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Energy Resilience for the Americas: Frameworks, Tools, Applications and Experiences in Reinforcing Energy Systems in the Americas

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Webinar Panelists

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Abraham Ellis

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Mauricio Cuellar

This Transcript

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Stephanie

One important note of mention before we begin is that the Clean Energy Solutions Center does not endorse or recommend specific products or services. Information provided in this webinar is featured in the Solutions Center's resource library as one of many best practices resources reviewed and selected by technical experts. Today's webinar is centered around presentations from our guest panelists—Abraham Ellis, Guenter Conzelmann, Domingo Mateo, and Mauricio Cuellar—who have joined us to discuss frameworks, tools, and practices for reducing energy system vulnerabilities to natural and manmade threats. Please note the first two presentations will be in English, and the case studies from Mexico and the Dominican Republic will be presented in Spanish. These case studies will be posted in both English and Spanish on the Solutions Center training page.

Before we jump into the presentations, I'll provide a quick overview of the Clean Energy Solutions Center, and, following the presentations, we'll have a question and answer session where the panelists will address questions submitted by the audience. And at the end of the webinar, you'll be automatically prompted to fill out a quick survey. So we thank you in advance for taking a moment to respond. This webinar is provided by the Clean Energy Solutions Center, which focuses on helping government policymakers design and adopt policies and programs that support the development of clean energy technologies. This is accomplished through support and crafting and implementing policies related to energy access, no cost expert policy assistance, peer to peer learning and training tools such as this webinar. And the Solutions Center is cosponsored by the governments of Australia, Sweden, the United States, with in-kind support from the Government of Mexico. This webinar is also being held in support from the ECPA ministerial, which takes place in Chile next month.

The Solutions Center provides several clean energy policy programs and services, including a team of over 60 global experts that can provide remote and in-person technical assistance, no cost virtual webinar training on a variety of clean energy policy topics, partnership building and development agencies, and regional global organizations to deliver support. An online library containing over 5,500 clean energy policy related publications. Our primary audience is made up of energy policymakers and analysts from government and technical organizations in all countries, but we strive to engage with the private sector, NGOs, and civil society. The Solutions Center is an international initiative that works with more than 35 national partners across its suite of different programs. Several of the partners are listed above, including research organizations like IRENA and IEA. Programs like SE4ALL and regionally focused entities such as the ECOWAS Center for Renewable Energy and Energy Efficiency.

A marquee feature that the Solutions Center provides is no cost expert policy assistance, known as ask an expert. The service matches policymakers with one of more than 60 global experts selected as authoritative leaders on specific clean energy finance and policy topics. For example, in the area of energy resilience we are pleased to have Mr. Michael Milton Wu of Converge Strategies serving as one of our experts. If you have a need for policy assistance in energy resilience or any other clean energy sector, we encourage you to use this valuable service. Again this is provided free of charge. And if you have a question for our experts, please submit it through our simple online form at cleanenergysolutions.org/expert. We also invite you to spread word about the service to those in your networks and organizations.

Now I'd like to provide brief introductions for today's panelists. First up is Dr. Abraham Ellis, who leads the Photovoltaic and Distributed Systems Integration Department at Sandia National Laboratories in Albuquerque, New Mexico. Following Dr. Ellis, we will be hearing from Guenter Conzelmann, who is the Director of the Center for Energy, Environmental, and Economic Systems Analysis at Argonne National Laboratory. The first of our two case studies, we'll hear from Domingo Mateo, who is the Director of Energy Security of the Vice-Ministry of Energy and Infrastructure at the Ministry of Energy and Mines of the Dominican Republic. And our final speaker today is Mauricio Cuellar. He is the manager with the National Energy Control Center in Mexico. And, with those introductions, I would like to welcome Abe to the webinar.

Abraham Good morning.

Stephanie Good morning.

Abraham So am I ready now?

Stephanie You're ready. Feel free to show the presentation.

Abraham Okay. Let's make sure everybody can see the screen.

Stephanie That looks perfect.

Abraham Great. Good morning everybody. Just as a matter of a quick introduction, let me say I've been working in this space of energy systems and renewable energy for a very long time. And I wanted to share with the group here, especially given the audience, that we do have some experience working in renewable energy projects in Latin America. That was actually my first job here, working in energy, in the energy sector, in the United States, was doing a lot of work in Mexico, Dominican Republic, other places in Latin America, looking at energy for development applications. What we're going to be talking about today in terms of energy resilience is kind of a natural evolution of application of renewable energy and other kinds of resources to the challenges that we have.

I do speak Spanish. I'm originally from Panama. So do feel free to ask questions if you like in Spanish, and I'll try to reciprocate. Let me first of all say the material in this presentation is very large. It's a lot of thoughts that came together to put this material here. I do not anticipate I'll have time to go through all of this. But I'll try to cover what I can in about 20-25 minutes at the most. Not all what's in here will be covered. But I'll start with some motivations and definitions here. I know Guenter will also reinforce some of his. I'll talk a little about some of the framework and tools we've been developing here at Sandia National Labs. But it's just a few of the many projects that national labs and others have to solve this problem. So when you hear from Guenter, you'll see all of us working in this space have different ways of approaching this issue.

Okay. So, next question. Let me see. I do want to get through at least one of these application examples. I have three in the package that will be distributed. One is for a city scale resilience example. Focusing on New Orleans, Louisiana. I have another focusing on a rural community in Alaska, called Shungnak, and a third one for a transportation system in the New Jersey area that's also very interesting. If you have any questions about those after you review the material, I'd be happy to follow up with you. This opening slide is just to give you an idea of the family of national laboratories that exist in the United States, 17 in total. You see the picture of Guenter there on the top right. He's at Argonne National Laboratories in Chicago. And a picture of myself in the south, here, with Sandia National Laboratories. We have two major offices. One in California, one in Albuquerque where I live. And I wanted to say that the Department of Energy National Laboratories, as well as many other government organizations here in the United States, are very much focused on helping to make resilience mainstream. It is not a cause that has been widely adopted. And definitely does require a lot of work to make it go mainstream.

In a matter of the motivation, I think this is something you all know. But just to briefly describe the reason why we're working on this. We look at trends in terms of threats to critical infrastructure. And those threats are on the rise. Some of it has to do with what's going on with climate patterns. Some of it has to do with the introduction of new technologies, like information technology for example, as an integral part of these critical systems. And as you can see there on the right hand side, there are vulnerabilities on the increase with respect to cybersecurity, and those types of things as well. The electric system is especially vulnerable to all of this. We have seen. Give you some figures there. Somewhere between $25 to $70 billion of economic losses in the United States are attributable to power system outages, as you can see. So for us, the resilience of the electric power system in particular is of great importance.

