in or-

der to minimize system costs while meeting other constraints like whatever decarbonization target they had, if any, and while ensuring reliability.

And so that kind of long-term, large-scale power system model that is where they might be feeding in new data rather than looking at the model itself and thinking about how can we reform it. I do think there are really exciting options for changing the process rather than just changing the data and those, to me, of most interest are things like robust processes where you think not how well would this one asset do under climate change or not, but asking how robust is a certain investment across a wide range of future climate outcomes because we have uncertainty, not just in terms of the emissions pathway, so not just in terms of how much the future will warm, but there's also tons of uncertainty in terms of if the world warms by 2 degrees Celsius by 2050 what does that mean for my local meteorology and impacts. And so, that is in the academic community what we talked about is deep uncertainty. Rand Corporation does a lot of robustness and so it's with that deep uncertainty in mind you don't even know how to think about the distribution of the potential outcomes where we can have some of these robust tools that are testing the sensitivity across a very wide range of future outcomes that I think could be very valuable, but I just have not seen uptake yet. Although, I don't IRPs all day, so this is based on the limited set of IRPs I've read.

MR. REITER: So, let me turn to Judsen because I know, Judsen, you have worked with Con Ed and Michael had just mentioned them. Not only with Con Ed, but with some of the other utilities and government entities you've been working with, what types of tools are they currently utilizing and what are the different types of tools for different types of events that are the most practical?

MR. BRUZGUL: Yes, Harvey, let me try to answer that. So, yes, we were the prime contractor to support Con Edison on their work with their vulnerability study and a subsequent climate change implementation plan that really took a deeper dive into ways to change processes and the planning that they do to help incorporate changes in climate.

So, I would say I very much agree with what Michael and Roshi were saying in terms of analytical tools, things like outage forecast models and the kind of modeling that goes into integrated resource planning. I think that continues to be important. In California, they incorporate some gradual climate change in their forecasts that are standardized for use in their Integrated Resource Plan, so there's a bit of integration there. That doesn't necessarily translate into the kinds of things you want to know for hardening your assets and the conversation that we've already been having, so I think that there is a gap when it comes to that.

What I would say is -- those tools, just as Michael said, I think can be helpful in understanding things like how temperature could impact future generation supply, as well as demand and load, so I think there's work that can be done.

We did some work in Ghana looking at an Integrated Resource Plan where we rather than take a least cost approach, we looked at a least regrets approach where we were thinking about this robustness that Michael refers to and I think that is an important way to reframe the application of some of the tools. It does require maybe using them a little bit differently. We were looking at drought

scenarios, for example, that weren't traditionally part of their Integrated Resources Plan.

The other thing I want to mention is -- picking up on Michael's comment about deep uncertainty and robustness, one of the things that we've been working with utilities on and in California has been picked up in some of their guidance materials is an approach called adaptation pathways and that is meant specifically to help plan in the face of deep uncertainty. It's one of several techniques that's been developed in the academic literature looking at how you think about the sequencing, the timing, and importantly, the triggers or signposts that tell you about how the future is evolving and what that means for the next investment that you want to make to follow a path that maintains your risks and provides an outcome robust to the changes that we're seeing.

And so, that's actually a technique that can be applied. It is being applied as part of planning and investment decision-making to think about in a new way if we have an uncertain future driven by the things that Michael was alluding to, how do we actually take action and not just wait and see or wait to see what manifests, as we were talking about earlier. So, I think that the work on adaptation pathways has been -- and applied in the energy sector is something that we see at the frontier of things that are useful in this context.

The other thing, just to mention, and Michael alluded to this a little bit, is something that Con Edison work in New York really did provide good information broadly, right? A lot of this is happening, we should say, at utilities not in a public way, especially if there's not a regulatory proceeding which is requiring that disclosure. So, just make sure everyone's clear that that's part of why exactly what's known and exactly who's doing what is often confidential.

I would say, though, when it comes to thinking about the way that they're designing equipment into the future and the power of a design standard in any infrastructure -- we see this in New York City, for example, thinking about the building stock across New York City and design standards to help them think about changing temperatures and flooding across the city.

