BEFORE THE

CALIFORNIA ENERGY COMMISSION

IEPR LEAD COMMISSIONER WORKSHOP

CLIMATE CHANGE AND THE ENERGY SECTOR

CALIFORNIA ENERGY COMMISSION

HEARING ROOM A

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10:00 A.M.

Reported by:
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APPEARANCES

Commissioners

Chair Robert B. Weisenmiller, Energy Commission
Commissioner Karen Douglas, J.D., Siting Lead Commissioner

Staff

Suzanne Korosec, IEPR Lead
Laurie ten Hope, Deputy Director, Research & Development Division

Presenters

David Pierce, Scripps Institution of Oceanography
Dan Cayan, Scripps Institution of Oceanography
Joshua Willis, Jet Propulsion Lab, and Dan Cayan, Scripps Institution of Oceanography
Garth Hopkins, CalTrans
Craig Bolger, Pacific Gas & Electric
Gregory Biging and John Radke, UC Berkeley
Todd Esque and Ken Nussear, USGS
John Maulbetsch, Consultant
Gretchen Hardison, LADWP
Kathleen Ave and Obadiah Bartholomy, SMUD
Andrew Petrow, ICF International

Public Comment & Questions

Gina Grey, WSPA
Richard Aslin, Pacific Gas & Electric
Steven Schwartzbach, USGS
David Michel, Energy Commission
David Show
Andrew Brown, ICF (online)

I N D E X

P R O C E E D I N G S

JUNE 4, 2013 10:00 A.M.

CHAIRMAN WEISENMILLER: Good morning. Let's start the meeting.

MS. KORESEC: All right, good morning everyone. Thank you for your patience. I'm Suzanne Korosec. I manage the Energy Commission's Integrated Energy Policy Report Unit and thank you for coming to today's workshop on Climate Change and Energy.

A couple of housekeeping items before we get started, restrooms are in the atrium out the double doors and to your left. Please be aware that the glass doors next to the restrooms are for staff only and will trigger an alarm if you try to exit the building that way.

There's a snack room on the second floor at the top of the atrium stairs under the white awning for coffee and things and for lunch we've provided a list of restaurants within walking distance of the building that you can pick up on the table out in the foyer. Today we also have the Farmer's Market going on at the park across the street and there are some food vendors there as well.

If there's an emergency and we need to evacuate the building please follow the staff outside to the park across the street and wait there until we're told that it's safe to return.

Today's workshop is being broadcast through our WebEx conferencing system and parties need to be aware that you are being recorded. I will make the audio recording available on our website in a couple of days and we'll post a written transcript on our website in about two weeks.

In addition to time for Q&A during today's presentations we'll also have an opportunity for more general public comment at the end of the day. At that point we'll take comments first from those of you in the room, followed by those participating in the WebEx. When you're making comments or asking questions please come up to the center podium to use the microphone, so we make sure that the people on WebEx can hear you and that we get your comments reflected in the record.

It's also helpful if you can give our transcriber your business card, either before or after you speak, so that we make sure that your name and affiliation are correct in the transcript.

For WebEx participants you can use the chat function to tell our coordinator that you have a question or comment. We'll either relay your question or open your line at the appropriate time. And for those of you who are phone-in only we'll open all the phone lines after we've taken comments from the people in the room and on the WebEx.

Please keep your phone lines muted unless you intend to speak, because otherwise we get a blast of static when we open the phone lines.

We're also accepting written comments today, on today's topics, until close of business June 18th. And the notice for the workshop, which is out on the table and also posted on our website, explains the process for sending in written comments to the IEPR docket.

Just a little bit of quick context for the workshop. Public Resources Code requires the Energy Commission to assess all aspects of the energy system, including progress toward reducing GHG emissions and addressing climate change.

The scoping order of the 2013 IEPR identified the potential vulnerability of California's energy infrastructure to the effects of climate change as a key topic this year following up on a workshop we held during the 2012 IEPR update proceeding on climate change, which we'll hear more about in the workshop overview.

Climate change issues continue to be a thread that runs through most of the other topics in the IEPR including the need to better reflect the impacts of climate change in our electricity and natural gas demand forecasts. And to consider the effects of climate change as we evaluate the need for electricity infrastructure in Southern California and the rest of the state to maintain reliability.

Our lead commissioner today, Commissioner Andrew McAllister, is in Washington D.C. He's unable to attend; he's asked me to read a statement from him.

"I am on Commission business away from Sacramento this week, and as regretfully am unable to be with you all today. First, I would like to extend my sincere thanks to all of you, who have come to the Commission in person or connected remotely, for your participation and substantive input.

"Second, I want to recognize the IEPR and division staffs who have wrestled with a wide variety of issues to put together a compelling agenda for today's workshop.

"Finally, I'd like to express my gratitude to Chair Weisenmiller and Commissioner Douglas, most immediately for leading this workshop today, but also more broadly for their complimentary roles in ensuring our state properly addresses the urgent climate challenge. California is already and will be increasingly indebted to them for their persistent efforts to drive our energy sector towards improved cleanliness and resilience.

"Please enjoy today's workshop and do make sure to get your thoughts on the Commission record. While you're doing that I'll be putting California's Clean Energy leadership on the Congressional Record in Washington D.C. It's a team effort. Commissioner McAllister."

So with that I'll turn it over to Chair Weisenmiller for opening remarks.

CHAIRMAN WEISENMILLER: Yes, I'd like to thank everyone for their participation today. As Suzanne noted this is a follow-up to last year's workshop.

And again, I think it's a good opportunity to look at the effects not only of energy use on climate, but also on climate change on our electricity or on our energy sectors. And certainly going forward I think all of us are aware of the potential impacts and the need for us to look at energy infrastructure in terms of ways we might enhance the readiness of it or preparedness of it, adaptability to respond to these changes.

So again we're looking forward to a very informative session. We want to thank everyone for their participation today and indicate that this will certainly be one of the things in the IEPR and also as we continue to scope out our next study that certainly we appreciate the content today to reflect that now thinking.

COMMISSIONER DOUGLAS: Good morning, everyone. I don't have much to add to that introduction. I'm very pleased to see this focus in this workshop and in the IEPR. And I'm looking forward to hearing from our speakers today, so thank you.

MS. KORESEC: All right, our first speaker is Laurie ten Hope.

MS. TEN HOPE: Good morning, welcome to the workshop. I'm Laurie ten Hope, the Deputy Director of R&D and I'm just going to provide a little bit of historic context for our workshop today.

Many of you have been following this issue for quite awhile. But the Energy Commission has a history of research in the climate science area starting around 2000, and have published about 20 projects in the area around climate science and the impact on the energy infrastructure. But more work is really needed to understand fully what the impact is on our system and how we can best prepare and mitigate these challenges ahead.

The research has been critical in framing the discussion on climate for decision makers and it's been compiled into three assessments. The first assessment in 2006 was influential in the passage of AB 32. The second assessment in 2009 explored the economic impacts and led to the first inclusion of adaptation in the 2009 Adaptation Strategy. And the Adaptation Strategy specified that the third assessment should focus on the vulnerabilities of sectors to climate change and explore what those adaptation options could be.

These peer reports that have been published and included in the assessments are peer reviewed. They're available on the Energy Commission's website in providing a transparent, publicly accessible source for climate science research.

The next two slides focus on the context from the last year's IEPR. And in the 2012 IEPR in April research highlighted the impacts of climate change -- sorry, I lost my place here. The workshop focused first on the impacts of climate and second on the adaptation strategies. Some of the highlights of the research were the impacts of hydropower units, snowpack on hydropower units, electricity demand in response to temperature taken all the way down to the zip code level, and identification of the power plants that are most vulnerable to flooding with sea-level rise.

The workshop also highlighted some of the strategies to prepare our system for a changing climate and two -- there are a lot of research projects in this area, but two we wanted to profile here that are continuing to be developed and used.

Our first, the INFORM Project, which is a decision-support tool that helps reduce the impacts of climate variability and helps us better understand how to manage our hydro-system as variability becomes more noticeable in future years.

The second is the SWITCH Model, which is allowing us to really look at various energy scenarios and really look at far out in the 2020, 2030 and 2050 time range of what our possible energy paths are to get to our GHG reduction goals. And then also take those scenarios and look at what are the potential environmental impacts from those various scenarios, so we can pick paths that have both the lowest GHG potential, but also avoid environmental degradation.

So this year's scoping order asked that the researchers and stakeholders go further. We've touched the surface on vulnerability and adaptation, but a deeper understanding is really needed on the potential vulnerability of our system to the effects of climate change including higher temperatures, reduced snowpack, sea-level rise and understanding extreme events like heat waves, flooding and wildfires.

So this workshop today is organized into three sessions. The first session focuses on climate projection and will profile new methods to improve demand forecasting, forecast extreme heat and precipitation events, highlight the relationship of melting icecaps to sea-level rise and present the impacts on the transportation sector.

Our second session focuses on the impacts on our supply system. And these sessions will present utility findings on hydropower, showcase a new project that's investigating the vulnerability of our natural gas infrastructure in the delta and showcase the cumulative climate and land use impacts on endangered species, which is an important for siting and DRECP as our commissioners are well aware.

Our final session is on the responses to climate change and includes the technology presentation on increasing efficiency of thermal power plants during hot weather, presentations by two utilities on their efforts to adapt to climate change and finally, a presentation on a tool to assist local governments plan for energy during emergencies such as extreme climate events.

Before I turn it back to Suzanne to introduce our speakers, I want to thank all the speakers who have come today. And I also want to thank the staff who put this session together today: Guido Franco, David Stoms, Heather Raitt and finally the last, and Sekita Grant. Thank you so much.

MS. KORESEC: Thank you, Laurie. All right, our first speaker is going to be Mr. David Pierce.

MR. PIERCE: Okay, thank you very much. Well, we're going to ease into the long-time scales here a little bit gently.

As you know, weather to climate is a continuum from something that's going to happen in 20 minutes to something that's going to happen in 100 years, so I'm going to start at the short-time scales. And the reason for that is because it allows you to give probabilistic information to energy firms. And hopefully, you know, as that interaction with the energy firms takes hold there will be a level of comfort associated with these probabilistic products. And it also engages the operational aspects of some of the energy firms, which is a little bit different from the planning. So that's the rational for starting here.

And I'm just going to just mention a moment about our data sources. I'm not going to bore you with this hopefully, but it's quite hard to get long-term good quality data of what's happening for the weather. So we just have a handful of stations that we can use for this and you see them there. And this is what we use to try to predict what the maximum electricity demand is going to be based on temperature.

Now this is a kind of picture you may have seen before. It shows the daily peak electricity load versus maximum daily temperature. And this particular example is for Pacific Gas and Electric. I believe we also looked at Southern California Edison and STG&E. And as you can imagine as the temperature gets warmer there to the right-hand side of the graph electricity use goes up.

Now one thing you really notice here is there's a lot of scatter in the data, so it's not a smooth confined curve. There's all sorts of other things happening here besides just temperature. Now some of these are what people do, so for example there is less energy use on weekends, we all know that, and holidays. But other aspects of this are due to other pieces of weather that are not just temperature. So a little bit later I'm going to get into that and how we can start trying to pick out more weather and climate information that's affecting our electricity demand.

Now typically the way that this is done is you use minimum and maximum daily temperature, and whether or not it's the weekend or a holiday, to project what that day's maximum energy use will be, electricity demand will be.

So again, here is an example for Southern California Edison and that blue line shows the results of this kind of procedure, it shows the predicted load based on temperatures and on the vertical axis is the actual load. So this is showing you, this is just for summer, because that's mostly what we care about for our peak electricity load in California. And it shows what I was saying before, but a little more easy to see.

There is some error here and what I mean by error is a very specific thing, which is there are some variations in the load that are not accounted in this rather straightforward way by temperature: daily minimum, maximum and whether or not it's the holiday or weekend. So let's call the error the difference between what we expect the load to be and what it actually is. And here for example, is the time series of this error for Southern California Edison.

And this is kind of interesting to me, when I look at this it's not just completely random, because you can see it's low for awhile, then it's high for awhile, then it's mixed for awhile. And when I look at that it suggests to me that there's some other deterministic factors that are influencing this departure between what the actual load is and what you expect it to be just based on temperature. So that gives you some opportunity to look for additional predictive power of how you could forecast some of these loads, how you could reduce that error based weather or climate phenomena.

Now one phenomenon that immediately will spring to your mind is cloud cover. So here for example, is a picture I took off from a satellite about a week ago. And there we are in Sacramento in the center of the state, you know, clear, sunny, very warm. Where I live down in San Diego totally socked in when I left this morning and it was overcast and cold and blah-blah-blah. But, you know, whether or not the clouds are there makes a huge difference.

Now I want to try to emphasize something as a little bit of a subtle point. I mean, we all know that whether or not clouds are there makes a difference to the temperature, because when you've got clouds they reflect the sunlight. I'm going beyond that. I'm saying, "Well, we've already taken into account what the temperature is, now do the clouds make an additional factor? Do they have an additional influence on the peak energy levels?"

Now there are a couple of reasons why you might think that maybe this is something worth looking at. Number one, if you've got -- if the sun's out, the sun can shine through windows, and you've got more interior heating than otherwise. And number two remember those stations I showed you at the beginning? They're really not that dense across California whereas these clouds can be very specific to the coast. So it could be that your general temperature indication for the whole service area isn't really that fine-grained enough to pick up these clouds too well.

In fact, the utility that operates the lights where I live, San Diego Gas and Electric, has gone to some effort to put in quite an extensive network of local temperature sensors to try to get around this. I haven't included that in my work, because it's a very short record and I'm trying to look at longer time scales, so we can't quite use that yet, but it's quite good for their operational purposes.

So what are the effects of these low clouds? Now continuing on the course of using Southern California Edison here you're looking at Los Angeles County there in the center, those lines are the county boundaries. And all that white in the lower left, that's cloud cover and the blue in the upper right, that's land. And if you look at where the cloud cover intersects the coast there you can see that the clouds are intruding into the coast. And this is the average cloud cover measured as how reflective the clouds are at 9:00 a.m. in the summer of 2010. So you can see like Santa Monica and other parts of Los Angeles that typically have cloud cover there in the morning.

Now what you can do is say, "Well whether or not we can try to relate whether or not there is actually cloud cover there on any particular day, to that load error that I just showed you." So we take this load error and say, "Well, is this correlated with whether or not you had those clouds?" And again, we're already taking into account temperature, so this is an extra effect.

And what you find is that if you look at the difference in cloud dependent on whether the error in load prediction is positive or negative you find this consistent pattern. All those blues are saying that when you've got more load than you expected just based on the temperature you had less cloud than typical. And the converse is also true. So when you had less error you had more cloud. So this is showing this relationship between the presence or absence of the cloud and the amount of load forecast error even after taking temperature into account. So there's another piece here besides just the temperature piece that is correlated to the cloud cover.

And these clouds are typically persistent, so if you care about the same day sort of forecast you can look and see if you've got a heavy cloud cover coming in, in the morning then you have some information about what it's likely to be that afternoon. It's probabilistic information, because you don't know for sure, but it has some probability of persisting that we can quantify.

Now this is about ten percent difference in the amount of cloud. When I look at that my question is always, "Well, how big of a difference is ten percent? I mean, is that a lot or a little?" So let me just add this final picture. This shows the change in cloud in terms of standard deviations. So one standard deviation is sort of the typical amount of variability and what you see is it's about a half a standard deviation. And in practical terms that means it's enough change to be significant. So for example if the middle panel were so small that we didn't care then this would be sort of irrelevant and I wouldn't be showing it to you, but nonetheless. On the right you can see it's about half a standard deviation, so it's enough to do something with. You can make some intelligent decisions based on this phenomenon.

And I already mentioned some of the reasons this might be occurring are the direct solar rays come through windows or perhaps the sensing of the average temperature over the region is a very poor proxy for what's actually happening. Now that's kind of abstract, so I want to make it a little bit more concrete by taking an example, and show you an example of how this actually works.

So here I've put down every day, I know you can't read those, but every little point there is a day in the summer of 2010 in Southern California Edison. And it shows that the date and what the temperature was. So these two in red near the upper right are two days that had very similar temperatures, but they had quite different loads. So that's the kind of thing that's quite interesting to us. Now neither are a weekend or a holiday, so that's not coming into play. But the temperatures were similar, but nevertheless the loads were different. So I want to look and see, are the clouds perhaps different on those days? That would be some supportive evidence of what I just showed you in general.

So here are these two days, they happen to be August 17th and August 27th of year 2010. And the maximum temperature there is the top, you can see is virtually identical maximum temperature. Minimum temperature does matter to electricity a little bit. You can see it was a little bit cooler on the day on the left, but nonetheless if you look at the load it was a higher load on the day on the left and a lower load on the day on the right by a fair amount. And the cloud cover is shown at the bottom there. I hope you can see the outline in California.

So if you look at the Los Angeles basin down there the big difference you see between those two, cloud patterns. If you know this it's Southern California Edison are focused on Los Angeles it's that the one on the right had a lot of cloud cover on that day. Now again, same temperature so don't get that confused, but there was a lot of cloud cover that day where they had less load. So this is a way of trying to extract additional weather sort of climate information that goes beyond temperature, try to get to more effects. And there are other ones you can think about too. Humidity is an obvious one or perhaps wind. You know we're trying to look at some of those.

Now let's go a little bit longer, that was a 9:00 a.m. kind of projection talking about the middle of the day. Now I'm going to look longer, I'm going to look on a season as a few months. What can you say about the summer from say winter or spring?

So there's a couple of sources of what we call the seasonal predictability. One is El Nino, which I've illustrated here. That red strip across the Tropical Pacific that shows where ocean temperatures are warmer than usual during an El Nino. In the recent, I mean look how far away that is, it's quite a ways. The reason that matters to us here is because that tends to steer the storms, so it can steer them towards us or away from us, so it has an effect on our region. So that's the El Nino Southern Oscillation, El Nino.

Now another one, which you may not have heard of is called the Pacific Decadal Oscillation or PDO, and that has the pattern on the right. And again this, you know, it's out in the center of the North Pacific

Ocean, but it still has an effect on weather on us here in California. So what I'm going to do is I'm going to take these two weather patterns and see what effect they have on electricity demand in California.

And there is one last aspect I want to look at which is how wet or dry the soil is. Now this is known to make a difference in other parts of the country. The reason you might think this would make a difference is because if the soil's really dry, and when the sun comes out it's got nothing to evaporate out of the soil anymore, because the soil's dry. So the sunlight goes to heating. Now if the soil was all waterlogged and the sun came out it would go to evaporation. So if the soil's dry you get higher temperatures typically, especially on a sunny day.

Okay, so these are three sources of predictability I'm going to be looking at: El Nino, Pacific Decadal Oscillation and soil moisture.

Now what are we trying to predict? Well, this is the Energy Commission so of course there are things related to energy yes. For each of these three utilities: Pacific Gas and Electric, Southern California Edison and SDG&E I'm going to see if these have any power to predict the number of hot days, which is days gridded on 95 degree Fahrenheit; cooling degree days, a pretty standard measure of how warm a season is; and season average to average, season average temperature to average daily temperature, daily maximum temperature and daily minimum temperature. So those are the things I'm trying to predict. And there's a lot of details there I won't bore you with unless there are questions. Then I'll bore you happily.

Okay, so this is the number of hot days per year. A time series of that just observed in the three service areas in since 1950, so you can see how it's changed over time. So number of hot days per, number of hot days is one the things I'm interested in predicting, so I thought I'd be interesting to see how it's changed.