One example of this was in 2012 we had a major storm I'm sure all of you remember. Superstorm Sandy. It hit the Eastern Coast of the United States. Very dense population centers. And obviously it had quite a lot of impact there. It was by far the costliest and the largest natural disaster by several metrics we've had in the United States. Took over two weeks to restore power to a lot of the communities here. And almost nine million people were affected by the outages. Very, very large scale. This is the kind of threat that exemplifies the need for the concept of resilience. Because the reliability concepts that we have now for critical infrastructures do not include what we call acts of god or anything that is beyond the control of your sort of normal failure of equipment and things like that. So we need to have a way to do some practical planning and operations for large scale events like this.

Following Hurricane Sandy, there was a policy directive that came from the White House here in the United States. The President basically required all the federal agencies to look at strengthening security and resilience for all the critical infrastructure in the United States, for all hazards, and taking into consideration things like national security, economic stability, health and safety, and so on. A different view of what needs to be done. And so now the federal agencies are very well aligned, not just the Department of Energy, but also the Department of Homeland Security, Department of Defense, etcetera, are all aligned to comply with this policy directive.

I will also say that the same policy directive provided a definition of resilience that the agencies are using now. It is defined as the ability to prepare, adapt, withstand, and recover from these disruptions. And it also provided a definition of what all hazards means. Basically it requires these agencies to focus on low probability high consequence events, like natural disasters and cyber incidents, pandemics and such things, in order to do planning for the future. This graphic here shows, in a very simple way, the difference between reliability and resilience. In our point of view, resilience encompasses reliability, if you will. It focuses on like I said low probability and high consequence events, like ones pictured on the right hand side. Things that end up breaking down. Significant parts of the critical infrastructure. Then also as I mentioned before, this is not a concept that has methods, metrics, and tools that are well established or adopted by the industry. We still have a lot of work to do there. Therefore all of the efforts we're putting into resilience.

Very quickly here. I wanted to mention the Sandia National Laboratories, like many other labs, have been looking at resilience of critical infrastructure for a very long time. Something like 20 years ago, we developed a series of tools and frameworks to look at security risk for critical infrastructure, ranging from dams to transmission systems, all the way to biohazards and communities. And those tools and methodologies and software tools have evolved to what it is that we do today. You can see some references on the right hand side, some of that early work, again, over 20 years ago, but very much relevant to what we are doing now. This wheel here is what we call the Sandia Resilience Analysis Framework. Something that has been proposed to help the community kind of rally around a vision for how to do resilience in a manner that is consistent, that is—we are able to repeat in terms of the analysis. Something we can apply metrics that are consistent.

So basically the process is what you'd expect. It starts simply with a definition of the goals. You do have to define the system. You have to characterize the threats. You have to determine at some point through simulation or analysis the level of disruptions that might be applicable to the goals, the resilience goals of the system that you're working with. You have to calculate how those disruptions translate into consequences using models. Then finally you have to provide some evaluation of different examples or different proposed solutions that would increase resilience. So that's basically what the process is. Somebody else's framework because there are several of these basically go through the same process, and in my opinion there's different flavors of the same idea. But we do have to converge on some sort of framework. So here's one example.

We have also been using a different example here for urban resilience, specifically. It's a wheel, similar to the one before. This one rotates to the right. But as you can see, some of the concepts are very similar. Although the wheel is a little different. This one in particular emphasizes the need for stakeholder engagement. You can't really do very much in terms of investment and decision making around these very expensive projects unless we have the stakeholders at the table. But in general the result of this is the same. A set of resilience options that can be considered for investment. Whether it is the private or public sector. In terms of the metrics that are applicable, there is again a lot of discussion in this area, but there are a few places where we converge in terms of a vision.

We do want metrics specific to the threat. Metrics are defined basically with respect to the threat. They can be performance or attribute based. They need to be expressed in terms of the consequences. And I'll go a little bit more into that. We think they need to be probabilistic in nature. And as Guenter will also reinforce, they also have to be practical, scalable, and consistent across the application. Some of the metrics we end up using in a particular resilience analysis is not one metric but a combination of different categories of metrics. You can see some of these on the screen. The first has to do with electric services, things like how many hours customers might be out of electricity service. But as you progress down to the bottom, you can see some of the metrics associated with social and economic impact—for example, the number of people who do not have access to critical services like water, for example, or food, those kinds of things, or the impact to the local economy, are parts of the metrics that we also want to include in the analysis. So it gets fairly complicated.

In terms of the investment options, we found it very useful to provide tools and methodologies to arrive at a conceptual design. This is something that is very important to engage stakeholders and drive decision making. But basically these conceptual designs are technical descriptions of resilience improvements. We also have to attach to them a cost estimate, so we can then make a decision of how to proceed. So a lot of what we've done here in the last few years, in terms of resilience, is to provide some tools for the optimization of these conceptual designs.

Here's one of those tools that we use at Sandia National Laboratories. It's called the Microgrid Design Toolkit. It's a decision support tool that fits in this early stage resilience analysis framework to work with conceptual designs. It allows stakeholders to provide technical information for options, for specifically grid resilience solutions. And it does an optimization of those solutions in order to come up with the best possible investment alternatives to improve resilience. To mention before, these types of tools provide a lot of the information that will be needed, but there will still be required information for the specific application. There's an equipment database. For example things like energy production equipment generators, things like that—reliability information for those types of equipment. But we also have to put into it things like mission requirements. What is it you want to do? Of course, there has to be a description of the model. But what you end up with is a tradeoff of performance and reliability and cost and resilience, so you can compare solutions.

Here's one example of how we do it. All of these solutions represented by each of these dots on the screen are feasible solutions that would solve the problem, basically. But they give you kind of a tradeoff between performance and cost. So the highest cost solution would be the ones that are to the very left. So point A for example would be the most expensive solution. But point A would also be the solution that gives you the biggest or best performance. So you can see that as you progress to the right, you get solutions that are lower in cost, but also the performance is a little bit lower. So this is as you would expect from any normal decision making, a balance between cost and performance. This is the kind of tool that provides information in that regard.

So, Stephanie, how am I doing on time? Do I have five more minutes to go over an example here?

Stephanie Yes, you have five more minutes.