Con Edison similarly looked at the importance of a design standard that helped them anticipate not just today's climate, if you're investing in a new asset, but the climate over the lifetime of that asset. And for renewables it's 20, 30, 40. For transformers, it could 40, 50, 60, 80 years that you see a new substation in service.

So, thinking about incremental change that goes into the design of that asset, as it relates to temperature, as it relates to things like sea level rise, and coastal flooding and actually setting for engineers something that allows them an input to their traditional design and build models.

And I think that's a case where I would encourage the need for continued thinking about more adaptative design in the way we actually build infrastructure, but as that's happening engineers traditionally wanting that historical view of a number to build to, a design standard that incorporates forward-looking climate can help achieve something meaningful in the near term. So, I'd highlight a few of those examples.

MR. REITER: Well, let me just ask a follow-up question about design standards. When engineers talk about the desirability of having those for plan-

ning purposes, do you differentiate between design standards that would apply to specific types of technology as opposed to performance standards because I think there could be a big difference in the flexibility it affords entities to best adapt. Is that something that comes into their thinking?

MR. BRUZGUL: I think from the point of view of the utility, or the work that we've done anyway, it's less about -- it's more about the project outcome and actually designing -- you know how many feet should we elevate the substation transformer bank to achieve the broader goal that maybe, I think, your question, Harvey, at least in my mind, raises up.

Broadly we might want a certain system performance against traditional reliability metrics or other metrics that capture resilience a little differently and how you achieve that could come through a lot of different solutions.

I see that as a slightly different set of discussions from the design standard itself. I think it's an important one and relates to maybe your initial choice of investment, but once you have chosen you are going to pursue a new substation or you are going to do pole replacement or other things, understanding then, well, what standard should we build to and how does the standard of the past maybe show us to be insufficient as a standard we want for the future, that is where these design standards come into play.

MR. REITER: So, I wanted to ask a slightly different question of Heather with respect to the analytical tools that may be at the disposal of regulators and policymakers, and I'll open it up to others too, as well. What responsibility do regulators have to encourage or mandate best practices in this area?

MS. PAYNE: I think that that's a challenge because the specific discretion that each set of regulators have, right, is going to be based on state law in a lot of cases and specifically what they are tasked with and how specific that is. If their discretion is broad, then, obviously they can require those best practices.

I think that the other thing that certainly I'm picking up from both Michael and Judsen, though, is that even if regulators might not specifically want to request that of their utilities, of course, part of the way that that can still happen is if we have interveners in these different procedures, right, or dockets that would request that and simply ask specific questions of the utility around how they're doing this planning.

And I think with that it's really telling how little truly minuscule public participation we tend to get, especially in IRP dockets. I mean, yes, there are some notable exceptions, the South Carolina IRPs last year were notable exceptions, but I have looked at lots of IRP dockets where you have all of two filings. You have the initial plan that the utility put in and you had the Order from the PUC accepting or adopting it and that's it. There is nothing else in that docket.

And so, I think that one of the other things that communities that are interested in these issues and how climate change might be impacting their utility planning is actually finding a way to get involved in some of these dockets which can be exceedingly, exceedingly challenging. I mean I think we're starting to see a little bit more outreach, especially toward underserved communities,

but it's something that I think regulators need to work on is really finding more ways to have communication for people who are interested in these topics.

MR. REITER: Just for the court reporter's edification, IRP refers to Integrated Resource Plan. I don't know if anybody else wanted to weight in, if not, I'll move to another question I had in this area. (No response.)

MR. REITER: So, one thing that I think we've touched on is the interrelationship between actions that utilities can take and actions that governments take, more broadly, with respect to decarbonization, for example, but also with respect to mitigating the impacts of climate change. We're not just talking about keeping the utilities running. We're talking about making sure the bridges stay up, that roads don't get flooded. So, how is it that the interrelationship between utility planning for mitigating climate change impact and improving resiliency relate to the broader planning by federal, state, and local governments to deal with climate change impacts and are they doing enough?