Okay, well if you look at PG&E you can see there has been quite a substantial increase in the number of hot days per year. The light green ones are ones in spring. The reddish ones are in summer and the orange-y ones are autumn. So you can see that in PG&E the increase has been in all seasons really.

Now if you look at the next panel in the middle, Southern California Edison, you see an increase. There hasn't been an increase since spring in particular, it's a little hard to tell besides the spring increase exactly what the main thing is, probably summer.

At the bottom SDG&E, you don't see any particular increase, so the kind of changes you see depend on where you look, which service area you're interested in.

So what in fact does the El Nino Southern Oscillation have on these various quantities? Well, it turns out that the strongest relationship from El Nino is to Pacific Gas & Electric service region. And that mostly the strongest relationship is to the number of hot days early in the season, so May through June. The relationships fall off after June. It also has weak relationships to the seasonally averaged daily minimum and maximum temperature. Now, for Southern California Edison, that's the second strongest relationship. It again relates to the number of hot days early in the season. And for SDG&E again, number of hot days early in the season, but that's weaker than the other two relationships.

So to sort of summarize that El Nino has some predictive power for these various service regions, mostly on the number of hot days, almost exclusively early in the season.

So the bottom two pods are intended to show you what this means. I mean, I've just said it in words, but how can you get a handle on that?

So if we look at that bottom left one with the blue bars there that shows the number of hot days, 95 degrees or more in May and June and this is PG&E. And so it's low in the winter, so this is a prediction from winter to the next spring. And you see the little bar on the left shows that you're unlikely to have few hot days if El Nino is low. On the other hand you're likely to have many hot days if El Nino is low.

So this is the probabilistic nature of it, you see it's not that you're guaranteed by any means. It's not like sort of an operational call that it will be this. You see that there is a ratio here; it's actually about ten to one in this case. You are much likely to have a few hot -- sorry, many hot days than few hot days, but it's not guaranteed. There is years when that doesn't happen, so this is probabilistic information.

The one on the right with the pink bars is a similar sort of thing, but that shows when the phase of El Nino is the opposite and you can see the response over in California is again opposite as the phase of ENSO changes.

This is the relationships with the Pacific Decadal Oscillation, so the summary is there's 31 significant relationships between the PDO and these predictors in the various service regions. They're mostly just seasonal quantities, so there are not the number of hot days like it was for ENSO. So that's an interesting difference between El Nino and Pacific Decadal Oscillation. In general when there's a warm PDO it goes with a warm season in California and vice versa.

And again at the bottom left -- let's look at the bottom right just to be different. Now, I've chosen SDG&E just to show you a different service area. This shows the average maximum temperatures in spring when the PDO is high and you can see you're unlikely to have a cool spring when the PDO is high, but you are much more likely to have a warm spring when the PDO is high. Again probabilistic, it's not guaranteed, because there's some years you can see right there where it doesn't happen, but nonetheless the ratio is quite pronounced.

Soil moisture the same sort of story, so I won't belabor it, 33 significant relationships again mostly just seasonal quantities, a few relationships with hot days and it's mostly spring coincident. So if we have a dry or wet spring it's mostly reflected in that same spring and it doesn't hang out until summer or autumn. It's a little bit different from other parts of the country. We have a little bit less predictability here in California than other places do just based on soil moisture.

Now when we came up -- the next speaker Dan Cayan and I came up here a couple months ago, and one of the things we found people were quite interested in was the hottest day in ten years. And for us this is like a super-extreme event, because we typically look and see 95th percent, which is a 1 in 20 sort of event. Now the hottest one day in 20 year, you know, that's like a 1 in 40,000 sort of event or something pretty extreme. So the problem was that when people tend to look at this information, when they look at extreme days in the models they don't typically look at such extremes. But nevertheless we found that it was of interest here, so it's important. And we felt it was important to try to qualify the models to see if they were doing a good job predicting this, because it was so extreme and it hadn't been looked at.

Okay, well here is the existing method we used for regionalizing the climate information. And what I'm showing here is how hot it is on the hottest day in 20 years. And there are a bunch of colors there you can't probably read, but if you look at the right-hand panel it shows the difference between what the models are simulating over the historical period. I'm not talking about the future historical period, so it should be right, the difference between the models and the observations.

And see that blue fringe along the West Coast especially in California? What that means is that the models are systematically underestimating this kind of super-extreme for this quantity. Now this is a problem, because if you want to look at the 1 in 10 or 1 in 20 years' information from the model, this is going to be a little bit deceiving. So what we've done is what we're working on currently, this is a work in progress, but I can show you some results of it.

This is a method we have, a new method we have that's specifically intended to try to keep these very extreme events. And it's in the same format as before, so you can see that mostly it's addressed that problem of the underestimation along the West Coast, which was one of its design objectives you might say. It also tends to reduce the underestimation of precipitation extremes, which perhaps is not of interest, immediate interest of the CEC. But it affects flooding and so forth, so it's nonetheless important to California.

So let me just summarize my key points. There's some evidence that the marine layer cloud cover is implicated in load forecast errors in the L.A. basin. And again I want to emphasize what I mean by errors is specifically the difference between what the load actually is and what you might expect it to be just based on temperature. So this is a way of saying, "Look, these other meteorological quantities have a discernible influence and they have some persistence associated with them."

Now looking, that was sort of a day kind of scale. If we go out to seasonal scale there is some -- you can do probabilistic seasonal ouputs. ENSO has some relationship to 95-degree days in the various service regions. PDO relates more strongly than ENSO, but it relates to seasonal averages so it's relating to a different variable. So really which one of these you would choose would depend on what you're interested in as an energy producer. And dry conditions, dry soil moisture influences spring conditions, but not later in summer.

And we're interested to find out that there was some interest in this 1 in 20 years, of the hottest day in 20 years, which from our point of view was so extreme we hadn't even looked at it. The model, the current way of doing the models doesn't capture that very well, but we think on our way to getting a new method that might help with that. Okay, well thank you.

CHAIRMAN WEISENMILLER: I guess the one question I'd have is my impression is there's some research to indicate that the load is higher, say the third day of a heat storm?

MR. PIERCE: Yes.

CHAIRMAN WEISENMILLER: Even if the temperatures are the same?

MR. PIERCE: Yes.

CHAIRMAN WEISENMILLER: And so I don't know if you've looked at any of that sort of persistence phenomena?

MR. PIERCE: Yeah, that's quite interesting; you can see that too. We did that whole analysis including what the CEC calls this Temperature 6-3-1, which is 60 percent of today, 30 percent yesterday, 10 percent of two days ago. I just didn't show it here, because of time but nonetheless you do see an effect with that too. So there is a little bit of loading effect. It's not terrifically pronounced I would say and interestingly it's not real consistent year-to-year, but you can see it yes.

MS. KORESEC: Do we have any questions from the audience? All right, we did have one sort of general question on WebEx not specific to this presentation but sort of for going forward. It's from Gina Grey from WSPA. "A Canadian University of Waterloo study has just been published in the International Journal of Modern Physics where data from 1850 to present day indicates that CFCs rather than CO2 are responsible for climate change. There is an almost perfect correlation. Can one or more of the panelists comment on this study and the validity of the work?"

So I don't know if you want to speak to that or if we just have everyone keep that in mind as we're going forward.

MR. PIERCE: I can try. I'm sure other people might want to comment as well. There is a very, sorry I'm speaking to someone who's not here, but pretend I'm looking at you. There is a very clear and direct association between carbon dioxide in the atmosphere and the warming of the earth. And the reason is unlike CFCs or to a lesser degree than CFCs the quantity of heat that CO2 can absorb in the atmosphere and re-radiate back to the earth is tremendous, it's enormous. So CFCs do have some effect. That's included in all the IPCC reports. You can find it quantified there if you're interested. But the CO2 effect is much larger, so it's a matter of size. Size does matter, so there.

MS. KORESEC: Okay, oh yeah we do have one more question. Come on, come on up.

MR. ASLIN: Yeah, just (inaudible) around that way. I'm sorry, I did have one --

MS. KORESEC: We have one more question, David.

MR. ASLIN: -- or just a general comment, Richard Aslin PG&E. Just to say that we very much do support this additional research on the recurrence interval temperatures, because those are vitally important for system planning. And I know PG&E is very interested in this work. We'd like to see and help in any way possible, so please feel free to call upon me and I will be more than happy to get in contact with the right people at PG&E to make sure that happens.

CHAIRMAN WEISENMILLER: Thanks.

MS. KORESEC: All right, our next speaker is Dan Cayan.

MR. CAYAN: Good morning, it's a pleasure to be here and good morning commissioners, friends. So who needs a title, but the gist of this talk is aimed at extreme events and largely focusing on temperature.

But of course, our area is more than that, so we'll open up with things about other parts of the system.

Actually outsiders I think have the impression that California is pretty bland. And often when we get visitors they're shocked when we don't have sunny, moderate days but it happens as we all know. We've seen that observationally and of course, in the future the projections are indicating that we'll see even stronger extremes.

This is a lesson from precipitation records collected, these are observations collected across the United States. And let's see, I don't know where -- everybody's attention, if you focus back here we see these bluer, greener colors. That indicates that the volatility of precipitation, in this case this is water year, so it's the total precipitation on an annual basis. And the measure here is actually the standard deviation scaled by the mean at any station. And what you notice is that California is, by this measure, the most up and down location, region in the country. We are familiar with wet spells and dry spells and that really bears out in relatively long records of the data.

The other thing that -- another map attributed to my colleague Mike Dettinger, who works with us down at Scripps. Mike is a USGS employee. Mike here has taken three-day total precipitation at each location across the United States and what this map calls out are the locations, which accrue something in the neighborhood of 16 inches of precipitation or more in a three-day period. And what is not surprising, of course, is this cluster of these areas that do receive that very copious precipitation along the Gulf Coast, because of the rich Gulf moisture often times tropical easterly waves and sometimes hurricane-related activity.

But the other thing that really stands out here is the number of really wet events that have occurred in California. In fact, some of the greatest exceedances occur in the Sierras and areas that are exposed to moisture-laden air masses during winter storms whereas much of this activity in the Gulf is a summer activity. We are exposed to heavy winter storms here in California, hence our vulnerability to flooding. We have essentially the perfect situation: lots of moisture from the Pacific, aerographic influences, and then occasionally a lot of dynamics that are able to set that off.

The other thing is that, of course, we live on exposed coastline and while most winters are relatively well-behaved occasionally such as the scene here we get winters such as 1982-83 when we hit really massive storms. David was talking about El Nino, this is one of the great El Nino winters in our recorded record and we get often heightened sea levels, big storms. And when they coincide with high tides then we have, of course the ingredients for a lot of impacts.

Looking forward as mean sea level rises in the future the number of extreme events, the number of very high level sea episodes can be expected to cascade and we'll hear more about that later, so I won't belittle that.

I want to move ahead and talk about heat waves, because of its very strong bearing on electrical demand and also supply. This is a takeoff of David's remarks just a couple of minutes ago. Of course, there's very broad-ranging effects not only on the energy sector, but on human health, ecosystems and really across the board in various ways in California.

This is a portrait of heat waves that we've seen in the historical past going back to about World War II in California and this has been compiled by our colleague Sasha Gershunov at Scripps. The colored lines here represent essentially two flavors of heat waves. Heat waves, which are accentuated during daytime hours, so they have very extreme heat during the day and the blue lines here are heat waves, which are accentuated during nighttime hours. That is they have very anomalous warm temperatures at night. In other words it's not cooling off.

And what we see here is that by and large, of course these are fairly rare events, but when you look across this 60-or-so year record the daytime heat waves are happening, I would say, at a pace that really doesn't change too much over time. But the unusual thing that we've noticed is that over the last couple of decades there's been a real surge in events that have very pronounced nighttime extremes.

The two bars that you see here that are really impressive by this metric that Sasha invented, which has a spatial and an intensity component, these two events here are 2003 and 2006 no doubt familiar to many of you. Back earlier we have very large events in the early 70s and also the early 60s where the events were really flavored towards daytime conditions. So this, of course, could be natural variability, but on the other hand it may be something that bears watching.

It's interesting that globally essentially nighttime temperatures have shown the greatest increase as opposed to daytime temperatures. Of course, we all know that the earth has been warming, but thus far it's been accentuated at night and it seems to be perhaps a symptom of this.

The other thing that bears mentioning about the historical incidents of heat waves is that when we get warm temperatures here in California we tend to get very warm temperatures along the entire West Coast, that's the red dots. And interestingly, often times of course this is an atmospheric circulation-driven phenomena. That's the portrait here in the bottom. And going along with that there tends to be higher than normal pressures here over the west and downstream over the east, what we're essentially baking. We might look for this, this weekend. They are relatively cool.

Well looking toward the future this is an ensemble of climate simulations. The simulations are essentially integrated forward in time, but also done retrospectively. They're driven by greenhouse gases, volcanic loadings and so forth. These are global climate models. In this case there's a little more than a dozen climate models here. What we've done here is we've essentially smoothed out some of the variability.

There's three different greenhouse gas emission scenarios portrayed here by the blue, brown and red lines going forward. And of course, the red line is the higher so-called RCP 8.5. That means 8.5 watts per square meter out of energy balance by 2100, so that's the way we're classifying emission scenarios these days in the climate modeling community.

And then of course, the lowest trace there is the scenario that has the lowest amount of emissions. Of course, right now we're not really adhering to that lower scenario. We're more into taking this higher pathway, but you can see here that temperatures no matter which emission scenario are bound to rise as time goes forward in our future here in California.

This is a location that's extracted over Sacramento. This is the July temperature and the envelope here goes from approximately two and a half Fahrenheit to about nine Fahrenheit as a median amount of change. There's of course, still a great amount of inter-annual variability. There's natural climate variability that'll make some years cooler, some years warmer and so on. But there's this inexorable change towards warmer conditions as we go forward. The other thing to point out here is that warming is already begun and we are committed to further warming as time goes forward.

Suzanne, are you giving me the evil eye

already?

MS. KORESEC: (Inaudible)

MR. CAYAN: Okay, thank you.

Okay, so another point to be made is the recent generation of climate simulations. Again, here there is about a dozen of them.

This is the higher emission scenario, RCP 8.5, lower scenario 4.5. They're both expressing greater warming in the summertime than the wintertime. This is warming by the end of the century referenced to today's climatology. It's an incremental effect, but of course warming that adds to our summer heat of course is going to be something that is a challenge and is going to confront a lot of the systems, natural and human, in the state.

This is our census of heat waves. Time goes up here from 1950 through 2100 and the season goes across here from May through September. Each one of these little measles spots is a heat wave. Just to help you orient here, here's a time series of those heat waves going forward in time. There's actually on this plot here at the bottom there's two different emission scenarios. There's only one shown here on this spot chart, that's the RCP 8.5.

This is from a French general circulation climate model that happens to do quite well in replicating climate in the west and that's why we selected this one. But what you can see here is that compared to the historical era heat waves become more intense. The intensity scale is shown here at the bottom and of course, more frequent. And the heat wave season broadens as we go forward in time. That is heat waves are starting to occur earlier and also later in the season, so we're going to have more events and a longer season to contend with.

Interestingly, the eye of course picks out this spectacular region towards the top of the chart, but if we look at the numbers by the 2020s, 2030s we are doubling the number of heat waves that we are seeing, we have seen historically. So this is not a long-term future behavior entirely. This is something that is happening and will happen increasingly as time goes forward.

So just to give you a sense of how things are changing in terms of a heat wave count same model just portrayed differently. This is just a little bar graph. This is the historical 30 years from 1961 through 1990 made out from that model and at the bottom here what we've done is we have categorized each heat wave by its duration. So number of days, of course historically the one-day spells occurred more often and there's this sort of mean tail in the distribution when you get, of course, long heat waves. That Bob mentioned this is his question to Dave about the three-day heat waves. Those long ones of course, have great impact.

Let's look at what happens going forward in 30-year slices, so this is '05 through '34 in this climate model simulation. Notice here now that the two-day spells are the category that occurs most strongly and the tail is getting thicker as we go forward. This is the middle part of the century. Again, the two-day spells becomes even more, but of course there's just getting to be more heat waves and there's getting to be more that have this long duration. And finally end of the century of course, the population of heat waves really explodes and we're starting to see heat waves out here at the ten days and longer sort of category.

So now, rather than relying on just a single model what I've done is I put together a dozen models and shown you again at the bottom this is the number of heat waves, this is the same sort of time slicing as before. The temperature now is shown, so this is intensity on the Xes and each spot each is a heat wave that occurred.

So here's what happened in a collection of a dozen climate models in the historical period. Here's the first 30 years, note the color change. Pretty soon the green dots are going to sort of go tannish, because we're imprinting them with what happens going forward. And you can see here just the explosion of the number of what we would call today heat waves and some very long ones as we go out in time.

One more, finally one more slice at heat waves, this gets to David's point about the greatest event that we saw, David showed it, in 20 years. I'm showing here in the blue line the greatest event that occurred in 50 years of historical records here in Sacramento. And then the green traces are what happened in each year.

This is the hottest day of each year between '01 and 2010 from a climate simulation compared to this 50-year greatest event shown in blue. And what I'm showing here is the diurnal cycle, the hourly temperature data from early morning through mid-afternoon and then back to early morning again. And I've sort of concocted this. It's a little bit fictitious the way that's done, but it serves as an illustration.

And I just want to take you through the decades showing how essentially the daily profile of temperature behaves decade by decade, so each one of these traces is a decade. Notice here that in the 2011 to 2020, there's only one event that eclipses the one, the greatest one, in 50 years.

But now here's the next decade, there's three events if you look closely, that are greater than that one. And of course, the way I've constructed it they all have essentially the same profile, so don't pay too much attention to that. But what I do want you to pay attention to is the length of time of the day where temperatures exceed 40 degrees Celsius, which is 104 Fahrenheit.

So the thing about these very hot days is what they do, is they expose us to warmer temperatures for a longer period of the day. And now you can see as time goes on the width of this very intense heat increasing over time. So here's the end of the century and virtually every warmest day of that decade is greater than the warmest one that we saw in 50 years of record there.

So I have conclusions, but I just got a kick and so I won't go through those. So maybe it's okay to entertain questions. Is that okay? All right, thanks.

CHAIRMAN WEISENMILLER: So a couple of questions. So one, we've looked at temperature and precipitation. Do you have a sense also of wind patterns?

MR. CAYAN: Wind is more problematic. The climate simulations are calculated over pretty course scales. And to downscale winds to the texture and aerographic setting here in California has been done for numerical model simulations that are fairly specialized, but has not been done over a large ensemble of climate simulations. It turns out that those specific simulations are, I would say, still being digested and there's not an enormous signature to look at.

So you might wonder, for example, whether wind energy is going to be affected by climate change in California. And I think the answer to that question is that we're not sure at this point, so that's work that needs to carry forward.

CHAIRMAN WEISENMILLER: The other thing I was thinking of is certainly when you look at the winter storms, winter storms in terms of the increasing frequency effect, say PG&E as they try to deal with storms hitting their system. And at the same time Edison has been surprised recently by a really bad windstorm. So part of the question is how much do we have to worry about increasing wind storms over time? And realizing, again you don't have the model for that, but anyway I was looking more at that sort of impact.

MR. CAYAN: Okay, understand. So in general I would say that today if I had to bet I would say that the frequency of winter storms is perhaps going to diminish just a bit in California, the storm track, by I guess a rough consensus of the models is shifting pole-ward. But that's not to say that there won't be some intense storms amongst the ones that do occur, so we will still have those ingredients of big flooding events for example.

Wind storms per se, I don't know really what the answer is to that one. I think that bears looking at and I would guess the signal is going to be fuzzy amongst these models.