Abraham Great, thank you so much. I do have three as I mentioned in the packet that you are free to take a look at, and ask questions later, if you like. What I'd like to do today is go over one, which is an urban resilience example for the city of New Orleans. It is an example that has to do with a major flood scenario, a very timely topic, as you I'm sure have seen in the news. We're dealing with a situation like this in Texas. And the work we did in Louisiana was very much motivated by such a scenario. So, first of all, the city itself—you see where it's located, in the southern coast of the United States. It is a very peculiar city in the sense that much of the populated areas are actually very close to or slightly below sea level. The picture there on the bottom gives you an idea of the profile along a street, let's say, on the city. You can see there on the left hand side that the Mississippi River is—its normal elevation is quite a bit higher than the rest of the city is, shown in orange.

Over on the right hand side is a very, very large lake, called Lake Pontchartrain, which also happens to be above the level of where some of the city infrastructure is. During a hurricane scenario, where you have lots of winds, or a flooding scenario with lots of rains, the concern of course is that the level of those bodies of water might end up threatening or inundating parts of the city. So this was a very major concern there in New Orleans. How they deal with this threat is a combination of levies and pumps. Basically, as you can see there, on the picture, they have walls, levies is what the call these, around both the river and the Lake Pontchartrain, over on the top side. Those levies have been built by the Army Corps of Engineers over many years, very expensive infrastructure. And they are built of course with planning for things like a 100 year event and things like that. So they are planned with resilience in mind.

The pumps, as well—you can see a picture of a pumping station there on the top side—are built with the same kind of resilience in mind. Multiple generators with multiple pumps with multiple facilities so that you can basically maintain performance, even if you have failures in some of these systems. These are very unique pumping stations. They work not out of the normal 60 hertz utility power. They work at something like 25 hertz or something. So they're very specialized, very old equipment but also highly reliable. Obviously the best efforts, engineering efforts, are challenged sometimes.

So these are pictures of what happened with Hurricane Katrina back in 2005. There was a direct hit in New Orleans. Partly as a result of this history, the concern over the fact that the electric system was also down. Not just flooded. But the electric system that supplied the pumps also failed. Motivated the Department of Energy to collaborate with the city of New Orleans, Sandia National Laboratories, in partnership with organizations you see on the right hand side, working together to really try to understand how we can provide options for cost effective grid enhancements in the city of New Orleans, to figure out a way to apply these methodologies and tools, even though they're very high uncertainty, and show that we can do something in terms of decision making. Then decide how to best demonstrate the benefits to the stakeholders that need to not only pay for these facilities, but also maintain them and keep them in a sustainable manner into the future.

So consistent with the methodology that I described a minute ago, we went through the effort of defining the threat scenario. In this case a category three or two storm, with a surge in 20-24 foot range, with 20 inches of rain. We looked at two different tracks of a possible future hurricane. One of them was the Katrina track in 2005. The other was a 1947 storm that did not have a name. But we do have some data for that. We looked at pumping capacity down to about 50 percent. And situation where the city did not evacuate for that scenario.

So we do what you normally would imagine. We characterize the threat in terms of the wind and flooding patterns you'd see in the city. These are some examples of the results that we got. This information then was used to try to understand which parts of the critical what we call lifetime infrastructure services would be impacted. We looked at anything, including electric power, drinking water, all the way to things like food and transportation. Obviously there are many people involved here. City officials. Fueling stations. Schools. Commercial service providers. For example, the utility called Entergy, etcetera. So we did have to work with all these stakeholders. As I mentioned before, it is a stakeholder driven process.

I'm getting to the end here. The technical approach was agreed upon among the stakeholders. In this particular case there was an interest in making sure that each of these four sectors of the city had critical infrastructure provided for. So we also went through a consideration of various technical and social factors. For example, location of infrastructure, what power outages to be expected, where the population would move in case of a flooding, and things like the cost of providing these resilience options.

This is an example of the kind of analysis we did. Start with the location of where these infrastructure systems are. The ones on the left are more centralized. The infrastructure will provide services to the entire city. Whereas the ones on the right hand side are distributed resources like shelters and police station and drainage pumps that are more localized to the communities. We of course in this case used a GIS analysis tool to understand how these critical infrastructures cluster. Based on that we came up with a range of options on your screen now. These are now candidate microgrid deployments being considered by the city government in New Orleans to make some investments. So it works. We demonstrated in this case it can be done.

Let me jump over now to my summary slide to just say in conclusion here that critical infrastructure resilience obviously is a topic of very high interest. Energy especially is a very high interest to all of us working in this space. These problems are not easy to solve. They're technically complex. Deal with a lot of uncertainty. But we can do it with these resilience frameworks, metrics, and tools that we have developed and are trying to evaluate in many different places. We can show that this resilience approach is feasible in a rigorous manner. And more work obviously has to be done in order to make sure these principles are widely adopted. So, with that, I hope I stay within my 25 minutes here. Stephanie, I'll take any questions at the end.

Stephanie Great. Thank you so much. Now we would like to hand things over to Guenter from Argonne National Laboratories.

Guenter All right, hello. Can everyone hear me all right?

Stephanie Sounds great. And the presentation looks great, too.

Guenter Perfect. So, _____ _____ everyone. I'm honored to be part of the webinar. This is a topic that's near and dear to my heart. In fact my wife did grow up in the city of New Orleans. Her home that she grew up in was damaged, completely destroyed in the storm. I have a sister in law who used to live in the city of New Orleans. I'm told Hurricane Katrina hit, evacuated to the city of Houston, never moved back, stayed in Houston, is now exposed to Hurricane Harvey. So this is a topic that hits home personally. I'm excited to talk about the work we do. So Abraham introduced the national lab system and talked about the work he and his group do at Sandia. And of course pointed out Argonne National Laboratory. We're one of the nation labs that reports to the Department of Energy, one of 17 national laboratories. We're _____ _____ working together, trying to tackle this issue from _____ _____ perspective.

So the first slide basically shows we take capabilities across our national laboratories from advanced mathematics and computational expertise to develop models for various different purposes, then apply those models to address a particular critical issue. Resilience is one of those areas we do a lot of model applications. All the way to deploying those tools to outside external customers. Those customers could be grid operators, emergency management personnel, Department of Energy, private sector industry players, variety of different customers. What we do bring to the table in terms of capability is we sort of cover the entire spectrum of what you need to look at when you're trying to address and analyze resilience concerns. So we typically start out with defining the _____ _____. It could be an all hazards approach. Could be raising from typical natural event like a hurricane or blizzard. Earthquakes. To manmade events like cyberattack.