MR. BRUZGUL: I can comment a little bit if no one else wants to start. I feel everyone took a step back with that one, Harvey.

There are a couple of things come to mind with regard to this question. And to your last point, are they doing enough? No, I don't think there's enough. I think Heather makes a great point about the involvement in the rate cases. I think, in general, this coordination around what people are doing in a community around resilience remains a challenge and I think engagement and working groups working together are really an important aspect that can provide benefits, but there's just not that much of that happening.

One of the things that we saw in New York related to this, so first of all, the Con Edison work did have an active working group. The city was very involved with the work that we were doing with them as part of the vulnerability study and there were dialogues. I won't point them directly to the work within the climate change vulnerability study, but there were certainly dialogues within New York about how, for example, the storm water management system might relate to a vulnerability of an asset within the city, be it Con Ed or others, right? There is this interplay.

The city is investing in a large coastal flood mitigation project on the east side of Manhattan. What does that mean for assets that are either behind that protection and the responsibility that the utility has? Does the utility need to assume that that project will happen and so they're not going to harden their own system or do they need to assume that it won't happen and harden their own system? I think that kind of coordination is really important because, look, that's the sort of double spending that costs society more when it's lacking.

And in general, we're really at the, I think, starting point for those kinds of coordination and conversations and that's just thinking about the energy sector. The other thing to point out, and I'm sure others on the panel would chime on this, right? Coordination with other infrastructure is crucial as well and the interdependence of the energy infrastructure with water and telecom and transportation and others is really, really important.

So, what you are doing to adapt and mitigate risks in one might not do anything if all of a sudden you can't -- just as you were alluding to, Harvey, you can't access your substation because the road hasn't been maintained to be ready for future flooding or so many different interdependencies with storm water, with waste water treatment plants, and with telecom and you're relying on being able to reach customers via a telecom system that wasn't as resilient as you had anticipated.

All of those kinds of things are -- we're at the start of those kinds of conversations, as I see it, but one other thing I wanted to point out is, I think, on a federal level things like the FEMA, which I know has already been defined in acronyms, BRIC, which is Building Resilient Infrastructure and Communities grant program that is funding that goes to the states that can then flow to local communities for proactive investments in risk mitigation and in resilience that needs to incorporate consideration of future climate as part of the FEMA guidance. It also works to have partnerships between a local government entity and something -- either a municipal or an investor-owned utility to carry out those projects. And so, there's a place where significant funding, a billion dollars of funding flowing to addressing these issues that provide opportunity for folks to coordinate I think is a success story and I expect that there will be a lot more funding through that mechanism.

MR. CRAIG: I just want to add one thing. I'll defer to my co-panelists on whether more needs to be done. I assume the answer is yes, though, and this is one area where mitigation and adaptation can go hand-in-hand. A drum that we always beat for mitigation is regional coordination is important. California has their energy imbalance market where they're trying to bring in power from the Western United States, basically, and they import power from far away to get at those renewable resources.

In the East, we similarly when we think about how do we decarbonize the eastern power system, most of those plans rely on importing huge amounts of renewable electricity from out West, like the Great Plains area into the Eastern Seaboard where we don't have the renewable resources. And so, just the mitigation side of things requires a lot more interregional coordination to figure out how do we build those transmission lines and how do we operate a system that spans multiple Regional Transmission Operators or RTO, like PJM and MISO, for instance, coordinate.

So, we have that need in mitigation and that expansion, thinking about larger and larger regions and coordinating those operations and plans. That is one area where you can get a lot of benefits in the adaptation space as well. Because of these extreme events that are happening over larger footprints, you want to be thinking about how can I get more diversified assets that might be less vulnerable to the same type of climate event. And one of the ways you do that is by coordinating with your neighbors and thinking about, okay, if I have a heatwave can I come and borrow power from you.

MS. PAYNE: Yes, I would say that both of those, actually, really demonstrate, I think, one of the challenges with your initial question on more needs to be done because we don't really have a federal energy policy and we try to get

around that a lot of different ways. Maybe it'll get better. I think it was looking far more hopeful for that a year ago than it is now, but I think especially Michael's point brings out that a lot of this would be easier with a lot more transmission and if we actually had federal energy policy that was explicit.