CHAIRMAN WEISENMILLER: I guess the other way to look at it is I know we've talked a lot about the temperature changes for Sacramento. And so part of the question is, is the coastal region going to see the same level of impacts?

MR. CAYAN: You know, it's going to be scaled. Actually the amount of warming, what the models suggest is the warming will be greater in the interior or California than it will along the immediate coastal area, which is affected by the marine layer.

The ocean temperatures are going to essentially insulate to some extent, because the ocean is absorbing heat over a thick, mixed layer. And we think that warming will be less right along the coast than it is say in the central valley. But the details of how that's going to penetrate and whether the traditional areas: the Delta breeze and some of our interior valleys that enjoy a sea breeze are going to maintain, perhaps being intensified and so forth, again that's work in progress.

CHAIRMAN WEISENMILLER: Okay, now you had noted in terms of the climate warmings there's sort of the summer warming higher than the winter, interior warming greater than coastal, and nighttime warming exceeding those four points. So at this point does the evidence point us in that direction with (inaudible) --

MR. CAYAN: Certainly, the evidence for nighttime warming is actually based, it's predicated on observations, not so much models. Very few of the models show this asymmetry in night versus day. They actually are pretty symmetric, but observations are pointing to essentially a greater greenhouse effect or perhaps the greater effect of moistening that's increasing nighttime temperatures.

The interior warming argument I think is one that is coupled with the land surface, and that the argument goes that because we're drying continental areas more intensely with warmer summers we're using more of the heat in sensible rather than late in heating, because there's no moisture left and temperatures are getting warmer. So I think that's quite sound and so we can probably look forward to that occurring. We see that naturally over the Great Plains today, so we know that mechanism operates.

CHAIRMAN WEISENMILLER: Yeah, one of the ways that this could affect the energy system is that we're looking at more ED vehicles and people doing charging at night, that will obviously affect how much the transformers are allowed to cool off. So if we have more loading on the transformers at night and higher temperatures both, that's going to affect the reliability.

MR. CAYAN: Yeah.

CHAIRMAN WEISENMILLER: Okay, I think that's all I have.

MS. KORESEC: Do we have any questions from the audience? All right, we have no questions online, so Dan you did such a fabulous job we're going to let you give the next presentation. Okay, great.

MR. CAYAN: Thanks, Suzanne. This is a talk that actually Josh Willis, our colleague from JPL NASA Laboratory in Pasadena put together. Josh unfortunately, was doubly-committed today, so he asked me if I would present his talk.

And just as a backdrop Josh's talk is largely about global sea level with of course, implications on California. And I've done some work on sea-level rise with more of a regional flavor, so I've added some slides at the end. If I get a chance before I get the hook, we'll look at some of those.

So these are -- Josh's slides are really oriented around the immense problem that's posed by this huge storehouse of water that exists in the ice sheets in Antarctica and Greenland that is essentially the big source of uncertainty for sea-level rise in the global future. There is 70 meters or so of sea-level rise to be had if you liberated all of that water that's stored in those two ice sheets. Don't worry, 70 meters is not going to happen. It's been argued that it will be hard to achieve two meters by 2100.

But just to put this into context we have seen globally over the last century something like 20 centimeters or so of, in other words two-tenths of a meter. So a round number that I like to think of is two millimeters of sea-level rise per year has been about the historical rate. Now two millimeters is almost, you know, it's a little more than the width of your fingernail, but it accumulates and this is a 24/7 kind of thing. And it turns out that as Josh's story tells, this has been increasing if we look over the last 20 years or so.

Here, Josh is making the point that of course the reason that we have this threat looming is that we have warming temperatures globally. This chart shows temperatures going back to 1880 or so and temperatures have risen here something on the neighborhood of a degree and a half Fahrenheit when you average together the global surface temperature since then. And he makes the association here why are temperatures warming?

Well, this is the Paleo-CO2 record that's been collected from CO2 that's been captured in bubbles in ice at the poles. And what we can see from that compared to the more modern record where we're actually measuring CO2 directly in the atmosphere is that we have, since industrialization eclipsed the natural variability of the system on these 100,000 year time scales.

And now very recently you probably read the headline that we've broken the 400 parts per million in CO2. There's been a lot of debate about what is the dangerous level that humanity will have to contend with and there's some that would say that 350 parts per million is the dangerous level. There's others that have different definitions, but just suffice it to say that the scenarios for greenhouse gas projections would have us very likely doubling the pre-industrial CO2 concentration by the end of the century.

And if we're unlucky, if we continue to take this higher-end trajectory we will have triple the CO2 levels by the end of the century. That is an excess of 900 parts per million by the 2100 point.

This is a proxy record for sea level that's been constructed from sediments and various evidences in the sediments from North Carolina. And of course there's uncertainty here and so forth, but what Josh's point is, is the very rapid rise of sea-level rise once you get to the modern area. This goes back 2,000 years or so and so the evidence, this is only one location of course, but it's emblematic of global sea levels probably.

This now is the record that's collected from a collection of tie gages across the globe going back to 1860. You should know that in 1860 there was only a few handful of tie gages, probably about 30 of them. The number grows in time; there's been mathematical ways of using that information and trying to intuit the global sea level over that period. And it is reckoned that over this era we've seen -- well that's my number, 20 centimeters. So Josh has 20 centimeters happening in 140 years, I said in a 100 years or so, but it's the same order of magnitude.

The other thing to be made from this record is that when you look at it in pieces there's this disquieting increase in the slope, the rate of rise over the last couple of decades. So the two millimeter approximately number has increased to about three millimeters per year. And interestingly, and he tells us here how much this equates to in terms of water.

So the reason the oceans are rising is essentially two different mechanisms. One is they're rising, because of steric influences. The density of water is diminishing, so as it's warming it's occupying more volume so just thermal expansion. And the other reason of course, is we're melting ice on earth and you've all seen headlines of vanishing ice stocks in high-altitude glaciers and so forth.

San Francisco, and this is Josh's trace, actually has a sea-level rise rate that is very similar to the estimated global rate. And interestingly, while I would say ten or fifteen years ago it would have been said that thermal expansion was dominating the amount of sea-level rise the balance has shifted. So recently the ice melt component to sea-level rise has become as important and according to Josh it's more important than thermal expansion in recent years.

So there's another way now to measure sea-level rise and that's with very high-precision altimeters that are born on spacecraft. There's been three different spacecraft over the period since the early 1990s, the U.S. and also French spacecraft that have been sewn together here.

And you can see the record going back to 1993 or so through nearly present here. You can actually see a annual cycle in sea-level rise. That's because essentially the continents breathe in water in part of the year and then they release it in another part of the year. And actually the ocean levels reflect that.

It's a pretty interesting record, but that's relatively minor compared to this rise, which interestingly from a totally independent record that is measuring the altitude of the ocean's relative to the center of mass of the earth, the rate of rise is just about the same as what we see from tie gages. And when we look to the future here's where we are now, here's where we could be. There's a big envelope of uncertainty here going forward and essentially the take-home point of Josh's talk is why there is so much uncertainty is the uncertainty in the melting of Greenland and Antarctica.

By the way the altimetric record, that's the green one here, is compared to the tie gage record. That's the blue one here. So you can see the correspondence between the two. This is looking forward and this is actually looking forward to the year 2300 using climate model simulations.

The take-home point is here that from thermal expansion we can probably expect another two-tenths to three-tenths of a meter. Twenty centimeters is about eight inches, so eight to twelve inches or so from thermal expansion by 2100. But if you noticed these curves here, they are approaching a meter and the top one is actually approaching two meters and the reason for that is the potential for enormous amounts of volume added to the ocean from ice.

Now I'd like to change gears really quickly and say something about California sea level problems. And our problems, at least in the next 50 years or so are going to be largely, because we have big storms coinciding with high tides. And of course, that's going to be slowly aggravated as mean sea level rises, so again this is scene from actually Monterey Bay during the 27th of January 1983 where in many locations along the West Coast the highest sea levels were recorded and that record stands still today. And interestingly of course, the ocean wasn't like a lake at that point. It was more like a washing machine, so we had essentially took out all of the vulnerable structures along the West Coast at that point and time.

The other thing even though I don't have a slide to show, is that we have not only an exposure to the open coast in California because of sea level and storm problems. We also have the Bay Delta, which is a locus of essentially the plumbing system for the California water conveyance as well as a lot of infrastructure, some of which is electrical and transportation and so forth. And I think we're going to hear from our colleagues from Berkeley who are going to talk about some of the transportation aspects.

This is a record of big sea level events historically going back to 1950 in San Francisco. And this is that winter, 1982-83 when we had the total number of exceedance hours by my measure here, which is essentially exceeding the one in fourteen months level of exceedance in an hourly basis. And what you notice here is that those things don't happen every year, they tend to happen episodically and they happen big time in 1983 and also in 1997-98, the other very large El Nino in our recent record.

Interestingly one thing that you should know is that sea-level rise since 1998 has essentially been non-existent. We've been flat here along the West Coast. This is a picture from the altimetric record showing the amount of sea-level rise across the global ocean. And if anything we've actually been a little negative since that early 1990s period when we had altimeters.

But what you see is this really excessive rates, in some cases approaching ten millimeters per year in the Western Pacific. This is thought to a wind-driven ocean circulation phenomena and part of the natural variability of the Pacific Ocean. And of course, one of the $64,000 questions is when that low frequency change is going to reverse and we will resume sea-level rise here along the West Coast.

There was an NRC, National Research Council committee that studied sea-level rise along Washington, Oregon and California. I was part of that committee and they were charged, we were charged with looking at sea-level rise along the coast. This is sort of a take-home message. The committee's envelope of sea-level rise again was quite broad, but if you sort of chose a midpoint for California sea-level rise it's looking like about a meter by 2100.

This is south of Cape Mendocino. There's some tectonics that get involved. And so north of Mendocino sea-level rise will not be that large in a relative sense, because land is uplifting there. Interestingly if you look at previous estimates of sea-level rise they were down here.

Now we've really broadened the envelope and the envelope is getting broader at the higher end. I don't think I'm going to go into this, because it's a little busy and I'm sort of running out of time. I already mentioned this in the previous talk where if you look at the number of extremes and essentially just count the number of hours greater than X or X is a fairly high threshold, you start to see the number of extremes cascading as we go forward in time. And of course, that's going to create lots and lots of problems again, not only along the open coast but in the Bay Delta.

So in summary warming is already occurring.

Well, we're committed to further warming. The two millimeters per year that we've seen historically is going to very likely increase by double, triple, perhaps even more. Ice melt is going to be the dominant influence probably, but there's a large uncertainty. It's not well-modeled and well-understood at this point.

Along the West Coast we've not seen sea level rise since the late '90s and we're waiting expectantly to see what happens and the big problem's when we have large storms.

I guess the final thing that I would note is that this is really not a climate phenomena, but we have evidence from sedimentary record of once every two to seven-hundred years very large events here along the Cascadian earthquake fault where sea-level rise underwent one to two meters of change in 20 seconds. And of course, if that happens all bets are off and that will have enormous consequence. It's something that we have to be aware of. I'm not predicting, it's just it's happened many times before and it could happen again. So I think that's probably where I should stop.

CHAIRMAN WEISENMILLER: So how does the -- as the sea gets warmer how does that interact with the acidification of the oceans in terms of speeding up reactions and all?

MR. CAYAN: I should be a chemist. Well, I think if I am -- you know, this is bordering on kind of BSing, but I think that the rate of dissolution of CO_2 in seawater becomes greater, that is it expels CO_2, as water gets warmer. So if the ocean sank it may become a little less, but I think in order to really calculate that you'd probably need to know about bugs and plankton and stuff, because those probably have at least as much if not more than just sort of the inert water.

So maybe you need another expert to really talk about that, but over time of course I think the balance is that the acidification is most strongly driven by just the fact that there's this big gradient now in CO_2 in the atmosphere versus the ocean. So the ocean in general is going to be uptaking CO_2 and it's becoming more acidic. That's verified, that's happening and of course, there's consequences in the calcareous shales and all sorts of food chain ideas. So I would say the water temperature part of that is probably the minor part of the argument, anyway.

MS. KORESEC: Do we have any questions? Oh yeah, please come to the mic and give your name.

MR. CAYAN: He's a biologist, he might be able to say something about it.

STEVEN SCHWARTZBACH: Don't hold that against me, Steve Schwartzbach, USGS. Can you put up the first slide again of the second talk?

MR. CAYAN: I take it you didn't want the introductory slide, you wanted the --

STEVEN SCHWARTZBACH: That's this slide, yeah.

MR. CAYAN: Yeah.

STEVEN SCHWARTZBACH: Could you address the 2000 to 2010 period there and what's going on? If you look at the second slide after this with CO_2 it's a straight line up it looks like. And very different scales of course, but...

MR. CAYAN: It's very different scales. Well there is natural variability in the system and of course, the climate skeptics are always pointing at what happened last year in temperature. "My thermometer went down, what are you talking about?" So it's misleading to make too much out of really short spans of time and try to attribute them to global warming.

We know that -- let me go to another slide, Steve. Well, no I can't. It's in the previous talk and it's too difficult, but if you remember the temperature projections even in the models, which had this in general when you looked at the median -- that's okay Suzanne, you don't have to do that. They have really impressive inter-annual decadal variability just like we have in our historical record. And there's no reason why we should expect not.

Okay, so all these spaghetti, you know, each one of those is a model and those models are monitoring all over the place. For example, that's what we're seeing in nature, so what we're seeing is the climate system in its full regalia. And, you know, we should not expect just to see monotonic warming year after year after year.

But what we can say is that when we look back at the temperatures either globally or northern hemisphere or the United States, and of course you know people have done that, virtually all of the warmest temperatures have occurred within the last 20 years of record. So yeah, there's going to be wiggles, but I don't think you want to make a prediction that, "Okay, the temperature is going down now, we can call this off."

Because, you know, our diet for fossil fuel energy is unquenched and it is increasing and we're seeing that. You know, the writing is on the wall. Even if we were to shut off CO2 emissions today, put them back at natural levels, we are committed probably to another half a degree to a degree Celsius. That's approaching two degrees Fahrenheit, because the earth is not equilibrated to the loading that we've put in the atmosphere.

MS. KORESEC: Any other questions, yeah?

MR. DUVAIR: Hi Dan, Pierre DuVair, Energy Commissioner, just a quick question on that 15-year hiatus from sea-level rise since 1988, have both the two components been monotonically increasing the thermal expansion and the ice melt the last 15 years. And then what kind of explanations do we have for no increase since '98?

MR. CAYAN: Well, the no increases from '98 again is a regional no increase, right? So largely what that is, is that's ocean dynamics, kind of rearranging the bathtub, okay? And you saw the Pacific Basin, you know, there's islands in the Western Pacific that are really in trouble, because they've had three times the rate of global sea-level rise over this period. And they're really concerned and there's a film about, you know, somewhere there's a mountain or something like that, that speaks to that.

But as far as what's happened, so this gets a little detailed, but there's a set now of the ocean is being probed vertically with a set of floats. So the ocean now is populated with what are called argo floats. And from those we know that the ocean has been sequestering heat.

David Pierce back there has done some of the real pioneering work on understanding the signature of climate warming in the global oceans. And we know that 70 to 80 percent I think of the global energy imbalance has been taken up in relatively, I won't say it's imperceptible, but to most people except for Dave Pierce it's been imperceptible. It's distributed across the first thousand plus feet of ocean temperatures and Dave will correct me here.

But and so thermal expansion has largely -- you know, if you integrate it over this entire 50-year time spell or whatever you're thinking of, a big piece of it would be thermal expansion. A smaller piece would be ice melt. Over the last ten years or so thermal expansion is probably like it always was, but ice melt now is like that. So by Josh's reckoning 60 percent or so of sea-level rise in the last 20 years has been ice melt. And you've seen reports of Greenland melting more than it was before and so on and so forth. Antarctica is contributing as well, okay.

MS. KORESEC: All right, we're going to move on now to stay on schedule. Our next speaker is Garth Hopkins.

MR. HOPKINS: Hi, my name is Garth Hopkins. I'm with Caltrans in our headquarters division of Transportation Planning here. And we're going to shift gears a little bit. We've been talking a lot about data and now we'll be talking about kind of what Caltrans an organization is doing to address climate change issues.

First to put a little context on things, just kind of wanted to give you an overview of California's transportation system. I always think that that number's kind of interesting. Here we've got, what 38 million population and we've got about 32 million cars or registered vehicles in the state. But there's some data I'll be relaying to you, to climate change, that has an impact on climate change of course.

Also I think it's always important to note that, you know, transportation at least in California contributes 37 percent of the overall greenhouse gas emissions, which is the largest percentage of any of the sectors in the state.

Just a real quick overview of Caltrans; we've got, you know, about a $12 million budget. Unfortunately that's not enough to cover all the transportation issues that we here in the state face. We also own and operate the state highway system and we've got a little over 19,000, used to be 23,000 at time so we're getting smaller, employees statewide. And we have 12 district offices around the state and we operate a little over 12,000 pieces of equipment in a little over 7,000 cars and light trucks and about 1,800 medium heavy-duty trucks and the remainder is specialized equipment. All that equipment is estimated to produce a little over 190,000 tons of CO_2 emissions from those operations.

And Caltrans, as I said earlier as an organization we have 12 district offices, and so I'm from headquarters here in Sacramento. But we have 12 district offices around the state and those are kind of just a real quick overview where those offices, district offices are located. And now on to kind of what are we doing as an organization to address the mitigation efforts and, you know, why are we doing it?

Well, first of all I think all of us know we have -- you know, we're legislatively required here in California to do so. And speaking from the State Department of Transportation or DOT perspective there's not many other states that have a legislative requirement to address greenhouse gas emissions.

And in discussions with some of my counterparts elsewhere around the country I think as we all know, climate change is kind of a political issue in some respects. And some of my counterparts in the other state DOTs they're not even addressing climate change whereas I think in California, and particularly we've been working with our counterparts in state DOTs in Oregon and Washington, and I'd like to say we're a little more progressive than some of the other state DOTs around the country. But we also have Governor's executive orders that not just impact just Caltrans, but other state agencies that carry weight as well with other state agencies.

We have two documents that I'm just going to be speaking about real, real quickly that were just released, I mean within the last month or so. And the first one is what Caltrans has done as an organization to reduce its overall greenhouse gas emissions. And that document is available on our website and was just released last month as a matter of fact. The report itself addresses these several factors, you know, as Caltrans as an organization.

Like I say we're a large organization, but it's broken down by what we can do or have done to address greenhouse gas emissions reductions from a planning and environmental perspective. And when I say from planning, you know, transportation systems or the environmental side of the environmental impact documents and whatnot, also materials, concrete and our maintenance and operations. You know, it's the guys driving around. It used to be the orange trucks, but now it's the white trucks with the white stripes that maintain the highway system throughout the state.

Also our facilities administration, you know, as I said we've got 12 district offices around the state. So we do have large office complexes and we've done a lot to make those a little greener.

And so, you know, this is kind of from a planning and environmental perspective. These are some of the documents, the planning documents that we at Caltrans are relying on to do our various planning requirements. And then also they are starting more and more to address greenhouse and climate change issues as well, which is the right thing to do of course.

The largest reductions that we've seen in greenhouse gas submissions over the course of the past few years has come from using new materials in our construction activities, primarily on the concrete side of the house. And this is something also I want to touch on that we're going to start looking more and more into is the rolling friction reduction of various pavements to achieve both reductions in fuel consumption, but then also in climate change.

You reduce fuel consumed you're going to reduce the greenhouse gas emissions from the transportation sector and I think that's something that we're interested in and we want to push elsewhere and see what kind of benefits or would-be cumulative benefits there would be statewide to having lower friction pavements utilized.