You then translate that initiating event into a physical impact. What infrastructure, what particular assets are being damaged? What transmission lines are being knocked over? What substations will be flooded? What power plant is going to be inundated? Then you do a system modeling where you try to translate those physical impacts into a system impact. Will the loss of a number of power plants or substation transmission lines lead to cascading events where you might have a local or regional or larger scale outage, blackout, for power generation for example? Then of course you have to worry about how can I bring back the power as quickly as I can to as many people as I can? So you need to look at restoration efforts, restoring the power, shipping equipment, shipping supplies. So there's response logistics, there's logistical modeling involved. As well as restoration and response modeling. So all of this is—we have tools that cover this.

So we go from taking data, a lot of these models require a lot of data, as you might be aware, so there's data of course involved that describes the hazards.

Then there's data you'll need to describe the infrastructure that you're modeling. Then you have to take this data into the model and you want to prepare—you want to use your models to design tools that span these large scale events, to be resilient to these major events that occur every once in a while. But at the same time, you want to make sure that while it's resilient to these occasional major events, it's also on a day to day daily operation that the systems are economically operational and typical daily reliable operation. So you have to be concerned about both, the liability as well as resilience. And then you can take it from modeling simulation to operational assessments an real time collaboration in terms of exercising events. To try to prepare yourself better, often what we do is we prepare drills. We prepare exercise. And we try to get ready for the situation should an event occur. So we can apply these models and tools and data to these real time exercises and drills. Even can take this to real time events. And I'll show a few examples down the stretch.

So, in terms of data, obviously there's a lot of the infrastructure data, and that's very country specific. We have a lot of data sets on the US electrical infrastructure and the petroleum infrastructure, natural gas infrastructure. So we have reasonably good information on the infrastructure. Then of course we have to define the hazards, and the hazards can of course—typically described as using historical information. But of course given climate change, we have to look forward. So if we want to design a system that withstands not just current events, current hazards, but possibly future hazards, then we have to see how the weather will be different 20 years from now, 50 years from now, towards the end of the century. So we have a supercomputer. We have models that allow us to develop very detailed downscaled very local 12km by 12km resolution climate data that allows you to download this. This is 600 terabytes of data. That was running our supercomputer for millions of computing hours.

And this is typically used in the US to do regional resilience studies. For example, to analyze not just what might occur to a current event. But what might occur to an event were it to happen in 30 years from now, midcentury, or towards the end of the century. So this is data that covers the entire American continent, including the Caribbean. And we're currently also working on some downscaling data for South America, including Brazil. So in terms of the modeling, we think of it as a few major buckets. Four major buckets. What can you do to prepare yourself before the event? If you can anticipate the event occurring, think of Hurricane Harvey being projected to make landfall at the Texas Coast. So what can I do to prepare? What can I do during the event to mitigate the impact of this event? Then how can I quickly respond and recover? So if you think of this timeline, as the event occurs, then we have tools that fall into those four buckets. And obviously I do not have the time to cover all of those.

If you are interested in a particular topic or model, feel free to send me emails. Contact me through the webinar link. Or by email. And I can send more information. There's a range of tools available. Just to highlight a few, there's models that look at the electric power infrastructure to say what if an event happens, how does that impact the grid? Are there pockets of outages, smaller or local pockets of outages expected out of this event, or are there regional outages? Same thing we can do for natural gas infrastructure, the petroleum infrastructure. We also have a tool that looks at the telecommunications infrastructure. Then of course we have tools specific to hurricanes. And I'll talk just a little bit, show you an example of how we use this HEADOUT model in terms of estimating electrical impacts from hurricanes. Then we have models that look at the restoration of the physical infrastructure, the repair time as well as rate of restoration. What if you had a major outage? How long would it take to bring power back to individual customers, down to the zip level or county level or state level?

This is a tool that shows you—this now takes you into the exercises. So this is the plat information sharing, situational awareness tool, a platform that's been developed over many years for the emergency management community in the United States. This provides essentially situational awareness, and a common operating picture during drills and exercises. And you see a few examples of these drills that have recently been held with state agencies, or with power companies, and even with retailers. But also during the actual event. This tool is widely developed, widely distributed, largely used. Lots of organizations use this. And this is used for regional exercises as well as national level exercises.

Here's an example of the over 60 regional resilience studies that Argonne has done over the last seven, eight years. These are studies that cover all kinds of infrastructures. They could look at oil. They could look at gas or electric infrastructure, water infrastructure. They typically identify vulnerabilities to a system in particular events, then try to identify resilience measures of how I could minimize that vulnerability, how I could fix that vulnerability to reduce the impact of that event, were it to occur.

You can see we have done almost nationwide coverage in supporting emergency preparedness and emergency management agencies. This includes exercises, drills, modeling, in terms of preparing yourself for major events. This slide shows you a few of the exercises we have done for the Department of Energy, typically regional exercises once for a particular event, looking at the impacts, how can I prepare myself, how do I respond to something like this? And not just the power grid operators, but how does everybody respond together to minimize impacts, economic impacts as well as casualties.

Here's an example we've recently completed for the Midwestern United States, where we simulated a cyberattack on the power grid. You can see the chart—the middle bottom shows you the regional outage, the power outage that occurred. Then trying to simulate how long would it take, location by location, to restore power. All the way to clockwise it goes all the way to the chart at the bottom right, which shows you these customer restoration times. How many customers get restored after one day, after three days, after five days, after one week, two weeks, three weeks, four weeks. Very important to prepare yourself for this. If you have power out for four weeks, you have a major logistical issue, so you have to work together across the community to correct and address this. One or two more examples, and I'll wrap it up.

So we do work for the government, government agencies, variety of government agencies, but also we work with private sector. This is the midcontinent independent system operator we worked with them for the last two years. They do their own drills and exercises. They do two drills every year, one in spring, to prepare themselves. And this always happens to be a hurricane very close to Harvey. Then in fall they typically drill on their response recovery—how could I get back power if there is a major power outage in the nation? Power out in essentially half of the country. And so this is the last example I'm showing.

This is the tool we're actually currently running nonstop. This is in relation to Hurricane Harvey. So we're on standby. Any time a hurricane is expected to make landfall five days out, we're providing real time information back to the Department of Energy as well as other government agencies. What might be the estimated impact? How many customers do we expect to be out of power four days out, three days out, two days out, one day out, and then every time NOAA comes out with a new storm trajectory, we update our model, and this information gets fed to a situational report that goes to DOE, then circulates through all the federal government as well as all the impacted state governments. So this is happening in real time.