MR. REITER: Let me ask Roshi a question on this. And actually, it's prompted by seeing Michael's Carnegie Mellon diploma in the background. Jay Apt ran the Electricity Center there. I remember him talking -- this was before the Energy Policy Act and the reliability rules and enforcement authority that went to FERC. And he was talking about how we recover from disasters. He wasn't talking so much about climate disasters then, but he was saying what happens when we have an inevitable outage. We can't prevent them all.

If you have tall buildings and we have an outage, how do we keep the elevators operating, how do we keep traffic lights operating? Should we install solar panels on a small scale? With local government, can its zoning control do it?

Roshi, I know you're working with DOE now and they're looking at energy efficiency and also performance standards. On that smaller scale, can that have a beneficial effect on the intersectional issue between government and the utilities?

MS. NATEGHI: Sure. I'm not sure how well I can respond to this question. Firstly, I'm still learning a lot about various different efforts that are happening at the DOE. So, I'm learning my way around there for now.

But if you don't mind, I would like to maybe circle back to some of the comments that the panelists were raising and they were making me think of all the challenges and all the work that needs to be done. And as Judsen was mentioning, so there's already quite a lot of coordination happening between federal agencies, FEMA and DOE with utilities, especially when disasters happen.

But then, my understanding is -- so you were mentioning incentive to mitigate for different states. My understanding is even those coordinations or policies that are in place need to be rethought more for example, for FEMA to release some of those funds to different states, the damage needs to be a certain dollar per head. So, if the amount of damage does not meet the threshold, you won't get the cost share that is suitable for your recovery. So, in a way, you're encouraged not to mitigate and sustain a lot of losses to be able to qualify for that funding. I know that there's lot of efforts there to rethink some of those allocation policies.

And to Heather's point about lack federal energy policy and a lot of the panelists already talked about different reliability or performance metrics of the power distribution systems and bulk power system. My understanding is a lot of these reliability metrics also, again, I'm probably just repeating what has been already said, but these reliability metrics are also calculated based on historical data. They don't really characterize future risks, including the climate risk, right?

And then even if that wasn't the problem, there's really no accountability, is there, for missing certain performance targets. So, as the panelists were talking, I was like, oh gosh, yes, there are so many challenges and so much work to

do. But taking your point about technology-specific investments that I need to read and think about and maybe get back to you.

MR. REITER: Okay. Maybe we will get an article out of you in the Journal.

MS. NATEGHI: That sounds good.

MR. REITER: So, I'm going to take our topics out of order and I want to turn to the affordability question before we talk about what some of the regulators are doing around the country and internationally, so let's turn to this question of affordability. And I think it's something all of you have touched on directly or indirectly that we've got kind of a regulatory triage problem that we will have to deal with where we have long-term impacts of climate change and immediate interest in mitigating harm and keeping their systems resilient.

So, what are the responsibilities of the utilities and regulators for weighing the different costs for resiliency and longer-term mitigation and how do that strike that balance? How should they strike that balance? Let's just start with that question.

MS. PAYNE: I mean that is one of the biggest challenges that regulators are facing throughout this, right? We all know that transition and the transformation of our electricity system is not going to be cheap.

For my perspective, I think that there's two things that regulators should focus on. The first is that we can use existing programs I think more efficiently than we do. So, if we think about energy efficiency programs, right, yes, I can go to my local Home Depot and energy efficiency money will make it so that I can purchase reduced-priced LED lightbulbs.

I don't think that's necessarily the best use of our energy efficiency funds in the State of New Jersey, right? I think that we actually should be funneling all of our efficiency money to address the energy burdens that we know exist and are much, much, much more important, in my opinion, than us making LED lightbulbs some percentage cheaper.

And so, I think that there are two different problems for regulators, in my opinion. The first is look at the programs that we have. Look at the money that we're already spending on things like energy efficiency programs and let's actually repurpose those programs really to make it so that the energy burdens that we know exists can be minimized to the greatest extent possible.