On our maintenance and operation side Caltrans is one of the, or the largest single consumer of biodiesel in the state. And those are some of the numbers in terms of the use of alternative fuels and the percentage of CO2 GHG reductions achieved. And then also on LED lights, this is a second on the energy side of the house.

You know, I think one of the largest percentages or the second-largest percentage received after the concrete materials was energy reductions through the use of LED lights and around the state. And also, you know, the traffic signals as well. And so, you know, we really achieved a huge reduction in energy usage from the highway signals around the state and the traffic lights and the lighting systems.

On the side of our facilities administration side, you know, we've got three buildings in our district offices. And these are large office building for hundreds of people that are LED or are lead certified should I say, that have been constructed in the last ten years or less and so that's something that we're really quite proud of. And we also have a fair amount of employees and we walk the talk in terms of trying to get people out of our cars, single-occupant vehicles and on to mass-transit, bike and walking.

Kind of shift gears in terms of what we've done to mitigate, but now what are we doing to plan for adapting to our changing climate as a transportation agency? And the three major impacts that I think we'll be seeing on the transportation side of the house are the sea-level rise and of course, you know, how it's going to impact transportation is in increased flooding and the washouts and damage to the substructure beneath the roadway and as a result of that flooding event due to sea-level rise.

Also in intense weather events, you know, what kind of impacts is the increased and intense rainfall going to have on transportation is something that we need to start planning more and more for, because we are going to have more flooding. And the resultant landslides and the bridge scours as well due to erosion under our bridges, structures and whatnot. And then lastly higher temperatures can have an impact on pavement buckling and rutting and thermal expansion on the bridge joints as well, you know.

And also changes in vegetation, because Caltrans does maintain a significant amount of landscaping around the state and our landscape architecture folks are having to look and see what kind of vegetation and reduce water needs or for the irrigation of those vegetation as well. And we're also going to have the landslides and the wildfires as a result of the higher temperatures and the forest fires as well.

In terms of Caltrans participation from state government I have to tell you I've been in transportation planning for over 20 years now. And climate change from the state government perspective I think, in my opinion at least, has been one of the most dominating kind of issues if you will that -- multiple state governments, because each of us from a state government perspective, you know, we all have our own charges. And we've all been able to rally around climate change in terms of addressing that from multiple state governments and also at the federal and the local perspective as well.

You know, we've also been involved nationally with the National Association of State Highway Officials and then also Federal Highway Administration has been very active on climate change issues and how it's going to impact transportation. We also work with our local and regional partners. There's a number of regional transportation agencies around the state that do planning as well, so we work with those folks not just on the highway side of the house, but local streets and roads, railroads, aviation as well.

And the second document I was going to touch on real quick is something we released several months ago and it was to help provide guidance to regional transportation planning agencies, either metropolitan planning organizations or our regional transportation planning agencies on how to address climate change in their long-range transportation plans also known as regional transportation plans.

These regional transportation plans look out 20 years for a specific region or county in terms of what are the transportation needs in that particular area. And we feel it's very important that these regions start looking at climate change impacts to the transportation system. And so the purpose of this document was to help provide information to these MPOs and RTPAs as I just said around the state, if they so choose to look at climate change adaptation. There's no legislative requirement for them to do so at this time, but from a planning perspective it just makes planning sense to do so.

In terms of future directions for Caltrans and other state agencies, and this is just kind of my two cents, I think it's important to continue the climate change dialogue as I said, you know, I think at the state government level and at all the various forms of government. At least it's been my experience. I think that's moving ahead pretty well. We need, the thing that we do need to work on I think is coming up with some of the common assumptions of climate change impacts.

And I know what Dr. Canyon's working on and we had the National Academy of Science or the NRC report that came out, what last summer? We had a hope that that would help clarify and narrow the assumptions such as sea-level rise, but I know it's a very -- and the science I guess, is not that exact right now.

But from an infrastructure standpoint it's difficult for our engineers to design future transportation structures to accommodate for example, sea-level rise or in increased precipitation rates if we don't know a little bit more, you know maybe refined, what are the higher levels that we need to design for. And also from a regulatory standpoint Caltrans gets permits from certain agencies such as the Coastal Commission to build our transportation projects.

And we all have to be on the same page, so to speak. And if we're not on the same then it's difficult for us and it's difficult for the affirming agencies as well.

Also from the Caltrans standpoint we're going to be continuing working statewide with our Caltrans staff to communicate climate change issues. This is just one more issue in the whole host of things that our staff statewide needs to concern themselves with, but we want to make sure that we are planning and preparing for climate change as best possible in addition to other issues that we have to deal with on a day-to-day basis.

We will be developing further policies and procedures on how to incorporate climate change issues into our guidance, but like I say it kind of gets back to the thing I spoke about earlier in terms of coming up with some common assumptions. And I know the State of Washington, fortunately they're all able to -- they are legislative mandated I think to use I think it was the University of Washington data rather than -- you know, there are so many organizations, scholastic and governmental organizations, that are doing these kind of assumptions work and well which organization do we use? What assumptions do we use on the climate changing, but up in Washington state they've been able to just use one set of assumptions.

And then we're going to continue to develop guidance for Caltrans staff on how to address climate change in our various plans and designs and ongoing of the transportation system. And those are just the two titles of the documents I just read or discussed and there's some links, copy them real quick of you want to. Now, I'll be serious. I mean, we can provide the links if need be later on. And that's all I had, thank you.

MS. KORESEC: Great.

CHAIRMAN WEISENMILLER: Well, a couple of quick questions?

MR. HOPKINS: Sure.

CHAIRMAN WEISENMILLER: One is you mentioned

191.3 tons of CO_2 emissions. Is that per year?

MR. HOPKINS: Yes.

CHAIRMAN WEISENMILLER: Okay, and the other one is have you seen much effort in this area by the Federal Department of Transportation?

MR. HOPKINS: Yeah, you know, as a matter of fact both the U.S. Department of Transportation and also specifically the Federal Highway Administration or FHWA have been very active on climate change issues and helping provide some guidance to, you know, the states and others in the transportation community on addressing climate change.

And they've also provided some funding. As a matter of fact we've got some funding to do a climate change vulnerability assessment up in the North Coast of the state up around Eureka, of vulnerability -- it's tough for me to say -- of the transportation system up there to climate change impact. So yeah, the federal government has been. You know, we definitely would like them to be a little more active, but they have been there at the table definitely.

CHAIRMAN WEISENMILLER: Okay, and the final question is when you mention climate change impacts on transportation do you have a sense of what the dollar amounts are associated with some of these impacts?

MR. HOPKINS: No, we're just starting to get to that, that kind of information. And as a matter of fact we're trying to get some funding together to do an assessment of the climate change impacts to the transportation system, but it's just getting off the ground. It's going to take us, I would probably say, five or more years to get a statewide estimate, a real conclusive. Because I mean we're looking at for example the culverts, the drainage culverts, you know, the pipes underneath the freeways that drain water. You know, we've had to get a better handle in terms of what the rainfall impacts would be, and is our culvert sized right, dimension, diameter to accommodate that additional rainfall.

CHAIRMAN WEISENMILLER: Okay, thank you.

MR. HOPKINS: Uh-huh.

MS. KORESEC: Any questions in the room? Richard?

MR. HOPKINS: Hi.

MR. ASLIN: Hi, Richard Aslin, PG&E. On the topic of common planning assumptions I think that would be a very good thing for all the parties to get together and see if we can come up with some common planning assumptions. The one that I think has been most hard to pin down is in the actual value of GHG reduction in terms of dollars per ton of GHG reduction. I'm just wondering, in your advice to the other parties do you have a figure that you're using at Caltrans?

MR. HOPKINS: No, nothing in that respect, no in terms of the value.

MR. ASLIN: Okay, I think it would be a really good sort of subgroup to get together to see if we could come up with something that was common, because there are so many analyses that use that as a key input. Thanks.

MR. HOPKINS: No, that'd be good, certainly agree to have to work with you on that this year.

CHAIRMAN WEISENMILLER: Okay, thank you.

MS. KORESEC: All right, since we have just a few minutes before lunch I do want to open up the phone lines in case any of our callers have any questions for any of our morning's participants. So Annette, can you open the lines? All right, all your lines are open, do we have any questions for this morning's presenters? All right, hearing none I think it's time for us to break for our lunch. We'll be reconvening at 1:00 o'clock. Thank you very much.

(Off the record at 11:55 a.m.)

(Resume at 1:10 p.m.)

MS. KORESEC: Hi, everyone. Thank you for your patience. We're going to go ahead and get started again with our afternoon panel on Impacts of Climate Change on Energy Supplies starting with Craig Bolger from PG&E.

MR. BOLGER: Thank you. Okay, yeah I'd like to say that a lot of what I'm presenting today is work that has been previously driven by Gary Freeman. So Gary is, I guess he wouldn't be the acting, he's the real principal hydrologist, and acting was the best term I could put on there. But we're here today to present results that we've seen over the years on our data sets on our large system of hydroelectric powerhouses.

And just to give you a quick overview of PG&E's system: we have 68 powerhouses, 110 generating units and that's a total megawatts of 3896 in hydro-generation. We have approximately 2.3 million acre feet of surface water that we manage through that system. And, of course, with that there's a lot of infrastructure that goes along with it: 99 reservoirs, 174 dams, 184 miles of canals, 44 miles of flumes and 135 miles of tunnels, 19 miles of pipe.

There's also a lot of lands that are associated with that, but we have 26 Federal Energy Regulatory Commission licenses and we have 3 projects that are actually unlicensed due to their size. And our system extends from Shasta in the north down to the Kern River around Bakersfield in the south. And we do have one little unit out here in Potter Valley that's on the Eel River.

And you would think with all that it'd be more, but it's only about five percent of the total energy mix for California's energy.

The purpose of this slide is to give you an idea. I want to stress the fact that our hydroelectric system stretches over 500 miles. And in that the elevation is much lower in the north and that elevation increases as you go to the south and there's a lot of geographic and geology changes, which occur over that stretch. To the north we have large aquifer-fed systems, which have a large percentage of ground water. To the south it's mostly stream-fed systems.

And the Feather River, which we're going to focus on a lot today is actually a system that's to the northern end of the Sierra. It's pretty topographically complex. It has a lot of lover elevation large acreage area watersheds and it actually goes through the Sierra Crest and drains, what would really be the considered the east side of the Sierra's with over 1,000 miles of acreage in just that one basin on the East Branch of the Feather River.

And this is our traditional mix of our hydroelectric. You can see that 37 percent of it comes from snowpack, 25 percent is rainfall and then 38 percent of it is actually groundwater or from the aquifers. And by far a huge majority of that is from the Feather River north on the Pit-McCloud and the Feather River systems.

What we're doing here in assessing our hydroelectric system, and the impacts we're seeing, is really to look at our historic data sets. We have large data sets that go back to the early part of this century. And then daily we have a large, operational database, which will take the gauged flow through our projects and we can turn that into unimpaired sub-basin flows. And we forecast our runoff taking that river reach and turning it into smaller sub-basins.

And we take those sub-basins, and I apologize on that third bullet there's probably in your hand-out, it wasn't complete. I noticed that somehow I chopped a chunk of that off. But when we can then go back and look at the smaller sub-basins that were forecast it allows us to look at it from the aspect of elevation topography, whether it's a rain-shadowed basin, and the other factors that would influence why there might be difference in the old data set of runoff that we're seeing in that area.

And before I jump into some of the data and show you I'll tell you what we're seeing from looking at our data sets. Most change has occurred with time, which we would attribute to climate change, on our relatively lower elevation northern Sierra basins. These basins have large surface areas. They're lower in elevation and they are more readily impacted by temperature change, so we do see our greatest changes.

Water year runoff has declined in two of those basins in the upper North Fork. And that would be the sub-basin for Lake Almanor, which is about 500 square miles and then the East Branch and the North Fork of the Feather River, which is about 1,000. And both of those are rain shadowed. They're in a situation where there's a large amount of aerographic lifting, which occurs before the storms move into that part of the basin. We see it rain shadowed and we see the effects of that and we see the effects of temperature on that.

It's interesting to note that other North Fork Feather River basins that are spatially located close you would expect to see a change in those sub-basins too. But we're seeing in those, particularly those ones with strong aerographic cooling, that there's relatively little impact that climate change is having on them other than we do see a little bit of increased runoff in March. And we'll look more at that.

Water runoff, water year total runoff, full natural flow has not changed a lot in those sub-basins. A good example of that would be the Bucks Creek Watershed, just as an example if you're familiar with that.

We're also noticing if we take a look at, particularly those rain-shadowed basins Lake Almanor in the East Branch and North Fork Feather River, we're seeing that the average minimum temperature -- and if you look at the numbers you see here five-six degrees for Lake Almanor basin for January and as much as nine degrees in the East Branch and North Fork Feather River basin. And so that's quite a change and if you look at those lower elevation basins you can see why those amount of temperature changes would have a big impact on them.

There's been a large decline in the aquifer outflow of the springs into Lake Almanor, which I will show you that.

And we also, in looking at the North Fork

Feather River snowpack, a lot of those snow courses aren't as high as you would see in the southern Sierras. They're basically lower, with the exception of the Lower Lassen Peak course, which has no shown any decrease, but the others show April 1 total snowpack as decreasing with time.

So let's jump right in on this particular slide. This is a 30-year moving average of the east branch of the North Fork Feather River. And this is the April through June mean run-off. And what is really interesting to note on that is you can see the trend from -- I almost have to take these glasses off to see this -- from 1964 through 2012. And you can see that we're seeing a very large decrease of almost 40 percent in the 30-year mean average. This, keep in mind here, is April through June.

If we take the same analysis and apply it to what we're seeing in the month of March, you see quite a bit of a increase in run-off with time, into the month of March, nearly a 40,000 acre-feet increase since 1964.

So what causes that? I spoke earlier about the temperature changes in the east branch and the Almanor Basin. This year gives you an example of how much the temperature has changed in two successive 34-

year periods, but this isn't -- I gave you higher numbers earlier, because that was all days in January. But if we just look at the days when precipitation is falling in the Almanor Basin you can see that January actually is now 2.3 degrees warmer than is was in the period '43 to '76.

What that does of course, is it's going to give you on average you're going to see a higher concentration of rainfall or precipitation is going to come in the form of liquid rather than solid precipitation. And what you also see from the higher temperatures in January in general, and into March you're going to see more runoff and melt occurring that you would have seen in those previous years just due to the temperature increase in those basins.

We also took a look, I mentioned earlier that the aquifer inflow to Almanor has also changed with time. These are three successive equal length 29-year periods where we extrapolated the low flows in August and September to determine what the base flows would be. And this would be the annual average for '23 to '51 period, the '52 to '80 and then the '81 to 2009. You can see that there's been a 36 percent decrease in the actual aquifer outflow.

This slide probably goes somewhere I don't really want to go, but Gary produced this. And I think it’s a very good slide, yet I'm not quite sure I totally understand what its showing. But what Gary has done is he's taken the 30-year moving average for both the Canyon Dam precipitation and the Lake Almanor unimpaired natural flow for the 30-year period. And he's superimposed them, got the scale to where it superimposes.

And you can see that it does track and it tracks right out of that very dry period that we had in the first part of the century. But you can see that after about 1987 or so there is a big difference in the tracking and what changes there. And Gary feels that you might also be seeing the big effects of less logging practices, decreased logging and seeing the effects of more evapotranspiration taking place in the watershed.

It's just something that we should look at more and if there is another way to really try and quantify that.

This slide goes along with what Dan spoke of earlier about there being more variability in recent years. If you look at the period 1935 through 1975, and you look at dry years of the total unimpaired flow on the North Fork of Feather River at Pulga, those years below 1.2 million acre feet are classed as a dry year. And in that period from '35 to '74, there was one that met that criteria and since '76, there have been 11.

But if you look at the total difference, up here on this little section right there, the difference there is really little more than ten percent in those two time periods. And the amount of variability you see in the dryness isn't there, so I think if we had another slide we need to produce the same thing to show the wet years. And I think you're going to see a significant increase in the '76 to 2010 period also, on wet years. And that would explain and that fits right in with the variability that you would expect to be seeing.

In this particular slide we looked at '42 to '76 as one period. We're looking at the monthly average unimpaired flow for each month. And if you look at the period '76 to 2001 you see a big shift from the April-May-June. You see that the runoff in those periods, in those months, has decreased their percentage of the total water year runoff. And if you look at February and March, you see a big increase in runoff earlier in the year.

Now this is for the North Fork and the

Feather River and we focused on the North Fork. But if we take that one step further and look at really the same analysis to look at the percent change of every other watershed that we have, and you look there at the 4.4 percent, that is the Feather where we've said we see the biggest impact. But you see a marked change as you go from north to south in all of the watersheds that you're seeing more runoff in the month of March, in recent years. And that begs the questions then if we're seeing more runoff in March what's happening with the entire water year?

So from north to south this is the -- just to summary it, south of the Yuba the water year runoff has increased for the most recent 35-year period. You can see that it crosses there and it looks like everything to the Yuba River, everything to the Yuba River north has had a decrease in overall runoff while the southern Sierras, the southern portion of the state -- actually it's not that far south, it’s the American south, has had an increase in overall runoff for the water years.

And if you think about it when we talked about the large sub-basins or the large basins like we're seeing on the Feather River that are large and sprawling lower in elevation, and you throw climate change on top of that, if you go to the higher elevations where there's less surface area per change in elevation it only makes sense that you have a warmer atmosphere that can hold more moisture. You're going to see an increased rainfall.

And I recognize that this is hard to see and maybe you can see it in the handouts. What we did is we took the April through June runoff periods, and that change that we saw from the two time-step periods, we extrapolated that out. That slide that we made earlier was done in 2009. So if we extrapolate that out going forward, this is our prediction based on the current rate of change we see in the April through June run-off, which sub-basins and what kind of decrease we're going to see going forward. Now, that's a straight trend line from historic record, which really just takes the history of what we've seen and what we see happening in our data and what we see in the physical parameters going forward.

It just imposes what we believe we've seen from climate change now and how we think it will impact us going forward, so these are the conclusions we've come up with. As we said, we're seeing climate change having its biggest impact on our Northern California watersheds. I mentioned the Feather River. The Pit in McCloud, if you'll notice from those previous slides, didn't show as much a decline. And we have more work to do there on those, but we're not seeing the percent aquifer decline that they have either. They are primarily very large aquifer-fed systems, the Pit River and McCloud and the Fall River systems. And that mechanism, still we need to do more work to understand the entire mechanism as to how those progress, but we feel that what will impact them in climate changes they have relatively low elevation sub-basins also.

And we feel that if you see more precipitation falling as rain it runs off without the opportunity to percolate and recharge those aquifers. And we think you'll begin to see them there too. It's just they're much bigger in scale from their contribution compared to what we see at the Lake Almanor.

March runoff has increased for all water sheds. Adaptation is an important management planning tool. Based on the information we see, particularly where Almanor being one case and other places where we have reservoirs, we're typically holding higher on our reservoirs recognizing that we're getting more of that runoff early. Holding it, which works fine if you're doing it from a generation standpoint, but when you get into flood control that's a whole other issue and fortunately we don't have to address that.

Water year runoff has increased in the recent 35-year period for water shed south of the Yuba. And as I shared if that current rate continues we don't think that we will see impacts to our overall hydro-generation portfolio for the next 12 to 15 years. But however we think if that trend line plays true and we think if variability continues in same manner it is, higher flows, higher precipitation, bigger drier dries, there's going to be impacts that we can't yet quantify. So we feel pretty safe that in the next 12 to 13 years, overall hydro-production will be about the same.