So in summary we have extensive experience and expertise and offer a range of tools to meet stakeholder needs, not just in the energy sector, but also in the emergency management sectors, because both have to work together to reduce the impacts of a major disaster occurring. We provide tools that allow you to attain better, enhanced situational awareness. Identify vulnerabilities in the system. Identify possible resilience mitigation measures. And then also we're supporting actively operational drills and exercises for faster and more efficient response and recovery. So we work with a range of different diverse stakeholders, including industry participants in the electricity, the power side, the natural gas side, telecommunications side, as well as emergency response agencies. And we look forward to engaging with some of you in the next subsequent to this webinar.

So if you have any questions, there's email addresses and phone numbers for a number of people who work in this space at my lab. With that, I'll turn it back to the organizers.

Stephanie

Great. Guenter, thank you so much. That presentation was wonderful. Next, we will go into the case studies that will be presented in Spanish. Our first case study panelist is Mr. Domingo Mateo, who is from the Dominican Republic. And, Mr. Mateo, over to you. All right. It looks like we're having a few connection issues, so we are going to skip ahead and we'll actually do the case study from Mexico first, and try to get Mr. Mateo back on the line. So we'll hand things over to Mr. Mauricio Cuellar. And Mauricio, can you hear us all right? All right, we can see your presentation, but there isn't an audio right now, are you able to hear us? All right, everyone, one moment. We're going to try to fix the audio for Mr. Cuellar. Hold on, please. Apologies for the delay, everybody. We are just trying to connect Mr. Cuellar's audio in one moment.

Mauricio Can you hear me now?

Stephanie Yes, we can. That sounds wonderful.

Mauricio Okay, sorry.

Stephanie No problem. Please, feel free to go ahead.

Mauricio Okay.

Mauricio Voy a hablar en español. Estos son los desastres naturales que tenemos en México y para los cuales operamos el sistema eléctrico para evitar o tratar de evitar interrupciones a los usuarios y restaurar el servicio lo más pronto posible. Tenemos huracanes, frentes fríos o tormentas de nieve, que nos pegan muy poco, el efecto es severo pero son muy poco frecuentes en México. También tenemos la parte de incendios forestales, tornados en la parte norte del país y sismos.

Explicaré primero las medidas preventivas que usamos en el caso de huracanes. En huracanes primero prevemos la ruta, el seguimiento a la trayectoria del huracán. Formaliza amos las acciones con los diferentes procesos tanto con los generadores, con el dueño de la red de transmisión y con el dueño de la red de distribución. Es decir transportistas, distribuidores y generadores. Preparamos las instalaciones. Tenemos un poco más de personal en los centros de control involucrados para estar haciendo análisis de seguridad operativa en tiempo real. Hacemos escenarios por donde va a pasar el huracán, de perder todos los corredores de transmisión o los más, los que tengan mayor probabilidad. La parte de CFE, Comisión Federal de Electricidad, nos proporciona las rutas en el mapa de por dónde va a pasar y los mayores riesgos de la red de transmisión. Entonces nos preparamos desde el punto de vista del sistema eléctrico para tratarlo de hacer confiable soportando incluso contingencias dobles, no solo sencillas, dobles o hasta triples en el caso de trayectoria que vayan juntas de la red de transmisión.

Ya cuando está el evento ubicamos reservas operativas, sacamos políticas operativas, determinamos qué contingencias pueden ser probables, ubicamos la reserva, la reserva de degeneración, la reserva rápida, la reservada fría. En la red de transmisión se bloquea a lo que se llama el re-cierre para que si—el re-cierre monopolar, por si hay algún daño no re-cierre automáticamente, porque ya puede haber una falla, puede haber muchas probabilidades, que la torre esté derribada, que haya elementos en la torre, láminas, etcétera, derivados del mismo huracán. Revisamos los esquemas de acción remedial, o los RAS, en inglés RAS. Seccionamos la red si es necesario. La frecuencia la mantenemos en 60 Hz. Hacemos—si se nos formaran islas eléctricas, tratamos de que las islas pues sigan manteniendo los 60 Hz. También regulamos el voltaje y hacemos control de flujo de potencia para prepararnos para la siguiente contingencia.

Durante el evento, lo que les comentaba, tenemos personal haciendo corridas de seguridad operativa con herramientas en tiempo real, herramientas de análisis de redes. Hacemos re-despacho de generación, si hay que re-despachar la generación según lo que vaya ocurriendo, nunca sabemos qué va a ocurrir. Hacemos procedimientos para restablecer usuarios, restablecer carga y red eléctrica. Y hacemos un reporte de las condiciones hasta ese momento que vayan en la red.

Después del evento pues se identifican qué elementos de la red eléctrica tienen falla permanente, obviamente mantenemos, seguimos manteniendo el sistema, las variables como son frecuencia, voltaje y flujos de potencia. Aplicamos procedimientos de restablecimientos si se requieren y de mantenimiento de la red. Recuperamos muchas veces—se afecta también la comunicación, la telecomunicación, entonces usamos radios satelitales muchas de las veces, radios y teléfonos satelitales. Como les comentaba, si hay islas eléctricas, pues nos dedicamos a su sincronismo. Se hace una reunión con los mismos procesos del inicio para que en los daños permanentes nos den un panorama de cuándo se recuperarán los elementos para volver a la normalidad.

En el caso de frentes fríos o tormentas invernales, que son poco frecuentes pero ya nos ocurrió uno en 2011 muy severo para el norte de México. Prácticamente es algo similar a lo de los huracanes. Vemos las instalaciones que pueden ser dañadas en el frente frío. Verificamos la área de influencia, ahí particularmente checamos con la parte de transmisión porque el SF6 se puede congelar, el aislamiento se puede congelar y también los transformadores, y de los transformadores de aceite ya tuvimos varios eventos con frentes fríos, que el volumen se reduce y hace que opere la protección Buchholz del transformador y se pierdan transformadores. Entonces todo eso lo estamos verificando previamente, previamente. Vemos la parte qué condiciones de generación existen. La disponibilidad de combustibles, que es muy relevante porque en este evento como en los huracanes pues no es fácil suministrar en ese momento combustible. Nuevamente preparamos el sistema eléctrico para soportar contingencias que sean altamente probables, multi contingencias, dobles o triples también, y preparamos las estrategias para en caso de ser necesario restablecer el sistema.

Durante el evento pues seguimos monitoreando las condiciones del clima y del sistema. Hacemos nuevamente el control de flujos en la red para soportar las contingencias creíbles. Se hacen evaluaciones en tiempo real con análisis de redes, análisis de contingencias y también para ver si no tenemos algún problema de voltaje. De ser necesario se realizan cortes rotativos de carga y se restablece la red cuando es posible.