The other thing that I think needs to happen is we do need to have more of a conversation within regulators and utilities about, okay, if we have a vision of where we're going, if everything that we are currently doing does it all still have to be done or as we make that transition are there things that we should stop doing or not do, given what we think that end state is going to be and save money that way. And that's a conversation that I have never actually really heard happening because it seems like the idea is always that we always have to keep doing everything that we are currently doing and then we add stuff around the energy transition on top of it.

And so, I think that we actually need, basically, to start from the bottom up and say what do we still need and what realistically needs to go. In a lot of circles, this is usually done through something like zero-based budgeting. And I think that it's time for us to start having those kinds of conversations within utilities to really see what we can do to minimize the cost of the transition to make it so that we could actually minimize those energy burdens since we know that they exist.

MR. REITER: Let me as you a follow-up question. One is when you talk about repurposing the funds -- it's going to be a two-part question -- where would you repurpose them? And if you still want to encourage people to switch to LED bulbs or other energy efficiency measures, can you do that or should you do that through decoupling devices in setting utility rates so that they have an incentive not so much to sell electricity, but to meet certain targets that would achieve some resiliency goals, as well as efficiency goals?

MS. PAYNE: So, no, I'm not really a fan of decoupling and that's probably too deep to get into in this conversation. How would we repurpose it? Well, I think that some of the main ways would be to focus on low-income programs where we could actually do a lot more good with that money to reduce energy burdens, right? So, we have a very high percentage now of residential smart meters in the United States. We can couple that data with other population metrics and actually start targeting much more than we are now to make it so that energy efficiency improvements will help those that are most in need.

MR. REITER: More of a means-tested type of

MS. PAYNE: Exactly, much more than we are now, yes.

MR. REITER: So, Judsen and Michael, I know you both touched on these things, so let me ask you about what types of things the utilities are looking at? How are they making some of these decisions, these tradeoffs between decarbonizing and ensuring reliability?

Michael, let me just start with you because I know you talked about some of the complicating factors in even making these judgments because you've got measures to decarbonize that are going to exacerbate some of the problems with restoring or maintaining resiliency at the same time.

MR. CRAIG: Yes, I'm actually going to put up two -- in my mind, actually, that are most relevant to regulators and then I'll turn it over to Judsen and Heather and others can swat down what I think is an issue if they don't think is an issue. But first of all, what was driven into my head in all my regulation and law classes about the electric power sector is beneficiary pays, meaning if I make an investment, I should not make everybody pay for it, especially those who don't benefit at all from it. The people who benefit from the investment should pay.

But you have situations where now people who are most impacted by climate change, wildfires are a perfect example, are exposed to tremendous costs

in upgrading the grid and those same communities might be the least able to fund it. So, if I have a rural community in Oregon that is now facing public safety power shutoffs, I can underground that line. The undergrounding of the line really only benefits that community or to a vast extent benefits that community. It's going to cost millions of dollars. Can that community pay for it? So, I think that is a challenge, to me, in terms of how we think about regulating and distributing these costs.

I think the other issue is there are some principles by which a public utility commission determines whether to approve or deny plans from utility and that is rooted somehow in the public interest. I want to mention that you're spending money that is going to be in the public interest that passes some cost benefit analysis test or some other test.

If we think about the future, the benefit of any climate adaptation investments are uncertain. Some of them are extremely uncertain. And the benefit of any investment has always been uncertain to some extent. The benefit of building a gas generator is uncertain because I don't have perfect foresight of gas prices. But there is this new element I'm deeply concerned about what future climate will look like, what future climate impacts will look like, and what the benefit of climate adaptation investments will look like that I think can complicate that cost benefit procedure and how will a utility and a regulator interact with one another. And for the regulator to figure out whether this investment is actually good and a robust, adaptive investment or an investment that seems to be good at first glance, but in reality is not going to provide value.

So, to me, those are two larger issues that can complicate how regulators view adaptation investments and how they think about approving or denying them that I think are a challenge for some of this coordination.