I already addressed the aquifer outflow issues. March runoff is currently greatest in the Feather. We talked about the minimum air temperatures and how they're impacting the aerographically challenged sub-basins. Recent years, as I showed, increased the number of dry years in North Fork to the Feather River has increased quite a bit. And we're going to continue to monitor and track, particularly looking at these small challenged sub-basins. So, that's it.

CHAIRMAN WEISENMILLER: Thank you, a couple questions. First, at one stage I always thought of the PG&E hydro system as roughly one-third pondage and twothirds run of the river and more from an energy perspective. So part of the question is how do these trends affect at least the mix of run-of-the-river pondage?

MR. BOLGER: Well, of course pondage gives you more flexibility. And you're obviously -- when I speak of a basin that's going to get runoff in March hey I can still capture that runoff in March and utilize it. We do see a problem though on our run-of-the-river-type locations. A lot of what comes in March, an increase there can equate to spills and not generation, because you can't utilize it.

CHAIRMAN WEISENMILLER: Right, other question is sort of also think of the PG&E hydro system in terms of not only expected value, but adverse hydro and high hydro. So do you see the variability in, you know, decreasing the adverse and increasing the high or how do you see the distribution?

MR. BOLGER: In what terms are you using adverse and high?

CHAIRMAN WEISENMILLER: Sort of low energy production, so maybe your worst hydro year or among the worst for an adverse planning purpose. And then high hydro obviously is again sort of something where you try to capture the value. But presumably the planning is done on an average and at least adverse side.

MR. BOLGER: Well and that's where you try and be a little bit adaptive in your philosophy and move away from a more of a statistically-based model and move towards of a more deterministic type whether it's in a modeling or in your operations and knowing that going into it. I'm not sure if I answered your question though.

CHAIRMAN WEISENMILLER: Yeah, it's just is the worst going to be worse or is it going to be no change in them?

MR. BOLGER: Yeah probably, probably. I think if you see very dry years we know how those have impacted, you end up with less generation. The one thing that we have as a saving grace is that we do have those large aquifer-fed systems. So in those dry years the percentage that they produce is actually very high up on the Pit and McCloud. So unless we start seeing what we say that we think that the aquifers get challenged as climate change continues, we'll still see good, underground storage being utilized during those dry years.

COMMISSIONER DOUGLAS: So I have one question and I didn't see it directed in your presentation, so you may or may not be able to answer it. But one of the constraints on operation of hydro systems is management for endangered species protection, for example, and ecological systems. And so my question is what kind of work has been done to look at how the changes that we are seeing and projecting in rainfall, for example in these river systems, how might they impact ecological functioning? And might there be some additional constraints or even opportunities, I don't know, that could affect -- or I think more likely constraints that could affect how flexibly these systems are operated?

MR. BOLGER: You know, I think probably the best way I can answer that question is if I look at what's going into our relicensing processes and you see much more now as we're relicensing. We're trying to, in our in-stream flow releases for aquatics and biology, we are trying to mimic more the natural hydrograph and do things like that. And I think that's where you see. You look at past practices and you look at insights going forward.

I don't know if it's specifically that I can say that I know we've had opportunities where we're saying how are we addressing climate change in this license? But I think the fact that they're trying to put more flexibility and more variation in those in-stream flow releases will help do that.

COMMISSIONER DOUGLAS: Thanks. That's helpful, because as I try to think about how we need to think about the hydroelectric system and how it may change going forward, it seems like there are some changes that might just be brought about by different perspectives on how these systems should operate that are coming out in today's relicensing proceedings, for example. And in addition there's climate change, which has some physical changes.

And in addition to that there are certainly ecological changes that the climate change could precipitate that may impact operations themselves. And I don't really have a good sense of whether all of those shifts are going in one direction or whether, you know -- and what impact they likely would have.

MR. BOLGER: Yeah, you know, just comment on that having been doing this for 30 years, and coming in with licenses back then that were 25 years old and that have been renewed. And I look at the licenses that we have now and the adaptive management that's been incorporated into those, the ecological review committees, which continue to look at the results of the license implementation there's actually a lot of good changes that are going on there. There's a lot more modification and thought goes into those licenses.

MS. KORESEC: Any questions from the audience? All right thank you, I think we'll move on, thank you. Oh, sorry.

MR. CAYAN: Boy, she is fast on the trigger. Interesting talk, I wondered how confidently you feel about the temperature records you showed?

The reason I'm asking this question, we've had I would say a real challenge establishing what the historical change and variability is in Sierra temperatures. There's a lot of instrumental problems in mountain stations and the amount of temperature rise you're seeing is really impressive. It seems to correspond to the changes in the runoff fractions and snow declines and so forth, but do you have any idea what the uncertainty is? I'm Dan MR. CAYAN:, I'm UCSD Scripps and USGS.

MR. BOLGER: The particular gage that was used there, I have to go back and see what was used on the east branch, but the particular slide which showed the Lake Almanor basin I believe that was based at our Canyon Dam gage, which has been a manually-operated gage daily read. So from an instrumentation standpoint we had good mercury old-thermometer information. So it's probably about as solid as I would think.

Now, are there systematic errors imposed in the newer period of record? I would have to look, but I think they're still manual there also even though I know the current information is coming in through the CDEC system. So it's a very good question. I'll chat with Gary about it.

MR. CAYAN: Yeah, I guess the other thing I wondered was the north-south change that you saw in the total annual runoff if I got it right, declined in the north which transitioned actually quite rapidly to an increase in runoff. Does that mimic precipitation or is this hydrology that is doing something other than the spatial gradient in precipt?

MR. BOLGER: And I don't have the temperature slide in there and that would be a good one to look at. I actually thought of that today, that that would be a good question that someone might ask.

MR. CAYAN: All right, well we can talk about it --

MR. BOLGER: But I believe that is what we're seeing. We're not seeing an appreciable decrease in precipitation as you go south in chatting with Gary and with the other forecasters we have out there.

MR. CAYAN: Yeah, I guess the question would be is there a decrease to the north that would (inaudible) --

MR. BOLGER: Yes, there is I can tell you, in the Feather River Basin.

MR. CAYAN: Okay.

MR. BOLGER: Yes.

MS. KORESEC: All right. We're moving on now. The next presentation is Gregory Biging and John Radke.

MR. BIGING: Okay, thanks.

MS. KORESEC: Sure.

MR. BIGING: Commissioners and public, fellow researchers, this was our initial title but when we thought about it further we thought this was more characteristic. And of course about 30 minutes ago we might want to remove the term "just gas", but we might add "Gas and Liquid in Pipelines."

So we're looking at pipelines, specifically transmission pipelines that come from the National Pipeline Mapping System. This system has both natural gas pipelines and it also has hazardous liquid pipelines as well. And these are pipelines used for gathering, transmission and distribution. And their size varies and the pressure of the product varies, etcetera.

And I appreciate that Dan mentioned this morning that we might hear about transportation, but that was our last talk. And although we could talk about transportation failures, but we thought we'd move on and look at the gas infrastructure and the pipeline infrastructure. Now, I want to thank Dan and David and Joshua. It's always good to have the mornings scare us. And every time I hear them talk it gets scarier and scarier. And that's why I have a cabin in Canada, next to Lake Superior just in case I need to get out of town for those very warm days.

The arrow is pointing to an actual truck. It’s a Department of Water Resource truck driving along a levy on Sherman Island underneath Highway 160, the bridge. And the truck is being overtopped by a storm surge. And this isn't one of those "one in 20 years"; this is just an average storm that's happening in the winter. And we heard there was a storm coming, it sounded like it was a good one, and thought we'd go out and take some pictures.

So the point is that global circulation models and Dan and David and Joshua's information hopefully frightened us enough that we do have a crisis. And we have these infrastructure systems. They're technologically aging and you'll find out more about the Delta, how old it's getting. We have natural disasters human-caused, we have malfunctions along with global change. And we want to thank Dan and others, his research team, for running some models. And we chose to look at 1.4, which I think is reasonable. But I noticed a slide up there this morning, 1.41 and so maybe we might want to change that. Taking from what Dan and others have done, that they're becoming more frequent, we heard that this morning as well. More frequent as sea level rises and it turns out that it doesn't take a huge storm event to have the same impact as we move further into this century, because of sea-level rise.

And so what we're interested in is modeling the coastline and modeling the impact, the inundation, and getting it as exact as we can. And trying to understand what the impact on the pipeline infrastructure system is. Almost a year and a half ago we talked about what the impact on the transportation infrastructure was. And we thought we would move on to something that is a little more dangerous, I think.

And we start off with some surface models and what we've done is we've managed to acquire lighter data for a lot of areas. And we build from that both the digital elevation model, which is pretty common and then a digital surface model. This data is gathered by aircraft, a number of different flights by a number of different government agencies and we've been stitching them together. And this is the last pulse, so that's the elevation model. And we add to that the surface model, because we found that we can build a more accurate model of how land might be inundated by including those two get two together. And the first pulse is that which the LIDAR hits first or the tops of trees, the tops of buildings, etcetera.

We have coverage from along the coast of California, and thanks to the NOAA we've managed to gather all that data. And we've been in the process of -- I want to point out we're just at the beginning stages of this research and we've been verifying that data. And I read a piece of email this morning from one of the graduate students and we're verifying that data with other data bases to make sure that it's quite accurate. We also have the Bay Area and we also have the Delta. And we're in the process of processing that data to build surface models.

Now a little bit about the accuracy of these models, because I'm not sure how familiar people here were or are with them, but they're very accurate. And here we have a photograph over top of a levee, a constructed levee of concrete, outside SFO, San

Francisco's airport. And you can see it shows up quite nicely on our model of that area.

The National Pipeline Mapping System, that's where we gathered our pipeline data. And I must say we are in the process of talking to the major pipeline operators to make sure that this data is accurate and up to date. It's supposed to be, but we just want to make sure. They only have to report it once every year.

And the Pipeline Hazardous Materials Safety Administration, they have it updated every December 31st. I think that's when they publish new updates. But they're also updated in March as well, so there's different dates and we're in the process of making sure that we have the latest data. And of course that is handled by Michael Baker Corporation out of Washington or Maryland. And so we go through them to actually get the data.

In the world of pipeline infrastructure it turns out that that database is what you see in this red box. And it wasn't just gas infrastructure, it was also liquid. And the liquid we realized was very dangerous. And in fact if it is compromised, if the pipelines are compromised, it turns out in some cases certainly environmentally more dangerous and could be, actually more dangerous if it ignited, because some of it is jet fuel going to the airports and other forms of liquid fuel.

So this is the database for California and down the left-hand side are just the lists of all the operators. And, of course, the two largest and most important ones are Pacific Gas and Electric, who just gave the last talk, and Southern California Gas Company and those are really the major players. And we've been talking to and having meetings with PG&E making sure that the infrastructure that we have is up to date. And also you'll see later on trying to understand what they're doing and how vulnerable they feel to different kinds of changes and inundation caused by climate change and sea-level rise.

So here's the pipeline infrastructure in the Bay Area. And inside the database there's a number of records, and the ones highlighted in red are the ones that were -- really have in the Bay Area. And there's zooming in on San Francisco Bay and we see that there's actually a jet fuel line going to the airport. It actually goes under the Bay, comes up at the Oakland Airport and then heads up Walnut Creek up to the refinery in Martinez.

And then this is the Sacramento-San Joaquin

Delta and the infrastructure that lies there. And, of course, you see that there are some liquid pipelines through the Delta, but the majority happen to be gas pipelines. And there are some large storage facilities: one at Sherman Island and one at McDonald Island, McDonald Island being the largest. And both those islands are at risk even if there wasn't climate change and sea-level rise, but they are at risk to storm inundation.

On Sherman Island there's just going onto Google Earth and taking a look at the pipeline, it comes up above this slough likely because it was just too risky going underneath it. There would probably be a lot of movement in this area, so they chose to go above. And there's that close-up shot at how large those gas pipelines are.

Inside this database there's typical records. The ones that are just highlighted in red are the ones that occur for every pipeline. There are some other data in that record, but not consistent enough. Those are the records that are consistent and likely the ones that are necessary. In any kind of database, some records are required and other ones are optional. So as we look through the database for all of California those are the ones we found were completed for each record, each pipeline.

So on to the inundation, because we're going to then model how do these given climate change, given sea-level rise, given these storms as they increase how might they inundate the land and what is at risk? The idea is if they do and they start to permanently occupy the land then we have pipeline with saltwater lying on top of it. Or even just water lying on top of it, because we learned recently that water, a lot of water over a long period of time on top of the surface, no one really knows how that might impact the pipes underneath. Not just corrosion, but also causing some damage to the pipeline itself, because no one anticipated that much weight being on the land.

The reason why we talked about both the digital elevation model and the digital surface model is if we just used the digital elevation model and we inundate, using a bathtub model, just filling up the bathtub, the one on the left shows a lot of land inundated. But it turns out if we use the digital surface model there are things that act as natural breaks, railway tracks. And so they actually act as a levee, a natural levee, or even a manmade or human-made levee to hold back some of the water.

So it turns out in this one area where we modeled, the bathtub approach is on the left, the pathway approach is on the right, shows that there is a lot of land that would be behind some sort of levee that wouldn't be impacted. So this is actually a good thing. The model becomes a little more accurate.

We used this equation; peak water level was equal to the sea-level rise plus the 100 year flood. We ran through four scenarios and we've done that in the Bay Area and we're doing that in the Delta and we'll do that up the coast. And this is just an example of that rise, the blue being the lower sea-level rise all the way through yellow and the orange or the red being the 1.4 meter rise at 2100, predicted at year 2100, with the 100-year storm event. Now the 100 year storm event, if you go back and to one of -- if I went back and showed you it's going to start to occur more often, more frequently, because of sea-level rise. So the same impact we're going to get happening eventually year after year. And that's why you want to model.

Katrina was probably the 100-year event and we're still trying to recover from that and it's been almost over a decade. And so if this happens every year we can't recover, so there's some infrastructure if it gets inundated, we have to consider moving, not trying to armor. Right now the process is armoring some of the levees in the Delta and there's a debate, an ongoing debate whether that's an effective use of dollars. Here we have the sea-level rise for the Bay Area, so that's complete.

Now let me go -- that was one inundation where you move in a pathway. Let's go to this other inundation, it’s the Delta. And it has different dynamics. So if we look at the Delta we've got the picture of, I don't know, Sir Francis Drake showing up with the boat and going up the Delta. And then of course, there was going back as the late 1800s trying to permanently create islands. The islands would occur on the Delta, but they'd move around year after year as the water meandered through. And in fact, they would enrich the land. So they'd flood and the land would be enriched and it was a great place to grow things.

So farmers got hold of that, but they wanted to stabilize the property. They didn't like the idea of being flooded and moving around, so they built earthen levees. That's the bad news. They built earthen levees and most of the 1100 miles of Delta, most of them are earthen levees. In fact, there's rumors of X-raying some of them and old tractors being just pushed in and become part of the levee.

So what happened if you look at this slide in the 1900's we start pumping out the water. And we get to 2000 and we pump out the water every night. Actually, on Sherman Island five pumps operate every night to pump out the water. And there are areas of Sherman Island that are minus 24 feet below the Sacramento and San Joaquin River.

And I really delight in taking my students out there and driving over the bridge and descending down onto the island. And when you do that, you have no sense that you're below the water level. I just love to do this, city kids, and driving up on the levee. And then I turn around quickly and look at the back of the van and I see the horror on their face to realize that we've been driving around 24-feet below water level. So the island's getting worse, because we have all kinds of chemical reactions and the land has dried out completely. And if it floods, if there's a levee failure, that's what happens.

Well, unlike New Orleans with the levee failure -- and here's just some of the information we know about the levees, we know about their heights through the LIDAR. We have some organic material, because they have been tested and we have under-seepage continuing to happen. So we have this dynamic environment, which in fact we used earthen levees to hold back the water. And here's what it looks like and those poles should be straight, but they're not. And you see the water and you see the sheep, they haven't got a clue that they're about 20-feet below water level at this point. That's highway 160 on the right.

So if there is a breach, if there is an overtopping, the levee fails. And unlike New Orleans, where they actually put barges in, the Department of Water Resources if it's too dangerous, will not try to stop the lever from flooding. It's too dangerous, so they'll pull back and let the island completely fill up. It takes about three months to pump out an island and that three months of water sitting, depending on the size of the island, water sitting on top of the infrastructure is a very risky thing.

It amplifies, or course, with sea-level rise, storm intensity, seismic activity. And here are just some pictures of past events, some of them caused by storms and some of them just caused by other ways of damaging a levee.

And this is Sherman Island and this is just a bathtub approach to Sherman Island filling up. We actually have run some different models, inundation models on this island, and it floods differently. But of course, you have to break the levee at certain points and but that's what it would look like before they started to fix the levee and pump it out. And you can imagine all the infrastructure underwater.

So pipeline impact, here's the Bay Area, there are the pipelines. There are the different storm surges and colors. And here's a zoom-in of the airport. There we see the jet fuel line coming up to the airport and it will be inundated. And of course, it's inundated and the red lines on the left-hand side are the ones that are inundated, so they become under water, some of them permanently.

And on the right-hand side is just zooming in down near, down around Freemont. And we see that there's 275 kilometers or 171 miles of pipeline that is inundated. But the reason why I zoomed in is, look that other number, 498 segments get inundated. So it's not just the length it's these segments and if you notice there are bits and pieces of the segments. And in between those segments there's long pieces of line, in this case gas line. I have some gas line. So it turns out that we're at more risk. This number of 275 kilometers or 171 miles is a low number, because the pipes that are in between that won't get compromised are still going to be out of commission, if in fact we have a break, or if we have some corrosion that takes place.

So we have our to-do list and this is doing the Delta at a very high resolution. And then doing the coast at a lower resolution just to get a good sense of what's going from San Diego on all the way up to Eureka. And what we've been doing is implementing this process. We've employed this process where we've gone through the literature and then we have these recurring key informant discussions with the operators of both natural gas and hazardous liquids, understanding how they're preparing for climate change, how they're preparing for inundation and what really concerns them.

And we've had some very, very positive discussions with PG&E so far where we've both learned a lot, I think from each other. And it's helped certainly enlighten our research. Some of the things we thought might not be of concern to them turns out were. And some of the things we thought that they should be concerned about, they were not and they're now concerned.

And then our final slide is to determine where the inter-connected critical pipeline infrastructures are impacted, because it turns out that oil and natural gas -- and oil would be those liquids, jet fuels etcetera, diesel fuel -- turns out that there are only two parts of the entire infrastructure. We have transportation, which we actually have modeled before, talked about at one of these events. But it also has to do with electric power, telecomm and water, because all of these are interconnected. And if one breaks it takes down the rest of them much like a domino.

So we're in the process of really finding out and measuring where the gas infrastructure is going to be compromised over the next 90 years. What people are thinking about and what they're doing about it. And also trying to understand how that might have a domino effect on the rest of the infrastructure, so it's always nice to follow Dan and David and Joshua telling us what's likely going to happen. And then, of course, we're pulling up the rear trying to say well if that does happen, what's going to be the impact? Can we foresee it and can we do something about it?

So I really appreciate the people that were planners that were there ahead of me talking about some of the planning issues in Caltrans etcetera, and in PG&E, because planning to me is critical. If we start now, think now, act now we can actually redesign infrastructure. I could go on and on and on about what's going on out in the Delta and I've been there watching them armor plate earthen levees. And some engineers just shake their head and say, "Well, that's actually making it worse."