Después del evento—esta es una imagen de un evento que tuvimos en febrero del 2011 entre el 4 y 7 de febrero del 2011, que prácticamente toda la parte del país, en toda esta parte perdimos la generación, toda la generación eléctrica salió de servicio. Entonces el control que estuvimos haciendo fue con compensadores estáticos de VAR para control de voltaje, y obviamente hubo afectaciones de usuarios, bastantes usuarios. Aquí están los números de la generación que se afectó, aquí está el total de la generación afectada y el número de usuarios que tuvimos dañados. Esas son gráficas de aquel evento, de toda la parte de carga que se afectó. Bueno, finalmente al final del frente frío cuando pasó se hizo lo mismo, un recuento de la infraestructura dañada, un plan para la restauración y mientras se seguía operando con los elementos que estaban disponibles en el sistema eléctrico tratando de abastecer la mayor cantidad de energía eléctrica a los usuarios.

Otro de los fenómenos meteorológicos que también nos impactan. Este no es meteorológico, parte por sequías se puede provocar el incendio, pero muchas veces es provocado por algún descuido, pero las sequías sí tienen una interacción muy importante en estos eventos.

Los factores a considerar en los incendios son quema de maleza o de caña, que en México hay bastantes sembradíos de caña y muchas veces hay quema de ellos. Y factores meteorológicos, como ya lo comentaba, la sequía. El personal de campo en estos casos, no hay trayectorias definidas, no hay alguna alerta satelital que nos pueda decir que hay un fenómeno, simplemente es por personal de campo, personal de campo de los diferentes procesos; transportista, distribuidor o generador que se da cuenta de que hay un incendio que pasa por líneas eléctricas normalmente o cercanos a subestaciones y pues ahí es donde nos damos cuenta y empezamos a hacer lo mismo que en los anteriores.

Hacemos la verificación de qué red de transmisión puede salir de servicio. Aquí hay unos ejemplos de casos reales que nos han ocurrido y que afectan directamente la estructura eléctrica y por lo mismo pues afectan el suministro a los usuarios y tenemos que hacer medidas de inmediato. Ahí bloqueamos en el re-cierre, que como les comentaba, es un equipo en las líneas que nos permite liberar fallas monofásicas transitorias, pero en este caso se bloquea porque ya tenemos un evento, hay un seguimiento estricto, se busca a protección civil y pues hasta que se controle el incendio se normalizan las condiciones. En algunos casos la infraestructura es dañada por el conductor, el conductor se daña, o en una subestación se puede dañar equipo como transformadores, interruptores. Las acciones que comenté, prácticamente esas son las que ya comenté.

En el caso de tornados. Los tornados en México se dan en la parte norte del país y aunque también en el centro, son tornados pequeños pero sí existen. Ahí hay una asociación en México, es el CENAPRED, Centro Nacional de Prevención de Desastres y Protección Civil, que tienen alertas tempranas, nosotros estamos siguiendo esas alertas tempranas. Como les comentaba, la mayoría de los tornados son débiles, aproximadamente el 90% son débiles, excepto en la parte norte, pegado a Texas, ahí es donde más severos hemos tenido, eventos más severos y se han dañado infraestructuras, líneas de transmisión de 400 kV y 230 kV. Y los meses de mayor incidencia de tornados pues son de mayo a junio, es donde tenemos mayor problema de tornados.

Los tornados, les decía, tenemos algunas alertas, normalmente se producen—hay alertas de previa formación, le damos seguimiento y también preparamos la red de transmisión para soportar contingencias dobles o triples. Hay muchas veces que no se pueden prever y no son soportables las contingencias. El año pasado, perdón, este año en abril tuvimos apagones severos en la parte frontera, nosotros le llamamos en esta parte del país, tuvimos una afectación de 1,000 MW por caída de cinco líneas de transmisión; dos de 400, dos de 230 y una de 138 kV, que un tornado tiró en 5 minutos. Esta vez pues no pudimos más que abastecer muy poca carga y en 2 o 3 días después de que se recuperó la generación, porque al haber un black out total las plantas salieron de servicio, muchas—dos plantas no pudieron aplicar sus procedimientos de emergencia y tuvieron daño en los generadores de vapor, eran ciclos combinados, tuvieron daños en los generadores de vapor y entonces subimos una situación que duró casi 1 mes. Sí abastecemos la demanda pero estuvimos en estado de emergencia prácticamente en esa zona del país.

Esto es lo que les comentaba, básicamente en el estado de Texas es donde hay—pegado al estado de Texas es donde tenemos la problemática más fuerte, es menos recurrente pero más fuerte, los tornados son más fuertes en esa parte.

Después de los tornados, pues prácticamente es lo mismo que hacemos en todos los eventos. Nos reunimos con todos los procesos para ver qué infraestructura va a tener un daño permanente y hacemos estrategias para recuperar esa infraestructura, en lo que no está la infraestructura disponible pues usamos otro tipo de generación, incluso generación diesel más cara, o podemos trasladar generadores móviles dependiendo del monto de carga que se tenga que suministrar.

Finalmente en sismos. Como todos sabemos, un sismo no es previsible, se da en un momento inesperado esta parte no se puede predecir desafortunadamente. Nosotros tenemos—México está en una zona altamente sísmica, tenemos bastante sismicidad y tenemos algunas alarmas, alertas sísmicas pero cuando ya el sismo está presente, sobre todo para el centro del país, si se da en el Pacífico el fenómeno tenemos aproximadamente 50 segundos para que el personal tanto de los centros de control de electricidad, que ese es nuestro negocio, como el demás personal, el personal civil, pueda evacuar las instalaciones. En el caso del centro de control pues nos preparamos. No sabemos nunca qué va a pasar, si se va a perder generación y también carga, o solo generación, o solo carga. Es muy—pues no es certero siempre un sismo. Se presenta en un momento y no sabemos los años que nos pueda ocasionar.

En esa situación nosotros pues monitoreamos siempre la frecuencia porque es el balance entre la carga y generación, y tomamos medidas dependiendo de qué esté pasando. No lo sabemos en ese momento, solo por mediciones. Aquí hay un ejemplo de un sismo que nos ocurrió el 21 de abril del 2013 en plena demanda máxima del sistema eléctrico en México, donde hubo una afectación de carga de este orden aproximadamente fueron 2,000 MW de generación y carga que se afectaron en ese momento. Esta gráfica es una gráfica típica y aquí es con la presencia del sismo.