MR. REITER: Roshi or Judsen, do you want to add anything?

MR. BRUZGUL: I just agree, Michael, with your comments. I think what I have seen mostly --so, backing up for one second. I just want to say on the utility decision-making around tradeoffs between mitigation and resilience, by and large, what I have seen is that these conversations within the utility tend to be pretty siloed still. So, I don't know that they're fully really grappling with what it means to trade off these dollars. I don't think we're seeing that yet.

On the question of the beneficiary pays, I do think we have seen some examples where regulators have denied requests for things that might build resilience like a micro-grid, for example, where a certain community would benefit from that, but the justification for why the entire rate base should fund it wasn't sufficient.

My impression is that folks are increasingly moving towards, maybe slowly, a more open mind about how to interpret that and think about that from the point of view I think the level of connectiveness within society, in a way, and across a customer base in that there are arguments to be made for how the benefits to one community spread more broadly than just that community. So, I think that there's economic techniques to help support that.

I think there are ways to improve benefit costs analysis and rationale that can make it easier for a regulator to see those benefits and in protecting the best

interest of the public still approve those kinds of investments. I think that there's more to be done there, but I'm maybe optimistic that there can be work to be done.

I think on this question of understanding benefits that Michael raises, especially the timing of benefits, if you're planning for a low probability event and that's where you're going like avoid billions of dollars of damage it's 1 percent annual chance flood, when do we get that?

I think there are some techniques that are different from just a simple benefit cost analysis ratio that help think about that little bit differently, things like break even approaches, but it's a challenge. And I think accounting for the benefits in a way that articulates the full range of benefits again, in a cost benefit framework or other framework that the regulators have established remains a gap, again, an area for work. I think I am optimistic on that front as well, though.

MS. NATEGHI: Maybe I can briefly follow up on also important points that were raised by Heather and I'm reminded -- like I recently read in an article that was raising the fact that despite the federally-funded energy system programs that we have, like the low-income home energy system program and the weatherization assistance program they've been around for over 50 years, spent billions of dollars in assistance and yet, one in three U.S. households are considered energy poor. So, the article was also alluding to the lack of effective metrics to evaluate and track success and more systematically invest in a way of alleviating energy poverty as opposed to addressing in a piecemeal way. So, I just wanted to mention that as well.

MR. REITER: That was a segue to a question actually that I was going to ask about, which is when we're talking about affordability, one component, in fact, it's part of President Biden's Executive Order, is that, at least at the federal level, regulators have to look at the impact on disadvantaged communities. And so, how do we integrate our analysis of affordability, not only in a general sense, but with the goal of making sure that poor communities don't take the brunt of some of the mitigation measures themselves, but what role do you see utilities playing? Have they thought about this and what are regulators looking at or what should they look at? So, I just open that up, generally to the panel.

MS. PAYNE: I mean I think that that's going to take a very state-specific focus really based on the state. I know that certain states --like California has a fantastic environmental justice mapping tool, for example, that I certainly hope utilities would, along with everybody else, be using.

New Jersey has a specific EJ law that went into effect that does limit where you can site specific facilities as well and so I think that we're going to see more and more of a focus, Harvey, not just on affordability, but really on the impacts of infrastructure as well.

MR. BRUZGUL: I would just add on that to build on the California example, California had a proceeding specific to climate adaptation where they resulted in a rulemaking requiring the investor-owned utilities in California to do a climate vulnerability assessment and also along with that is to build out a very

robust community engagement plan such that the disadvantaged and vulnerable communities, as they term them, the DVCs, which take into account the tools that Heather was describing, plus some other factors to understand where these communities are within their territory to do significant engagement with them as part of input to their vulnerability assessment, as well as shaping the investments that would come to address those vulnerabilities.

I think there was a lot of dialogue during the proceeding around the importance of consideration of the disadvantaged and vulnerable communities and the resulting Order, I think, really does a lot to highlight this issue and I just wanted others at least be aware of.