So I think we have to take our heads out of the bog, so to speak, or out of the silt and take a good look at this. And maybe think of redesigning some of this infrastructure, because if Dan and David and Joshua are correct we could stop burning fuel now and it's still going to happen. We're still going to get sea-level rise. We're still going to these storms and we have to make sure we protect. And I don't think that building higher levees, even if we build them out of concrete, they tried that in New Orleans, is the way to go. I think we really need to rethink.

Now I've showed you some islands, Sherman Island and McDonald Island. Those are two islands that actually where they store a lot of natural gas. And McDonald Island is actually built, so that it can be inundated, but I don't think for a long period of time. And we've actually been discussing that with PG&E on how long can that island be underwater before suddenly the rest of the gas infrastructure in the region is impacted? And if we are impacted, and if it happens in the winter well then, you know, good luck, because gas plays a critical role in generating electricity and also heating our homes. Thank you, questions, yes?

CHAIRMAN WEISENMILLER: Yeah, are there any easy adaptation strategies we can use in this area?

MR. BIGING: Easy?

CHAIRMAN WEISENMILLER: Relatively easy or the easiest?

MR. BIGING: Yeah, I was asked the question down in San Diego how much would it cost to fix the transportation system? And I said it wouldn't cost anything, you mean dollars? It wouldn't cost anything. Politically it's huge, because you'd be making political decisions now, planning and political design, policy and design decisions now that would be fruitful 70-80 years from now.

So that's a tough one. But we need to start thinking about doing this, because if we do it correctly we can start moving some of the maintenance money that we spend on infrastructure now, that is kind of wasted money, and redesign the system so that when we do have to climate change, we do have inundation, its far enough away from the inundated area that we shouldn't have to worry. You know, I take my students out to take a look at some housing developments that are planned and approved and they just shake their heads, because it's just insanity. People putting money into areas that are going to inundated.

And so I think the short term solution is come up with a good plan, have a good long-term plan, and start using some of the maintenance money to redesign and rebuild our infrastructure. You know, on the transportation I took a look at local roads and as they get impacted and houses get swallowed up by the ocean, should we be concerned? And I'm not a heartless guy, but the answer is, "No, don't be concerned, because as we lose those houses we also lose the services to those houses. And that's okay, because they're sort of gone. We don't need to service them anymore."

We're not doing that with the gas infrastructure, because that would be too complex a model. But I feel the same way that eventually we're going to have some gas infrastructure, not the transmission stuff, but the smaller stuff that will be inundated and they'll just cut it off. And it will become one of those pipelines that no longer has gas or any liquid flowing through it.

But these are the transmission lines and I think we need to do something, these are the main feeder lines to our system, our infrastructure system. And we need to really redesign and rethink how we're distributing that throughout the Delta to the major centers, San Francisco Bay Area and Sacramento. We need to rethink that; move them out of harm's way.

I was over at Delft, and Martine is here, she's a PhD in civil engineering from Delft University, the technical university in the Netherlands. And after giving a talk there I said, "I don't know what it is with you guys. Why after World War II you could have moved uphill and you would have avoided all this," but they love it. They love it down there. They love levees. So anyway, there's no easy solution.

MS. KORESEC: Any questions from the audience, David?

MR. MICHEL: Dave Michel, Energy Commission. After Super Storm Sandy you're seeing some of the utilities like Con Edison investing heavily on the armoring that you just talked about. I think they just spent $400 million, maybe another billion in the next couple of years, to armor some of the issues they had during that storm. And there's probably a tendency to continue that throughout the country, but also take a look at what you've learned that we're not doing. And I think that question is still out there, is the question of what do you armor and what do you not? So I think that so the community really needs to embrace that kind of look at it?

MR. BIGING: Right, so Guido a year and a half ago told me to look at the literature, I should be looking at this literature, pointed me in the right direction. And at the end of it I started realizing that we're doing more here in California to look at climate change and the effects of it than a lot of other places. And I don't know if I was surprised or not, but it's something I did learn that we're actually doing more. And we're looking and we're modeling more. We're more concerned.

We haven't done anything yet. You know, we haven't changed our ways. We haven't changed our ways in burning things either. But going to biofuel is still burning something. It's just coming from another source.

Hurricane Sandy is very interesting. You know, politically what you want to do is you want to fly in there with your helicopter or your stretch government limousine and you want to have a photo op and say, "We're going to rebuild." But there are times when we just shouldn't rebuild. It's ridiculous, especially the infrastructure. If you build the infrastructure then of course, people are going to go in because the infrastructure is there.

And I don't know of a study that has been looked at in inundation in New Jersey and in New York, but that should be done. And it's pretty hard to, especially for someone from California, to talk to a New Yorker. I know, because I'm married to one. And honestly the pizza is not that good there, but and the hockey team is worse. But the point is it's really hard to tell them, but that should be done.

Now I'll share something with you. Howard Foster and I, working on another project, we've designed an information system to help in a disaster. You know, how do you -- because what we realized, what we learned in disasters is that there's either too much information, it's not well synthesized, people are in a panic anyway. The alarm is going off and people don't work very well under panic situations. So in another NSF-funded project, we looked at an information infrastructure that would help solve problems during a disaster.

And then I was invited to New York to see the new center. I mean the old Emergency Center was in the World Trade Center, which was kind of stupid, because the heart or the brain of the beast went out right away. It was gone. So they moved it out to Brooklyn. Now that was a good move, because no one's interested in Brooklyn. But I went out there and I saw what they built. And what they built is wonderful technically, but somewhat dysfunctional, because they didn't solve the people problem.

So I didn't know that the NYPD do not talk to the FDNY. They do sporting events with each other and they turn into pretty tough brawls, but they really don't cooperate. And the emergency people that sit actually between them, in the same center, and they're the -- and after looking at that I said, "How are these people going to solve any disasters?" So that it hasn't worked its way back to planning and I don't know. It's awfully easy politically, to throw rocks on the side of a levee. It makes it look like you've armored it, but some of our engineers argue that rocks on the side of an earthen levee will help the levee be destroyed faster.

MR. SHOW: Well, Andy from ICF will speak to what you just said about the fire departments, the police and all of them talking. So that is happening in California to some small degree.

MR. BIGING: It is, yeah no it is happening in California and probably because we have more disasters, so that beautiful slide Dan had up there of California matters. And I was thinking, "We probably have more disasters more frequently than they do back East." Sandy was -- no, they had Irene and they had Sandy, but for the most part the biggest disasters are financial. And the fire department doesn't get involved in that and the police department doesn't either, too bad.

But we do cooperate, but the best cooperation -- my wife just wrote a book, actually its coming out this week I think or next week, and it's about this very thing, this risk management information systems. And she found the best one was the Olympics in Vancouver was the most impressive system, because it worked and they all cooperated. But that's it. You can design the perfect system, but if they won't cooperate it's just not going to work.

But actually, so Howard and I learned a lesson. And we found that organizations out here do try to cooperate, but we actually also realized that too much information and not well understood information by all in the system, in the very complex system, can be your Achilles heel. You know, so and we will have something coming out that will talk about what we think a better strategy might be so that we don't have organizations clashing, that they actually complement each other. That got off topic, sorry yeah.

MS. KORESEC: We did have one question from one of our online participants, from Andy Brown. "Has the modeling for storm events included midwinter pineapple express events with rain-accelerating snowmelt and runoff and resulting mountains to Delta Bay flooding?"

MR. BIGING: Well, we haven't gotten there yet. We haven't done the modeling yet, but thank you for the question and we'll consider that. No, we actually are looking at storm events with water coming from both directions. And we're finding out an awful lot about how you prepare for or how the utility companies prepare for extreme storm events. And actually they do a lot. They actually prepare, they put the troops in place ready for the worst disaster possible, which is really reassuring.

MS. KORESEC: All right, our next speakers are Todd Esque and Ken Nussear.

MR. ESQUE: Great, let's see here. Right, okay thanks. Okay I've got about ten slides that are going to set up several general concepts about how endangered species, climate change and renewable energy are relevant to this group here today. And then I'm going to turn the podium over to my colleague, Ken Nussear.

You might ask yourselves how is this relevant? How are endangered species relevant to climate change and renewable energy? And I'm really glad I sat through the previous talks, so that I could come up with a reason for that. This is a really good introduction to the aspects of this that are interesting and important to this group.

Endangered species, the most straightforward way to handle this question is that endangered species have to be considered in our planning for our renewable energy infrastructure. So we just heard a lot about planning and how important that is in the infrastructure and how important the infrastructure is. And part of that planning actually is built in with the endangered species and protected species involved, because in order to be in compliance with the laws that we have to protect the environment we have to consider these species in light of the infrastructure.

And just a second please, so as far as compliance goes we have to know about the species in order to know if we're in compliance. And from my experience many of these species are relatively static on the landscape. The information that we have is a static geographic area. When we add climate change to the equation we have to accommodate the movement of these species for the perpetuation of those species across the landscape.

And so bringing all these three together, they're integrally tied so that we're going to show you today how this one species, the Mojave ground squirrel, depends on these factors. I have a variety of people who have worked on this highlighted at the bottom here, people from the University of Nevada, Reno: Thomas Dilts, Peter Weisberg and Marjorie Matocq as well as Phillip Leitner, an independent scientific consultant, and then Rich Inman also from the USGS.

To keep the momentum going I'm going to pass over this, because we have this archived, this talk archived. And all of the agencies have stewardship in the California Desert have contributed information in the way of data about the squirrels and about their habitats and as well as many academicians. So the California Energy Commission asked us to, using the best available information, to develop current and future habitat models for the Mojave ground squirrel, which is one of the state-listed species, state protected species to evaluate gains and losses of habitat and genetic diversity in response to climate change and to evaluate habitat connectivity and all of this in relation to renewable energy.

So the background on this particular species, and then we're going to broaden things out a little bit, is that its listed as a threatened, under the California Endangered Species Act. And then in 2011 it was petitioned for federal listing, but wasn't warranted as a protected species under the federal law. But it is under the state law, so it has to be considered in the environmental compliance for renewable energy projects.

It has a very restricted distribution. It has extensive impacts on the landscape including lots of human development in the West Mojave Desert, direct habitat losses and road construction mortalities. Cumulative impacts to landscape level disturbances, including off-road highway vehicle use, agricultural development out in the West Mojave, and a great number of military operations leading to what's perceived as reduced populations and habitat connectivity of suitable habitat.

So in order to approach this problem of understanding how this species and other endangered species or protected species can be understood in light of what's going on across the landscape, there's an abstraction called Niche modeling. And this concept has been around for about 100 years, developed originally by Joseph Grinnell just about 100 years ago, over at Berkeley. And in this case he was studying the California Thrasher. This photograph is a closely-related species, the Le Conte's Thrasher. And it really boils down to what Grinnell was interested in was how these species can coexist and almost overlapping, but not quite. And having very similar requirements and not essentially running over one another.

And it started out mostly as biological considerations among closely related species. But this concept of niche caught on very rapidly and created a huge amount of research in ecology and was adapted in many different ways, so that we started looking at the relationships among species in how they acquired food, the predators that they had, their other competitors like we already talked about.

And more recently we've added what's considered to be biophysical envelope. So we've taken the biological aspect of all these activities and added aspects or factors like temperature, precipitation and soils creating the biophysical envelope where any species lives. And basically a species has all of its requirements for all of its life stages must be met within this set of factors that is the niche. On top of that we have some of these physical factors are short term, which affect individuals and populations like with weather. And in the long term its climate, so this brings us back around to the longer-term version, which now we'll look at.

The details of the names on this graph here are not so important, but on the X-axis here we have the number of specimens identified in a given site. So each one of these little bars, these polygons here are actually an individual species and its own graph in its own right and on the left margin here we have the carbon dating year before present. So we start at zero, which is present right here, all these different species occurring at a site in relative, different relative abundances. This one relatively rare, this one over there on this side a little bit more common.

And what we can see is through time to the last 20,000 years the relative abundance of these species at one site in the desert. This is near a place called Rock Site in the Armargosa Desert, which is near Death Valley. And so at just this one point, the species have varied in their abundance through time quite a bit. What might be surprising to you is that the three species on the right over here: the Joshua Tree, bursage and the Creosote Bush are really relatively recent arrivals even though we define the Mojave Desert by those three species essentially. Anybody that's talking about what grows in the Mojave Desert is going to use those species to define it. And those have just come here in the last several thousand years.

Also species vary through time dramatically. So looking through a very long time period at the peak of the last ice age, the Joshua tree, our icon of the Mojave Desert was focused down here in Southern Arizona and we know this from fossil record. And then, of course more recently this is the recent, just the current distribution of the Joshua Tree in the Mojave Desert. And so we have great fluctuation of these species through space and time.

This factor, this plate of slides introduces vicariance factors for various species across the desert. And vicariance is a term borrowed from biogeography basically meaning fragmentation. And so there are lots of different factors. It started out with plate tectonics. And so when there was one large landmass where species were distributed across, broke up and moved around, we had fragmentation of the species. And then over time there was speciation and we had different species.

This panel of small graphs here, six graphs, starts out at basically 9 million years before present, than 4, 2, during the middle of the ices age and then 6,000 years ago and then present. And we have different vicariance factors, including in this case the Bouse Embayment, which is this water body that came up through the Colorado River drainage. Also the Transverse Ranges then at about 4 to 2 million years ago rose up creating some basins and some mountain ranges. In this case the Colorado River still left over after the sea level dropped and the Colorado River became more prominent.

During the ice age we had pluvial lakes throughout the Mojave Desert and the great basin that created vicariance events for different species across the landscape. And today we have the Mojave River still somewhat a factor, but not nearly as much as it used to be. Then we moved up to present here.

Well, I'm going to go back to for a second here. So one more part about these graphs is that we start out with these two main boxes on the first graph way back in time, which represents groups of actually vertebrates in this case, that are separated by the

Bouse Embayment. In this case we've got, at that time we had the Joshua Tree, and the moth that's an obligate pollinator over them, and the fringe-toed lizard which lives on the sand dunes on this side of the embayment. And we had another group of them over on this side. Also we have the Mojave ground squirrel and its closest relative, the precursors of the Mojave ground squirrel and the round-tailed ground squirrel living on this side of the Bouse Embayment.

With time these animals moved through, moved across the landscapes and then these vicariance factors separated them through time, isolating them and then ultimately resulting in six different groups of species broke up. So we have the fringe-toed lizard started with a single precursor. In the end there were several species of those lizards based on these vicariance factors.

So that brings us up to present day. And at this point we're looking at a subset of the Mojave Desert here with a lot of the infrastructure for our society imposed upon it with urban areas in purple, proposed sort of developments in red, exit urban areas, former ag lands in yellow, quite a bit of that, proposed wind developments in blue especially over here in the far West Mojave and the major road infrastructure along which many of our pipelines. And then on top of that we have transmission corridors, especially right through this area.

So now we've come up to speed on the infrastructure that's available at the current time. And the question has come up to what extent are these features on the landscape that we've introduced vicariance factors for these species? And how that relates to, as animals respond and when we see all the things that have been explained this morning in the talks about climate change, all these changes happen. In order for species to continue to exist they're going to have to change and follow the physical temperature and rainfall amounts that they need in order to be able to exist on the landscape. They're going to have to follow them across the landscape. Will they be able to follow them in spite of these types of challenges that are on the landscape?

And at a closer view we have things like the utility lines have other factors. From a 15-mile up view it doesn't look like much of a landscape, but when you get down right into it you're on the roadsides underneath the utility corridors. We're seeing that we have trash dumped in these areas, increased access to these areas and which brings in things like subsidized predators, which have been well-identified as a problem for a lot of these species. And so at this point we're pretty sure that there are, we know that are issues related to these with some of these protected species. And at this point we're going to drill down a little bit closer to what this means for the Mojave ground squirrel, which is prominent in the West Mojave.

MR. NUSSEAR: So I just want to talk a little bit about the habitat model. In order to model climate change and its effect on this species relative to environmental factors and renewable energy development we needed to understand its current state of habitats suitability and what drives it. Prior to our work really there were, I think four to five core habitat areas identified and a lot of dots on the map. And that's really what we started the project with.

We've done some habitat modeling for other species before and we thought that a potential habitat model for the Mojave ground squirrel would be a really good place to start. And in this work the initial habitat model was recently published in February in the Endangered Species Research and the citation is there at the bottom. And it involved modeling of the habitat suitability and which is really just in a way, correlations between known locations and environmental factors that we think are important to the species.

And so what that is then is, you know, we sit down with who knows the species and all we know about desert biology. And we say, "Well, we have to have the right temperatures. Do we have the right precipitation, the soils have to be right to grow the plants, which grow food and cover for the animal, whether or not there are predators or disease outbreaks in a given area."

And then we have to consider are we concerned about fluctuations in rainfall or average rainfall? Is it minimum temperature that's important in the winter or is it how hot it gets in the summer? And so we wrestle with a lot of those things and then we have to ask, "Well, what on what time scale does that matter? Is it a daily fluctuation in temperature that's important, is it seasonal rainfall, is it inter-annual drought, is it Decadal El Nino events?" So all these factors have to be considered and we wrestled as a team of six I think on this one quite a bit on getting these right.

And then once we got them all right and we ran out into the Internet to try to get these layers we have find out well half of what we want, to model a species habitat, isn't there. And so a lot of the projects that we start with involve building what we need ourselves and some of those layers are what we used in that. And each of these layers then becomes, we think, something important in and of itself. And what we've done with these layers, and layers associated with our other projects, is to make them available publicly as USGS product on the database and website. So that anyone else that needed a layer like this to model something else could use them. And so those are available now.

So environmental layers when you think about it, are GIS layers. And we stack those up and we do math on them. We do quite a lot of math on them, more than it looks like here. And in the end we want it to be simple, but we want it to model well.

For the ground squirrel we ended up with four layers that we could use to really get a pretty good model for these guys. One of them is the surface texture, which is a model we developed using the remote sensing and the texture of the surface of the sort of the geological surface. We used Surface Albedo, which tells us a little bit about the components of the structure of that surface.

And then we looked at two things that we think were important for current and future climate.

One of them was the mean winter climatic water deficit and what that is, is how much rain went in and how much evapotranspiration went out with plant growth involved and what's left. And then that involves, of course, temperature as well as precipitation. And then precipitation itself was one of the raw valuable variables that came up.

Now we put in a lot of other things. In fact, we ran 80-plus models with all kinds of combinations of more things than I can list. And, you know, the two biggest questions we'd get are, "Well I know elevation's important, because when I go out walking around the Mojave Desert I climb the hillsides and the squirrels are never there." And that's true and it turns out that some people tell you that vegetation's very important, that definitely needs these species of spiny hopsage and whatever else to exist upon it.

And those may well be true as well and we did try those, and in fact elevation is a great thing to model with that. We've seen that in a lot of species. The trouble is if your intent is to consider future climate change, elevation is wrapped so tightly around changes in temperature and precipitation that it's really difficult to unravel what the effect of any of those things alone is. So you probably could get them as good predictors, but they interfere with modeling future climate habitats for a given species. And so we tend to try to build the best model we can without them and ask what does forecast climate change look like? And it turns out if you add these two in, the model doesn't perform any better, so we get a good model with just what we did.

So one of the first things we learned was that the core areas, these are just to give you an orientation on where we're at, how does this work? Button, oh okay so this blue depiction on the map is the predicted Mojave ground squirrel suitability given these four factors. And the one thing we noticed initially was that, you know, these four core areas that were given for this species is really an underrepresentation of the region of the species in the West Mojave Desert.