Y bueno, aquí como les comentaba, en este caso no hay previsiones. Sí hacemos algunos entrenamientos a nuestros operadores si se les presentaran estos fenómenos para ver cómo reaccionen, pero ahí pues no hay nada escrito, no sabemos qué va a pasar. Nosotros lo que hacemos es mantener el balance carga generación. Monitoreamos qué generadores están disponibles, cuáles no están disponibles y los montos de carga que se perdieron. Y obviamente el sistema eléctrico, como todos los sistemas eléctricos del mundo, tiene los relevadores de baja frecuencia 81's que desconectan carga automáticamente para tratar de balancear la carga y la generación, y que no haya un evento mayor. Aquí hay una gráfica de cuando otro de los sismos, cuando fue bajando la frecuencia por pérdida de generación, todos esos son generadores que se desconectaron. Y también carga y operación de 81's, de los esquemas de baja frecuencia para recuperar la frecuencia y el balance. Esos son ejemplos de sismos. Ese fue en 2013, el 21 de abril, es el mismo que les presenté hace un momento pero ya con mayor detalle y con un zoom en cuanto a los momentos.

Y bueno, las medidas después de –

Unknown [1:05:24] Mr. Cuellar, I hate to interrupt but if you could please wrap up in the next five minutes or so, so we can get to the questions and answers section.

Mauricio Sí, ya voy a terminar. Gracias.

Unknown [1:05:36] Thank you.

Mauricio Bueno, y aquí se identifican las medidas posteriores. Pues nada más es hacer los reportes prácticamente, y nuevamente ver qué infraestructura quedó dañada para hacer los planes de restablecimiento en caso de que se haya quedado algo dañado.

Y una parte importante, pues que tenemos un simulador de entrenamiento, en México hay un simulador de entrenamiento donde los operadores del sistema eléctrico están capacitándose para hacer las sesiones de qué pasaría si hay huracanes, se reproducen eventos que ya hemos tenido, eventos que ya nos han sucedido para que estén preparados y puedan actuar de manera rápida tanto en huracanes, tornados, frentes fríos, incendios y sismos. Todo eso pues cada año estamos capacitando. El CENACE en México, el centro de control está formado por ocho centros regionales y un centro nacional con su centro alterno. Todos los operadores son capacitados, cada quien en su área geográfica. Y los del centro nacional y el centro nacional alterno pues para todo el país.

Sería todo de mi presentación. Muchas gracias.

Stephanie Great. Thank you so much for that presentation. We are now going to go into the question and answer session. And we're still working on connecting with Mr. Mateo and getting him back online. So if we are able to connect with him, we'll jump into his presentation. Just a reminder for everyone, if you have a question, please enter it into the questions panel on the GoToWebinar toolbar. We will start things off with a question for Dr. Ellis. We received a question asking if you could go into details on some other resiliency measures that aren't directly tied to disaster events, necessarily, but have more to do with rural community application. And, Guenter, feel free to chime in as well.

Abraham Sure. Was the question in Spanish or English?

Stephanie English.

Abraham Sure. I'll respond in English then. There are—the question is other examples that do not involve interconnected situations. Perhaps—so I do have an example in the packet that I will share with all of you. In fact, if you're interested, I can maybe show a slide or two here. But let me just say we looked at resilience of rural communities also for a very long time. They tend to—let me share my screen here so you can see what I'm talking about. I don't know if you can see this example here. But this particular example has to do with resilience considerations related to fuel supply to rural communities in Alaska. As you know, the situation in Alaska is such that the majority of the communities in Alaska, over 250 or so, actually receive electric service through microgrids. And these are very extreme primal conditions, as you can imagine. For many months of the year the roads are inaccessible, it's very difficult to get there.

And also these are communities that are facing climate change issues. Places where the ice is melting underneath the location of the facilities, or the towns, and they're having to move, actually. Imagine that. So some of these affect obviously the electric infrastructure. There are many communities there that rely on diesel generators for the most part. In fact, this is a better picture of that. All of these little communities with the little drop of oil, most of those are primarily used in diesel generation to supply electricity. So this is an example of a project that Sandia, NREL, and others did in Alaska, in this community of Shungnak. The idea here is—how do we make this community more resilient to fuel supply? So that was the idea. In terms of resilience. And so one of the things we needed to do here is to see if we could apply some of these resilience metrics and methodologies to achieve a 50 percent reduction in imported fuel. We wanted to do that in a manner that was sustainable for the community. So it was not at any cost. But can you do something such as the addition of solar and wind and energy storage to meet this resilience goal in this case, for this particular community?

So we did a little bit of work here, at Sandia, using the tool I described before, the Microgrid Design Tool. You can see some examples on the right hand side of the kinds of results we got. But really we found out obviously there are many different alternatives you could try. This summary here talks about some of the specific design options considered for this particular community. Over on the right hand side here, you can see this is the baseline. We're using something like almost 13 gallons an hour of fuel, typically, in this location. What we're trying to do is find alternatives—for example adding wind and solar—that could reduce this fuel consumption by a large amount. You can see in this particular case, by adding solar and wind, we were able to reduce the fuel consumption to something like three gallons an hour. You can go even further, to something like two gallons an hour, but at an increased cost, as you can see there on this curve. So this is a very interesting solution here, because it is the least cost solution that provides the most change in the fuel consumption per hour.

So this hopefully is an example of the kinds of things that we look at for rural communities. There are many other kinds of metrics that can apply in this case. I mentioned before the case of New Orleans. We're interested in metrics that have to do more with social welfare. And so in a case like this rural community in Alaska, access to things like school and emergency services and things like that was very important. So we could have applied those metrics as well.

Stephanie Excellent. Thank you very much. The next question is for Guenter. For the prepare, mitigate, respond, and recover steps you highlighted, do they relate similarly for vertically regulated and deregulated utilities? And, if so, also, how can you demand response programs be modeled to integrate elements of resilience?

Guenter Okay. For the first one, yeah, I don't think we would distinguish this approach for different entities. I think these are the typical steps you would follow. So the analysis, the modeling, would follow all the same, regardless whether you are a regulated utility, or a deregulated generation company, or vertically integrated, or separated, where you have your different business lines separate. So I showed an example for the midcontinent independent system operator—that actually covers a vertically integrated utility in the South, as well as deregulated utilities in the North, so it applies across the board. So that would be the answer to that. So no difference.

For the second one, demand response—so we do—the Department of Energy is looking at funding research. There's a variety of different processes. Starting to look at this, and we'll continue to look at this, how distributed resources can provide—can serve towards resilience goals. So demand response would be part of this, but this would go broader, would include distributed solar generation, rooftop panel systems, battery systems at homes, or within neighborhoods. How can they make the system more resilient? So there's tools available that allow you to analyze this, and there's still work that needs to be done to get a better understanding of how this all works together. But it is actively being addressed by a variety of different laboratories, including Sandia, Argonne, NREL, and there's actually another large activity that's going to be an issue that's part of a recent call for proposals that the Department of Energy has where some of those projects will look specifically at that issue.