MR. REITER: It would strike me, even when we're talking about resiliency, that some of the measures that utilities would take if they were trying to put their dollars where they would be most effective a lot of times what they'd be guarding against, let's say, with respect to flooding in low-lying areas some of those are probably going to be some of the areas where some of the poorest of the population already reside and so reinforcing the system to withstand flooding or other similar events may also incidentally be most directed at the poorest that are most likely to be impacted.

Does anybody disagree? Do you think that's a correct observation or am I generalizing?

MS. PAYNE: I think that's especially true for inland flooding, but Michael probably has more detail around specifically that than I do.

MR. CRAIG: No, I was just going to mention, in terms of heatwaves, I think there's been very nice work recently. There was an article that came out maybe three months ago, looking at extreme heat under climate change and how it affects urban areas differently. I know it's written up in the New York Times earlier in the year. The New York Times had this nice article about how the heat island effect has a more concentrated impact in areas that are generally low income, looking at Georgia and Richmond and other cities. And so, you can imagine during outages you have more impacts.

And I believe Roshi mentioned the Chicago heatwave and there's a wonderful book -- wonderful in that it's a very nice book writing about a very terrible subject on looking at who of those hundreds of people who died, who were they, what was really the reason that these other ones who perished during that heatwave was often low-income individuals or the men who were isolated and alone.

And so, yes, there's all sorts of compounding factors here and so that adaptative capability that I think is a very important thing to consider when we're thinking what our assumptions are about reliability in the power system and making sure that, okay, our assumptions might be wrong because our assumption is based on history and no longer representative of what will happen in the future. So given that, how can we make sure that these communities that don't have much adaptative capacity can have it.

MR. REITER: Well, I'm going to – unless anybody else had something else to add, I'm going to turn to our last topic area and hopefully we'll leave a few more minutes for general questions from the audience.

And I really want to focus on a couple of things dealing with how regulators are responding around the country and to some extent internationally to deal with issues of climate change resiliency and mitigation.

We spoke before this conference in some of our discussions here about what we've seen around the country. So, I'm going to turn first to Heather to talk about what the legal framework is when we're talking about companies' failure to act on foreseeable consequences. And I know that there's been some litigation in New Orleans in the aftermath of Hurricane Ida and there's also been significant litigation in California in the aftermath of wildfires. So, I wonder if you could talk about the legal landscape there and what obligations utilities may face and what standards they have for prudence or other types of litigation risks if they don't take proactive measures.

MS. PAYNE: Well, I think that there is-- this is, again, one of the areas that makes energy law so interesting because we do tend to see different legal requirements and different standards in different states. So, of course, in California, we're seeing some litigation based on gross negligence, but we also have a very unique inverse condemnation law in California. It doesn't exist anywhere else in the country, so IOUs in California have a different legal paradigm that they're operating under.

I think that the Entergy litigation is going to be interesting more because of some of the previous statements of the utility. So, when they went to the New Orleans City Council to get approval to build a new gas plant, part of the justification was the fact that this would have a black start capability and would really enable the city to be much more resilient from a storm. And of course, with Ida we didn't see that and so I think that a lot of the litigation in New Orleans is really focused on past statements that were used to justify additional infrastructure.

For the most part, utilities are not going to be held liable until they meet a gross negligence standard, right? And so, I think that that is a fairly high bar in terms of plaintiffs actually suing their utility. I do think, though, that we are going to start seeing more of a regulatory focus. Not so much from lawsuits, but for a regulatory focus, to your point, Harvey, on prudence. And so, what is going to be found to be prudentwhen we're doing a review may end up being different. And I think it's still an open question, both at the state level and then for federal regulators. For example, the Nuclear Regulatory Commission, NRC, how much they're going to take the work that Michael is doing, specifically, into account, right?

So, we actually saw a very interesting situation with the relicensing of the Turkey Point Nuclear Plant where NRC didn't necessarily, in the feeling of a lot of views, take what is going to happen to that plant likely within that relicensing period into account. Where that's going to come up in prudence determinations as utilities try to move specific infrastructure investments into rate-base is still a very, very open question.