We got a little more information out of it when we added impact scenarios, so what an impact scenario is, is we take all of the agriculture, all of the known roadways, infrastructure, urban areas and those kinds of things and we put them on the landscape, not completely excluding squirrels, but degrading squirrels differently. So, you know, an open agriculture field may not degrade habitat as much as a parking lot and that's all considered in here.

And when you look at what happens to that landscape after fragmentation you can see that we've got big sort of cuts across this creating sort of these big vicariance potentially, cuts and fragmenting the habitat. And then we do end up with sort of this core area, this core area, this core area and one up here. So in a way the core area idea is naïve, but in a way it's insightful. But I think probably not drawn to scale, right?

So our initial habitat suitability results gave us the idea that presently 16 percent of the historic habitat, which was the panel on the left is impacted or lost to urbanization, which is right now starting out of the gate. In the future just with the renewable energy added to it we may find ten percent more of that area lost. So a total of 26 percent of what we think under current climate conditions could be there is either gone or likely to be gone given the current permitted facilities that are projected to be there.

The model's illustrated that habitat suitability, which is sort of the scale of how suitable a given spot was in higher in areas that are predicted or are sort of slated for renewable energy development then in the surrounding areas. That is some of the better habitat is under the proposed footprint of some of the future projects, especially wind I think in this case. And we think that the information in this suitability model can be used to guide and develop sampling designs for monitoring effects of climate change of renewable energy, of anything that you're putting out there. But not only that to evaluate corridors and potential impacts of climate change and I'm going to step into that piece next.

Ultimately the hope that this can be used to inform development and planning upfront, so that we don't go down a road, take a bunch of habitat and then say, "Oh gosh, we really did the wrong thing. Or we really need to learn from that and now we have a monitoring plan to understand how bad it is." Rather I think if we could think up front about what do these guys tell us, where should we look now and let's be proactive about where we put things, I think is what we'd like to take away from this.

So the future climate scenario came up. There is generally four emission scenarios out there, well there's more now, but when we started there were only four back in the stone age. And these came from the Intergovernmental Panel on Climate Change at IPCC Assessment Report. And we used two of those and we picked the A2 and the B1, because they represent sort of moderately high and pretty low scenarios. So we wanted to bound the problem of how little or how much impact we thought there might be. These were coupled with a GCM and we used the GFDL CM 2.1 to evaluate the potential impacts of climate change for the squirrel. So we used two scenarios, 1 GCM and two time steps. That's a lot of numbers in the end.

So this is just to give an idea of one of the things that we had to do right off the bat. Was in order to model habitat well you kind of have to contain the area to just that surrounding your points, because you get a lot of noise if the farther you reach out the more sort of fluff you put into your model and it gets really noisy. But in order to model climate change well you have to expand your search area out beyond where it is. Otherwise you see it running off the map.

And we did that and so we had to build sort of this in our initial footprint. We had to build another footprint even bigger to get out into areas that we thought would be likely to contain future habitat. And it could be that maybe, you know, we needed some more out here, but we didn't think so. And so that's one potential weakness maybe to the plan or maybe a strength, it remains to be seen.

So the numbers aren't too important here. What's kind of important here is that we did at two time steps in the future. One is 2030 and one is 2080 and these both happen to be for the A2 scenario, which is sort of the moderately aggressive one. And what we found was that by 2030 a lot of our current habitat, which is this white area that we saw before is now recessed back into what's predicted to be habitat here in the green for 2030.

Now there's another kind of thing that happened, which was that we started to see footprints of new habitat occurring, which is given here in blue out on these fringes where these squirrels don't currently exist and are quite far from it actually. And so in 2080 we see that sort of current body of habitat retreat a good bit more up into the sort of the foothills of this mountain range. And then by and large most of the predicted future suitable habitat by 2080's out here where squirrels don't currently exist.

So I think what we see is that given the changes in climate, and this is the case for the other scenario as well, there is a fairly large reduction in the amount of habitat available to the squirrel. And it takes what's a big sort of interacting mass of populations within the area and restricts them to a very narrow corridor running north-south along the left side of the current habitat footprint.

So one of the things we thought about with that future habitat being way out on the east side was could squirrels even get there, you know? So this is 2030, we still have a pretty big body of habitat here. But then we were concerned that all of this stuff out on the east side although predicted to be within the suitable envelope of their capability maybe quite outside their dispersal range.

So we did two things: one of them was a simple dispersal model where we used sort of a displacement that they could do on a given season and then model that out over the number of years there were. And, you know, leaving from where they were could they get across? And so the blue area indicates a very simple dispersal model where they probably could and the red indicates probably not. So even though we have a lot of habitat predicted to be up here we don't think that in the amount of time the squirrels had up until 2030 that they could get there.

This doesn't take into account limitations of habitat due to the fragmentation, because we don't really know the numbers on how that reduces movement. And the other thing it doesn't take into account is that the fact that Death Valley is running right down the middle of all of this, so one of the chapters in our report talks about connectivity and more of a stepping stone model where the squirrels are really limited from habitat patch to habitat patch. And what that analysis shows is that really the left-side corridor of all of this is really going to be the only viable conduit by which squirrels can adjust to these changes in climate.

This chart shows both scenarios for 2030 on the same map, so yellow is the B1 only and the darker sort of red or salmon color is the A2 only and orange is the one that we were interested in. And that is where do A1 and B2 overlap at this time step? And we felt that would be a fairly conservative bit of habitat to worry about, because that's where under either the most optimistic or the most pessimistic climate model we think squirrels are going to be there. And so these orange areas we think are pretty key areas to look at.

We also imposed urban infrastructure, which is these roads. The blue are predicted, proposed solar facilities and the orange -- or I'm sorry, the green color in here are predicted wind facilities also down in here. And then the gray are power line corridors that we talked about. If we zoom in on that important corridor area that I was talking about on the west side if we can back, let's see go back a slide here, that's this area right in here. We can kind of get a better view of the level of impact that we're talking about with respect to some of the wind facilities.

And although the wind facility may allow squirrels to exist underneath and in between we think there's a substantial amount of fragmentation that can occur. Especially when you start adding the transmission corridors and other things going on here, so that the areas that are predicted to be sort of core areas of habitat in the future are pretty well inundated and especially cutting off the northern and southern extents of the predicted suitable habitats, such that that western side of the map could be problematic with respect to connectivity for the species.

So in summary we created a habitat model for current conditions estimating current anthropogenic impacts. We constructed it with the idea that we could enable the inclusion of future climate forecasting to predict future habitat for the species. And then we identified key areas of habitat loss and areas that might be considered to be important for future connectivity. And we think we'd like to hope that this provides information for future planning efforts of utility scale renewable energy development. So that we can sort of run-off future listing problems and future compliance problems with endangered species acts while we're planning, and before decisions are made in the absence of knowledge.

Lastly this is just one species and so we've been working with a consortium of scientists to look at multi-species considerations. And so this particular is just published work that we did with Amy Vandergast and others. And this shows the genetic hotspots or genetic diversity of 17 species across the Mojave. One of them is here. In fact two of the hotspots are here right where the squirrel is in fact there.

And so not only do we find important habitat for the model of the ground squirrel there, but we find areas in the desert that are overlapping these areas that show patterns of key genetic diversity and divergence for multiple species all at once. And so we think that a bigger, broader view of more species than one at a time may give us some reason to stop and think. And one of the things that we're excited about is that the DRECP is actually doing that and they're using the information, this information and other models that they're developing and that we're developing to make decisions about where to place key energy.

So that's the references are at the back if you guys wanted to look up any of the papers that we cite and thanks very much.

COMMISSIONER DOUGLAS: Yeah, I guess I don't have a question, because I did get a pre-briefing on this work. I just wanted to say that I appreciate the presentation. There's obviously a tremendous amount of work that goes into it. And as you point out this is the kind of information that really can form the underpinnings of a planning effort around looking long term and looking at species conservation climate change renewable energy, which we're doing in the DRECP. So anyway, I really found that to be an interesting presentation. I appreciate it.

MR. NUSSEAR: Thank you.

MR. ESQUE: Thank you.

MS. KORESEC: Do we have any questions from the audience? All right, let me get that.

MR. CAYAN: Ken?

Mr. NUSSEAR: Yes?

MR. CAYAN: Dan.

Mr. NUSSEAR: Dan.

MR. CAYAN: So in evaluating the dispersion, dispersal characteristics was this the Flint’s 30-year sort of fixed time climatologies or were you looking at year by year, day by day?

Mr. NUSSEAR: No, no, it was one 30-year time step and then imposing an annual dispersal distance on top of that. We'd like to do a year by year, day by day, but we just don't have the data.

MR. CAYAN: So here's a dumb guy question about dispersion. So I'm reminded of Thor Heyerdahl, who set out to demonstrate that you could go from one side of the Pacific to the other. And the thing about him was that if he was constrained by the mean wind field and currents and so forth, he never would have made it. But what he did was he waited for the right synoptic, you know, or probably El Nino or something or something like that.

So what I'm wondering is whether you would derive the same answer for whether a ground squirrel can get from A to B if you actually had all the variability from one year to the next. My impression from my garden is that there's certain times where I have these invasions and then other times, you know --

Mr. NUSSEAR: Yeah, I think the answer would be different and we would like to spend the time to get there. And we have done some of that more in the connectivity chapter, not with annual predictions of climate change imposed yet. But with infrastructure and things like that modeled in, so we're working on getting there. And we recognize the value of that, we're not there yet. We're working as fast as we can though.

MR. CAYAN: Okay, and not a criticism, I was just trying to understand. So the other question was this very linear distribution of the new settlement or whatever you call it. Is that a hydrologically defined area, is it temperature, is it --

Mr. NUSSEAR: That's all four things put together. We do have some maps that we can do and I don't know, you know. Generally in any given pixel we can ask what's the limiting factor or what's the greatest limiting factor and we have those kinds of analyses that we do in there. And, you know, it could be that the west line has got a different limiting factor than the east line. I suspect that it does and so, you know, any given spot might have a different factor that limits that causes that to be the same shape.

MR. CAYAN: Yeah, it's just so distinct that you would think that there was something relatively similar going on along that line.

Mr. NUSSEAR: Yeah, it could be. I mean, but I think on the eastern slope over near Pahrump, Nevada and on the east side of Death Valley that we see a lot probably of influence of that climactic water deficit. That's a lot flatter habitat and tends to be more open facing slope for evapotranspiration than you would see on the eastern slope of the Sierra like you there. So it's probably different even though I think that they follow the same general route.

MR. CAYAN: Okay.

MS. KORESEC: All right, Joe Weisenmiller. We were originally scheduled to take a break this afternoon, but we're running about 20 minutes behind. It is okay for us to just power on through and have people take a break as they need?

CHAIRMAN WEISENMILLER: Yeah, we'll power on.

MS. KORESEC: Thank you. All right we're going to move on now to our next section, which is on energy sector responses. And our first speaker is John Maulbetsch.

MR. MAULBETSCH: Well as I think Monty Python said, "Now for something completely different."

We did get a pretty good setup this morning.

Somebody said it's always good to follow predictors, people who paint crisis scenarios, but we learned that things are likely to get hotter. And we learned that when things get hot, people tend to want more energy and more electricity. What maybe hasn't been said yet is that when it gets hot, power plants have a harder time. Most power plants have a harder time on hot days with reduced capacity and reduced efficiency. And so what I'd like to talk about for the next few minutes is why is that true and what can be done about it.

The answers depend on first on the type of plant we're talking about. If we're talking about peaker plants with combustion turbines that's one reason, if we're talking about gas-fired steam plants that's another and if we're talking about gas-fired combined cycle plants it’s a combination of the first two in all likelihood. And it depends on the type of cooling system.

The reason power plants have a hard time on hot days is for most of them, related to the fact that cooling systems have a harder time rejecting heat when it's hot out. And if they can't reject the heat, they can't condense the steam coming out of the turbines as well and the back pressure on those turbines increases and the characteristics of steam turbines are such that as the back pressure goes up, the output goes down and the efficiency goes down.

So we can talk about various types of cooling systems. And let's start in the lower right-hand corner, I guess. Once-through cooling systems which in California are mostly ocean-sided plants depend on the temperature of the intake water, and in case of the ocean that's reasonably constant, although it does vary seasonally.

If we're talking about plants with cooling towers where cooling water, instead of being drawn out of something like an ocean, run through the plant and put back at a higher temperature, the water is re-circulated. And it is cooled in the course of that re-circulation by evaporating some of it to cool the rest of it, and the remaining cooled water is circulated back to the steam condensers that's what most -- not most plants in California, but most plants in the United States now operate on either the once-through cooling or the closed cycle cooling towers.

And in the absence of the availability of water for cooling we have been going to dry cooling, where the heat is rejected directly to the air. And there are some of those in California.

The upper left-hand corner we're looking at an air-cooled condenser down at Otay Mesa. And we'll talk in a while about hybrid cooling systems where we have a combination of dry systems and wet systems. And they are used to maximum benefit as the conditions permit. There are none of those in California at the moment. I suggest that there will be.

So if we take those different types of plants and those different types of cooling systems and we put a California focus on it, let's talk about gas-fired plants either combustion turbines alone, as mostly peaker plants or gas-fired combined cycle. And since a major interest of the Commission and the State at large is water conservation let's start out with the use of dry cooling.

Start first about just the gas turbines. The reason gas turbines don't perform as well on hot days is because they are what's referred to as a constant volume flow machine. In other words there's a certain volume of air that gets through the compressor to be combined with the fuel to generate the heat to run the turbine. As the temperature goes up, the density of the air goes down. And so a constant volume of air has less mass that goes with it. So the mass flow of air through the turbine goes down. So air temperature goes up, mass flow goes down. As the mass flow goes down the energy output from the turbine also goes down.

It shows here, if we go from say 50 degrees Fahrenheit, which is 59 degrees I think is the standard design point for these things at around 100 percent turbine output if we get up to 110 degrees, let's drop down to close to 80 percent. So there's a significant reduction.

There's another line on there that suggests ways that that can be counter acted. You can increase the mass flow through the turbine by injecting steam and people do that. It consumes water and it costs money to produce the steam, but it does increase the turbine output at a given inlet temperature. On the other hand it does also decrease for a fixed percentage steam injection, as temperature goes up. S o the effect though at a higher level still remains.

The other thing you can do is say, "Well, the ambient temperature's gone up, maybe we can do something about the temperature of the air that the turbine actually ingests." And so there are schemes for cooling the inlet air to the compressor. A common one of these is so-called inlet spray cooling where high pressure nozzles are arrayed in front of the compressor inlet, water is sprayed in, high pressure, tiny little droplets. Those tiny little droplets evaporate in the air stream, the temperature of the air goes down and so for a constant volume flow the mass flow goes up. There's a little bit of mass associated with the water that was sprayed in. And you can, in effect, move back up to the left along that temperature curve by driving the compressor inlet temperature down below the ambient temperature and increase the output.

You can provide that same effect without spraying water in there with some kind of refrigeration system. You can put an inlet chiller on the front of these turbines, reduce the temperature of the inlet air.

There was an article in the issue of Power Magazine that arrived in my mailbox just a couple of days ago that showed a way of doing this that maybe is widely use. I just hadn't heard of it. In which many of you know there are two kinds of refrigeration systems: one is vapor compression, which is run by a motor and a compressor and the other is absorption refrigeration, which is heat-driven. And this was a scheme where you took heat out of the stack gas, used it to run an absorption refrigeration system, cool the inlet air and drive the turbine output back up.

Okay, so that takes care of the turbines, the combustion turbines. If we combine those with the steam cycle for a combined cycle plant, and these are the common types of new plants that are being built most places in the country these days: gas-fired combined cycle where the gas is burned in a combustion turbine. The hot gas out of the turbine is used to raise steam, put through a steam turbine.

The hot day problems here are compounded. We get the reduced gas turbine output that we just talked about. If the mass flow through the gas turbine goes down then the energy input to the steam turbine, which is extracted from the gas turbine flow, goes down. And if you want to keep the plant output constant, if the combustion turbine output is going down, you try to do something to increase the output from the steam turbine and that puts an additional load on the steam turbine cooling system. And the steam turbine efficiency can go down.

Here's a brief schematic of what I just said where you've got the gas turbine putting hot exhaust into the heat recovery steam generator. High pressure steam is produced, goes down to the steam turbine, run through a turbine, condensed, returned back to the heat recovery steam generator.

Now if you can't keep the combustion turbine inlet temperature down far enough through some sort of inlet cooling you can burn a little extra fuel to heat up the hot gas coming off the gas turbine in what they call a duct burner. And that through the combustion of additional fuel increases the heat into the heat recovery steam generator, produces more high pressure steam and so you shift the load on the plant from the gas turbine to the steam turbine.

If you do that, of course, you increase the amount of steam that has to be condensed. You increase the heat load on the cooling system and now the effect of the hot day is whatever effect it has on the steam condensing cooling system.

If we start with dry cooling, and this is an example of an air-cooled combined cycle plant, that large structure on the left-hand side is the air-cooled condenser. It's interesting that its larger than the rest of the plant. These things are big. You've got to have a lot of surface to transfer a lot of heat to hot air. They work as follows and we're not going to spend a lot of time on how they work, but you need to know something about it in order to see how the various schemes to augment their performance work.

Coming in from the left is steam from the steam turbine. It goes up and through that horizontal red duct at the top. Steam then flows down through those heat exchangers, which are the sloping sides. There are large fans at the bottom that blow air up and across those heat exchangers. And most of those sections, the red ones, the steam comes in at the top, condenses, flows out a pipe at the bottom and back to the boiler.

The blue ones are slightly different portions of the ACC, in which any steam that's not been condensed in the red ones gets pulled over to the blue ones and it brings with it any air that's leaked in. And air is very bad for the performance of these systems and so that blue section is designed to extract non-condensable gasses from the system and condense any remaining steam.

What can you do to increase the performance of that when it gets hot out? Well, we'll talk about a few possibilities. Hybrid cooling in which you add a wet cooling system in parallel with the dry cooling system; spray inlet cooling, where you try to reduce the temperature of the air going into the air cooled condenser; a wet-enhanced dephlegmator. Dephlegmator is the German word for those blue sections that take the non-condensables out of this. I don't know, it sounds like a German heat exchanger designer clearing his throat. I don't know what it means. You can deluge some supplementary cells and then we can talk for a minute about wind effects.

Hybrid cooling, you have the air-cooled condenser, which we just talked about on the right. And on the left you have the possibility that the steam off the turbine can go to condenser, a surface condenser, which is cooled by cold water coming off a cooling tower. And that cold water heated up when the condenser goes back to the cooling tower to be cooled again. It’s a self-balancing system.

When it's hot out -- well, let's start at the other end. When it's cold out all of the steam goes to the air-cooled condenser, because the air is cold enough to handle it all. When it starts to get a little hotter and the pressure at the back end of the turbine gets higher than you want it to be, you turn on the cooling tower and the steam now flows to the coldest place. So it splits. Some of it goes to the surface condenser in the cooling tower. Some of it goes to the air-cooled condenser. And it splits in the proper proportion, so that the condensing pressure in both of those units is the same. And you don't have to do anything to control it. It just happens.

These systems manage to combine the benefits of wet cooling and dry cooling in a way that they take advantage of dry cooling when it's cold out. They use wet cooling when it's hotter out. The largest system in the United States at this point a large 750 megawatt coal plant in Comanche. It’s the Comanche station in Pueblo, Colorado. And you can see in the lower left-hand corner a wet cooling tower with about nine little circular -- I guess I should be using this shouldn't I, how does it work, like that -- a wet cooling tower here, the air-cooled condenser here, steam goes where it wants to go.