Stephanie Great. Thank you.

Abraham I had a quick perspective here as well.

Stephanie If it's very brief. We just re-established Mr. Mateo's connection.

Abraham Okay, great. I'll be 30 seconds here. In some of these projects we work on, it matters sometimes from a regulatory and policy perspective what the solutions look like. And one of the interesting questions is whether customers can own certain assets, and whether those energy assets are able to monetize their operation in wholesale markets and things like that. Sometimes it matters—so that's another very interesting question as far as the regulated market, like we have now everywhere in the Americas.

Stephanie Excellent. Thank you both so much. We would now like to get Mr. Mateo—if you're able to hear us, we have—we'll turn things over to you. If you can share your screen and unmute your microphone, and we would love to hear your presentation. I believe your microphone is still muted. So if you can pull up your PowerPoint. Mr. Mateo, we can also pull up your presentation for you. Are you able to unmute your microphone? Mr. Mateo, if you could please click the button with the white microphone on the GoToWebinar toolbar, it looks like you are self-muted right now. Mr. Mateo, we are going to try and show your presentation on our end. We still can't hear you, unfortunately. It looks like you just unmuted. Are you able to hear us? All right, I apologize everyone for the technical difficulties we're experiencing. Just give us one moment while we try to get his microphone connected. All right, apologies, everyone, we're still having a couple technical difficulties with the microphone. I have one more question for Abe that has come in. We'll go ahead and ask that while we work on the audio for Mr. Mateo. And have any of the New Orleans microgrids or other recommendations been implemented, and, if so, could you give us a little detail on that?

Abraham The answer to the question is no. The recommendations are now the subject of decision making process that involves, of course, the city council, the utilities, and some of the state agencies. Typically what happens is that the designs that are provided through these frameworks, these resilience frameworks, have to go through the normal process of funding. So that's where that process is. But just to give you another plug for the third example I did not present, that's for a transportation project in New Jersey. We, with other national laboratories, and other partners, went through the same process. Provided a resilience design for microgrid, which was then approved for funding, and is currently under construction. So yes. They are part of the process. But the—you have to start with the definition of the options. And then the stakeholders themselves have to seek different things. Get the project to proceed.

Stephanie Excellent. Thank you so much. I'm so sorry. We're still experiencing some technical issues on the connection. So we would just like to get some final thoughts from the panelists, and if we can get a few words in from Mr. Mateo, that would be wonderful. But I apologize to everyone—this hasn't been terribly successful, technically. But why don't we start with you, if you don't have any concluding thoughts you'd like to leave us with?

Abraham I will just offer here that as you have heard from three panelists here, the concepts of resilience are not necessarily new. In my opinion, it's that bringing together these ideas to do proactive planning is where the innovation exists. So it's not just to react to some of these difficult events, but can we do something from an investment standpoint that can be approved through the normal process, and show, using these metrics and tools, the full set of values that investment and resilience can do for the population, and for the system, and for the economy. That is where we're trying to go with resilience, to include all those aspects. I'll also say that at the end of the day, whatever resilience options are selected for investment, we can never forget the fact that these stakeholders, the community in which investments are made, the governments that make those investments and so on, they are going to own and operate the system for a very long time. So it is very, very important to look at the sustainability aspects of these investments, everything included from a business case standpoint, all the way to the regulatory and policy aspects, how these investments are going to be sustained in the long term.

Stephanie Mr. Mateo, are you able to hear us?

Domingo Yes, we are hearing.

Stephanie Okay, great. If you could please—unfortunately we don't have a ton of time remaining on the webinar, but we'd still love to hear from you, if you - about five minutes of details we'd love to get from the Dominican Republic and your experiences, please, feel free to share.

Domingo Okay.

[Spanish from (1:23:33) to (1:23:55)]

Stephanie All right, Mr. Mateo, we only have a couple minutes left, so if there are just a few any details you'd like to share.

Domingo Hello, Stephanie. Are you hearing to us?

Stephanie Yes, I can hear you, but we only have a couple minutes. Do you have any of your experiences you'd like to present at this time? All right, unfortunately it appears that the audio connection is still experiencing some issues. So we are—yeah, I'm so sorry about that, everybody. We are going to wrap things up here. Guenter, did you have any final thoughts that you'd like to share?

Guenter Yes, certainly. So, to me, it's this entire topic of resilience is a very broad topic. We tend to work in a particular sector, so people who work on the grid. And we have people who work in the natural gas industry. We have these individual industrial sectors, and folks with expertise at each one of those. This is one that really requires bringing together people across the sectors, across the communities. And so we try to get there. It's just starting. Where we bring the grid operators, the power systems engineers together with the emergency personnel. Trying to understand how certain things work together. So we can make investments in our systems to strengthen the system, to reinforce our systems, our infrastructure. We can develop microgrids. We can upgrade sensors. We can upgrade levies around certain areas to keep water out. But we can be fairly sure the next major event will occur again. We don't know when. We don't know exactly where. It always means we have to count on getting hit by something. And we have to be able to respond and recover. So _____ is one thing. Investing in different technologies. Upgrade our infrastructure is another. But it has to go hand in hand with response and recovery. So I—

[Inaudible from (1:26:35) to (1:26:45]

Guenter … to take a holistic approach to this very complicated issue.

Stephanie Excellent, thank you so much. Mr. Cuellar, from the government of Mexico, do you have any thoughts you'd like to share, in English or Spanish, whatever you're most comfortable in.

Mauricio Okay, thank you. Well, I think it's very important for the governments to—with the incremental growing to the wind and solar generation is very important. Not forget the reliability of the system. It's important no close a lot of plants with normal generators, with oil or gas. To do a balance. Because we understand that the new and the ecological thing is solar and wind. But we try to—don't understand the reliability and supply to consumers is very important, the political. Thank you.

Stephanie Great. Thank you so much. Thank you so much to our audience and our panelists for sticking with us on this slightly technically challenging webinar. I invite you to check the Solutions Center's website if you'd like to view the slides, or listen to a recording from today's presentation. As well as any previously held webinars. Additionally, you'll find information on upcoming webinars and other training events. We are also now posting webinar recordings to the Solutions Center YouTube channel. Please allow about one week for the audio recording to be posted. And finally I'd like to kindly ask you to take a moment to complete a short survey that will appear when we conclude the webinar. Please, everyone, enjoy the rest of your day, and we hope to see you again at future Clean Energy Solutions Center events. This concludes our webinar.