MR. REITER: So, I know there are a lot more things that we could discuss. I have a bunch more questions, but we're running near the end of our time. I did want to leave an opportunity for participants to ask their questions or people in the audience. So, if you raise your hand, just hit the raise your hand button at the bottom of your screen, we can open your mike so you can ask questions directly of the panelists. So, why don't we do that for a couple minutes now and I'll look for any of the questions that we have.

MS. PAYNE: I did also, Harvey, want to make sure because I don't think we're going to actually get to much of the climate change litigation, but if people are interested in what is happening in terms of climate change litigation around the world, as well as in the United States, the Sabin Center at Columbia has a fantastic online resource that really can provide both a great overview and then also does a deep dive into all of the cases. So, that resource is available if people are interested since I know we're not going to get really into that at this point.

MR. REITER: Yes, I think that we've got a lot of shy attendees. You wouldn't know it most of the time, so I will use that to ask one more question from the panelists, though, and it really was prompted by some observation that you made earlier, Heather, about the continued availability of incentives to install gas-fired equipment in the home.

And so, the question I have is we have a number of states, most states, in fact, where natural gas is available where the public utilities laws require the gas utilities, like the electric utilities, to provide service on reasonable requests to newcomers as well. How do we deal with this issue, the one you talked about, and how are utilities thinking about it?

I know we'll be seeing some articles in future editions of the Journal about gas utilities, gas distribution companies and pipeline converting their infrastructure to move hydrogen, but how do we deal from an equity standpoint for people who already have this equipment – an affordability standpoint -- and the political issue of dealing with industries that employ a lot of people and that have a lot of infrastructure in the ground? How do we deal with that if we're also talking about longer-term climate change impacts that require more decarbonization? So, just a small question to end the session. Michael, I see, was throwing up his hands. I don't know if that's the answer he gave.

MS. PAYNE: I mean I know that for me I have two papers that bear directly on this. One I've already mentioned, so Natural Gas Paradox actually does talk specifically about how regulators should be thinking about shutting down the natural gas distribution system.

And to your point on the duty to serve, I actually have another paper, the draft is available on my SSRN author page. It's coming out next month in the University of Richmond Law Review called Unservice, and it specifically deals with the fact that we will need to modify the common law duty to serve, which is what you're discussing to deal specifically with these issues.

And I think we'll start seeing that with natural gas, but I actually think that as climate change becomes more extreme natural gas utilities will not be the only

ones that are faced with situations where it's going to be very, very difficult to continue service.

MR. REITER: So, let me open it to our panelists for any closing remarks they had, any last thoughts they wanted to provide before we end the session.

MS. NATEGHI: I want to thank you for organizing this and thank all the panelists. I learned a lot.

MR. CRAIG: And I would echo that. It was great. I just put links in the chat. One to another Sabin Center report actually on climate resilience that is great and then I put a link for a handbook as well, so a couple more resources. But yes, it's been great and thank you for coming.

MR. REITER: Thank you so much, Michael.

MR. BRUZGUL: Same from this side. Thanks so much. It was a great panel. I learned a lot from it. Thanks Harvey for some great moderating and good questions to keep moving. I would take away that these are important topics that have, I think, real challenges. There's a lot of work happening on it, but there's much more to do and I'm excited for where this will take us.

MR. REITER: I want to thank all of you for taking the time out to participate today and also to the attendees who've been here today. This session will all be transcribed and appear in the next edition of the Journal, which is coming out in mid-May, so we'll look for it there. And I hope that what we've heard from our experts today will prompt some of you out there to consider writing for the Journal on this or other related topics because this is a topic of very considerable importance to our future.

And the members of the Energy Bar can play a good, practical role with providing advice, both to the regulators, to the utilities that they represent, and to the public. So again, thanks so much to everybody. We look forward to you reading our next edition of the Journal and to any contributions that you might think about making. So again, thanks to everyone. Thanks to Sylvia for helping to organize this and to Michelle and Olivia from the Energy Bar Association for all their work in helping to organize today's program and we'll see you soon. Bye.