The benefit of these systems is that for a 750-megawatt plant if it were just a wet cooling tower that tower would be at least twice as big as it currently is. There is a cooling tower over there of the same size for another unit on the plant and that's only a 350-megawatt plant. If it were only a dry-cooling system on this plant that would be about three times the size that it currently is. So you can end up with a combined system where each element is smaller than it would be if it were used alone. It uses, depending on how you design it, significantly less water than if it were all wet. And it produces significantly better performance on the hot days than if it were all dry.

So that is, I think, sort of the coming trend in water conserving gas-fired combined cycle plants. And if you don't want to do that, you want to just have dry cooling and use a little bit of water, you can spray some water into the inlet air stream just as we talked about on the inlet to the turbine in a gas turbine situation. That's been investigated. There have been some projects sponsored by the Commission: one out at Crockett here halfway to San Francisco, one at a plant down in Southern Nevada.

And for a few percent, a small percentage of the amount of water used for an all wet system, you can enhance the performance of these air-cooled condensers on hot days substantially. Not as much as you can with the wet cooler and hybrid system. And the use of the water is not as efficient. Some of that water doesn't actually evaporate and cool the water. Some of it splashes onto the fan shroud and drips to the ground, but it’s a very low cost system. It's easy to install. You can retrofit it onto existing plants and it'll get you through the hottest days of the summer.

This is just some data taken on one of those projects that suggests that at this point we know how to predict pretty well how much you have to spray, under what ambient conditions, in order to get a given temperature reduction in the inlet air. And that based on data from those two projects correlates pretty well and it’s a system that we know how to design and build.

There is another system that again was looked at and studied under a Commission project. And that's the wet-enhanced dephlegmator. And here you modify the design of it slightly and you spray it up near the top. And you can get significant increases in performance not only of the dephlegmator section, but of the entire ACC with a modest amount of water. This shows for example, as the ambient temperature changes from up to 40-degrees centigrade of the -- I'm sorry, where do we go here? Yes, this the dark triangle there is the performance at hot weather of the water-enhanced dephlegmator system compared to a system where you would put in 30 percent more cells on a standard ACC. Without modification to the ACC you get a significant drop-off of about 20 megawatts in the output with either the cost of expanding it by 30 percent or enhancing the dephlegmator section you appear to get about the same performance.

That needs to be tested at a large pilot or full-scale and we look for volunteers.

All of this is affected by wind and in some parts of the world, in hot desert-y parts of the world, very often the hottest days are accompanied by high winds. This is data from a plant through the summer, which shows the pressure at the exit to the turbine versus ambient temperature with wind speed as a parameter. And so the lower line is zero wind up to just a few miles per hour. And the top line is wind speeds up to 20 miles per hour. And so you can see it's 100 degrees Fahrenheit, we're getting almost to two inches of Mercury back pressure increase, because of the wind and that can be a 10 to 15 percent reduction in the output of the steam turbine.

We're looking at ways to suppress the effects of wind. And two or three studies have been sponsored by the Commission on that subject. Here you see the wind breaks, wind screens placed underneath the thing. There are porous fabrics. They tend to kill the gusts of wind and reduce the cross-flow velocity underneath the fans and keep the air flow up to the fans.

There's a current project underway again under Commission sponsorship, to try to come up with a sort of general set of guidelines for how to place and how to design those wind screens. It's being done at the Caithness Plant, which is actually on Long Island in New York. But it was chosen for one simple reason, the screens that are on that plant are retractable. And when you're trying to measure the effect of screens on wind effects it's nice to measure it with the screens and without the screens. And all those plants that have permanently installed wind screens are surprising reluctant to let you take the screens down as part of your research project, because it’s a multi-week, multi-million dollar issues. But these you push a button and the screens go up. You can get the no-screen data, you push a button the other way and they can come down.

So that work is going to go on for the next year or so and we hope at the end of it to be able to tell people what kind of screens to put up, where to place them and how much benefit they'll get from it.

So the question that is posed to me is, "What do you do about getting more energy on hot days?" And you can use a little bit of water to enhance the output from gas turbines or to reduce the back-pressure on steam turbines. You can use that with inlet sprays. You can use it to enhance some portions of the air cooled condenser. You can actually spray more and actually deluge some of the things. And you can put up wind screens.

And all of these things cost a little bit of water and a little bit of money, but if you want more electricity on hot days there are ways to design the plant, there are ways to retrofit existing plants that'll do that for you.

There is I stuck two slides right at the end, and I don’t know how I'm going to doing on time, but just one more. There was report written three or four years ago called "The Cost and Value of Water Use at Combined Cycle Power Plants" and it looked at the various ways that water is used in a plant. And what happened to you if you didn't have it to use, what happened to you if you replaced the water-using components with wet stuff. And how much it costs and how much it increased or reduced the output from the plant.

And it covers most of the things that we just talked about and it’s a report that's a few years old, now but it's on the Commission website and it contains a lot of, I think valuable information that those of you that are interested in reading more about it can find, okay.

CHAIRMAN WEISENMILLER: Thank you. We are running a little late, but just one question. You talked a lot about gas-power plants and I just wanted to clarify, obviously we're doing this sort of thermal, we're doing a lot of other thermal power plants, which certainly require we watch the cooling. And so how much of these techniques could be applied to things other than gas-fired, but again thermal plants?

MR. MAULBETSCH: Virtually all of them could be applied to the other thermal plants. Any plant that generates power by running steam through a steam turbine whether it’s: a solar thermal or gas-fired, gas-fired combined, nuclear, coal. I guess you're not very interested in coal, all of these techniques.

CHAIRMAN WEISENMILLER: Yeah, no that's good. I mean, we tend to think of this a lot as a unique issue for gas plants. My presumption is it's any sort of thermal, any thermal plant has the same thermal efficiency loss.

MR. MAULBETSCH: Any steam thermal plant.

CHAIRMAN WEISENMILLER: Okay, thank you.

MR. MAULBETSCH: Yes, you're welcome.

MS. KORESEC: All right, in the interests of time we're going to move on. If you have questions for John I encourage you to contact him. Our next speaker is Gretchen Hardison from LADWP.

MS. HARDISON: Good afternoon. I'm Gretchen Hardison with the Los Angeles Department of Water and Power and I am in the Energy Efficiency Division of the DWP. I'm here today speaking on behalf Beth Gines who's the Director of Strategic Initiatives at DWP.

Just want to spend a few minutes this afternoon talking about some of the work that we've been doing at DWP and the City of Los Angeles, with respect to climate change: both mitigation and adaptation.

First I'll give you very quick background on the Department, review some of the city's past work on climate change, and spend the bulk of the time talking about two studies that we have done recently. The climate change temperature study done out of UCLA and a sea-level rise vulnerability study done out of the University of Southern California Sea Grant Program there. And finally I'll talk about a few initiatives at the DWP that are contributing to our mitigation efforts in the city and helping us adapt to our future climate.

The Department of Water and Power in Los Angeles is the largest municipal utility in the nation serving a population of 4 million within our 465 square miles in the City of Los Angeles. We have about 1.4 million electrical customers in distribution you see there: residential, commercial and industrial. And also about 657,000 water connections. DWP is a proprietary department of the City of Los Angeles wholly owned by the City of L.A. We have our own board of commissioners and an independent revenue stream.

As you can see the city's been involved in climate activities for many, many years. We've done municipal greenhouse gas inventories for 1990, the years 2004 through 2007, a high level community inventory, greenhouse gas inventory. The city and LADWP, both independently joined the California Climate Action Registry as charter members a way long time ago.

In May of 2007 Mayor Antonio Villaraigosa released the city's climate action plan entitled "Green LA: An Action Plan to Lead the Nation in Fighting Global Warming" and that set forth a goal to reduce greenhouse gas emissions to 35 percent below 1990 levels by the year 2020. The following year the city released Climate LA, which is our implementation plan guiding actions of various city departments to achieve the goal set out in the Green LA plan. And as you can well imagine as the electricity provider for all of the city's infrastructure and operations DWP really plays a major role in that.

One of the critical elements shared both between the Green LA and the Climate LA plans are the discussion of co-benefits. We took advantage of a number of environmental programs that were ongoing or planned and identified the greenhouse gas emission reductions that we can achieve from those, so that again we're combining efforts and leveraging those ongoing efforts rather than having to start a whole new regime.

In 2009-2010 our efforts expanded to include adaptation and key climate staff began discussing, with a number of community stakeholders, what types of issues we needed to look at in the City of L.A. We have a number of stakeholders as you might well imagine and a number of working groups going on at various times. We developed city department working groups to contribute information on city operations, how many vehicles we have, how much fuel we're using of various types.

We've developed with the County of Los Angeles the Los Angeles Regional Collaborative for Climate Action and Sustainability. And this group has really served as -- it's a network of organizations, local to Los Angeles County designed to encourage greater cooperation and coordination between local governments, business, academia, community groups etcetera. And this has really helped us broaden the conversation. They have helped attract new stakeholders. They hold discussion groups for us to really spread the word and help us at the city and DWP hear what the concerns are in our community.

We have partnerships that we've developed with a number of universities, but primarily UCLA and USC. And I'll be talking about the work that they've been doing.

So this is the first installment of the climate change project being done by a UCLA team led by Dr. Alex Hall, who's an atmospheric scientist at UCLA, and a member of the Institute of the Environment and Sustainability there. This first portion of the study is the study of temperature that he has titled "Mid-Century Warming in the Los Angeles Region".

The City of Los Angeles was lucky enough to have some energy efficiency and conservation block grant funding through the ARRA Stimulus Program. And we were able to retain Dr. Hall and his team to spend a great deal of time downscaling global climate models to the Los Angeles region. The models were downscaled from 200-kilometer grids down to a 2-kilometer grid covering an area somewhat bigger than the County of Los Angeles.

The downscaling incorporated the local topography and coastline information, so that it can give us more detailed information on the temperature changes expected along the coast, in the Los Angeles basin, in our local mountains, valleys and the deserts of Palmdale, Lancaster area. The model has been validated and Dr. Hall is now using that to develop future climate scenarios. Again, the first installment of this is his temperature study. And what he did was use a 1981 through 2000 as our baseline scenario and compared that to other scenarios 2041 through 2060, a mid-century scenario, and then what I don't have on the slide is an end-of-century scenario for 2081 through 2100.

The modeling and statistical analysis produce and ensemble mean warming scenario. And forgive me, but I'm giving the layperson version of these. And this is deemed to be the most likely warming impacts that we'll be seeing in the Los Angeles region. And though the average warming over the entire region is about 4 and a 1/2 degrees Fahrenheit at a 95 percent confidence level, that the warming will lie between 1.7 and 7.5 degrees Fahrenheit, there's quite a bit of variation between the coastal and inland areas that you'll see in just a moment.

But the coastal and central locations in the Los Angeles basin to downtown areas are expected to see about two to three times the number of extremely hot days, which are identified as days with over 95 degrees. And the higher elevations, including the mountains and the deserts and the San Fernando Valley are looking to see about three to five times the number of hot days. This is a slide I apologize, it's rather small. But it gives you a little flavor of the temperature gradients from the cost to the inland areas.

And this you can see a little more clearly. The graph on the left shows our baseline conditions from 1981 through 2000. This is the temperature profile. And then on the right is a business as usual scenarios through the most extreme scenarios that Dr. Hall looked at. And you can see that the areas along the coast have narrowed considerably where we will have only maybe three to six additional days of extreme heat per year.

You probably can't see on the slides, but there's a small image outline of the City of Los Angeles. And down at the knob at the coast there you can see the port areas will be expecting ten, twelve, fifteen additional days of extreme heat, but the San Fernando Valley is looking at thirty to forty additional days with no mitigation beyond that, that had occurred in 2000.

Dr. Hall also modeled a mitigation scenario which looked at fairly aggressive mitigations. And even in that scenario we would still be seeing two to three times the current levels of extreme heat. Dr. Hall also gave a presentation down at UCLA just last Friday, and he did release some preliminary results for other climate criteria that he's studying, so I'd like to just highlight those.

Another issue that he's looking at is snowfall, local snowfall in our local mountains. The modeling does show preliminarily a significant reduction in snowfall by mid-century in the 2041 to 2060 time frame. A little more than half of the baseline snowfall amounts under the business as usual scenario. And the mitigation scenario for that time frame also shows reductions, substantial reductions in snowfall.

Santa Ana winds I know earlier we were talked to and heard a little bit about wind patterns and how that does affect temperature, wild fires and many other climate criteria. The Santa Ana winds in the Southland are autumn winds that typically occur October through December as the desert cools and the winds rush towards the ocean. These winds are, through his modeling, expected to decrease which could, he believes, help decrease wind-driven wild fires in October through

December. Those that are driven by the Santa Ana winds and can threaten our transmission lines and actually, we have a fire right now down in South Coast in San Francisquito Canyon right near one of our power house is. But combining the wind information with the substantial increases in temperature, again preliminarily the results appear as though the temperature-driven summer wildfires are projected to increase dramatically. And that's really going to counter act the benefit from the reduced Santa Ana winds.

Dr. Hall and his group has also studied precipitation and again this has been difficult to get a handle on. But preliminarily his results show very little change in the actual precipitation, but he has not yet modeled snowmelt and some other impacts on the water supply. One other area that he will be studying is the low clouds and fog and a sixth element that I'm forgetting right now.

The second climate change study adaptation that we've been working on, is the sea-level rise vulnerability study for the City of Los Angeles. And this study is being led, or has been led, by the Sea Grant Program out of USC together with the primary partner, the City of Los Angeles, again the Los Angeles

Regional Collaborative and ICLEI.

The initial research of the sea-level rise and associated flooding focused on our three City of Los Angeles coastal regions: the Pacific Palisades, Venice, Playa del Rey and LAX areas and then further south around the Peninsula, the San Pedro, Wilmington and Port of Los Angeles areas.

The team used a model developed by the USGS and information was based on a January 2010, at that time, a ten-year storm. And again the city departments did contribute a great deal to the development of this study by providing information on our critical coastal infrastructure. So the study looked at how that infra structure might be impacted.

The sea-level rise results that they've determined through this study matches pretty well with other global projections. A five-to-nine inches increase between the year 2000 and 2050 and about double to triple that over the entire century. And obviously this can be exacerbated through storm surges and high tides. At this point the study has determined that roads and some water systems will be vulnerable to sea-level rise and storm surge impacts. We have a fair amount of infrastructure down around the port and other coastal areas that need to be addressed, that our

Bureau of Engineering and our Sanitation Department are reviewing and considering actions.

Cultural assets also along the coast: parks, open space, museums, aquariums can also be vulnerable to the sea-level rise and storm surge. But the port and energy facilities at this point appear to have low vulnerability to the sea-level rise.

Again, here are some additional studies that various city departments are conducting or have conducted recently. The Department of Water and Power has done a tsunami study that had very similar results. And we are looking also as social and economic impacts to those communities closest to the coast.

So along with our Green LA Plan, our Climate LA guidance document for achieving the goals of green LA, we have Adapt LA, which is a city-lead science-based participatory process to take a look at the climate changes that we're expecting in the Los Angeles area and help us identify vulnerabilities and actions that we can take for moving forward. We have a steering committee, a city department team and then our regional stakeholder working group, which again is being facilitated by the Los Angeles Regional Collaborative.

I will confess that I neglected to include a slide on two of the biggest initiatives that DWP is undertaking that will help reduce greenhouse gas emissions from our energy generation and hopefully reduce the amount of adaptation that we need to achieve in the Los Angeles area. First, as I'm sure you've all heard the Board of Commissioners and the City Council have adopted a plan to transition LADWP off of coal by 2025. As the first major step of this DWP will end power purchases from the Navajo Generating Station by the end of 2015; four years earlier than mandated. And the second step calls for DWP to completely transition out of coal power from the Intermountain Power Plant in Utah by 2025. And that transition is expected to begin by 2020.

This is a huge change for us. At the moment, we have about 41 percent of our portfolio is coal-based. And we'll be transitioning that to zero in about twelve years. We will be increasing our use of natural gas to supplement our large investments in wind, solar and geo-thermal power. In addition DWP and the city in May finalized a 150 megawatt feed-in-tariff program by adding 50 megawatts to the previous 100 megawatt FIT program that was approved in January. In addition to the solar power the coal resources will be replaced by a combination of greatly increased commitment to energy efficiency and expanding other renewable resources.

So since I'm from the Energy Efficiency Division I'm going to leave you with a slide about what we're doing. We've been lucky enough to have the board increase our energy efficiency funding budget by about two and a half percent up to $265 million over the next two years. And so we are frantically working to put that money to good use, expand existing programs and to add new programs to our energy efficiency portfolio. One big initiative we're doing is to partner with the Southern California Gas Company on a number of joint rebate programs. So that will allow our customers to access some statewide programs that the IRUs are currently operating for new construction and for existing residential and other programs as we move ahead.

But we've also trying to take a look at cooling incentives. And again under the RF funding, a couple of years ago, we were able to add a couple of rebates to our portfolio including our residential cool roof rebate that applies to single and multi-family housing and a whole-house fan rebate. I will tell you the whole-house fan rebate has not been terribly popular, because the cost of a permit which is required for the rebate is about the same as the rebate itself, but we've left it on our menu in case it does attract some additional folks.

We're looking into cool pavements. We're doing some work with L.A. Unified School District and we're hoping that we'll be able to demonstrate some cooler pavements there. And we are financially supporting Million Trees LA Program, which can also help cool our communities. Thank you very much.

CHAIRMAN WEISENMILLER: Thanks. I was wondering, over the next couple of years, if you have identified the high priority areas for future research?

MS. HARDISON: Well, I think we'd like to get a little more detailed results from the Alex Hall group on the wind, precipitation and snowfall and snowmelt and the low clouds and fog. Our fire department obviously quite interested in that as our power planners and water planners are. I believe we'll be doing some additional work on the sea-level rise and coastal challenges as well.

CHAIRMAN WEISENMILLER: And one last question. In terms of as you looked at the effects, are any of your substations in vulnerable areas?

MS. HARDISON: I believe so. I don't know for a fact, but I believe so. Certainly the valley generating station will certainly be in high-heat area. There is some wildfire risk out there as well.

CHAIRMAN WEISENMILLER: Okay, thank you.

MS. HARDISON: Thank you.

MS. KORESEC: I think we have one question from the audience. Come up and identify yourself, thanks.

MR. SCHWARTZBACH: Hello, I'm Steve Schwartzbach with USGS. And I wanted to ask if the information from Alex Hall is published, particularly the information on Santa Ana winds projections?

MS. HARDISON: The Santa Ana wind study has not been published yet. I expect in about two weeks, I believe on the 18th, Alex will be giving another presentation and releasing some additional information. There is a website, letter C-Change.LA, that is keeping up with the results from his studies though and they'll have that.

MS. KORESEC: Thank you. All right, next we have Kathleen Ave and Obadiah Bartholomy from SMUD.

MR. BARTHOLOMY: Okay, hello and I thank you for all your attention this late in the day. I'm going to go ahead and give a brief introduction background on this topic and Kathleen Ave, my partner, is going to be sharing some of our current assessment results. She'll have the bulk of the presentation.

So first off, I'm going to just give a quick SMUD overview and talk about specifically our energy resources, which are relevant to our adaptation planning. I'll also talk about our board directives and some of the background that led us into the impacts and adaptation area for assessment. And then Kathleen's going to cover our current climate readiness strategy and give a summary of findings and our plans for future work regionally and in the research front.

So just by way of overview, I think to orient you we're about 11 million megawatt hours in sales, so we're the sixth largest POU nationally and about four percent of the annual energy sales, about five percent of the annual peak demand for California, in terms of electricity. We're an electric-only provider and we're governed by a locally-elected governing board, which has seven members that are directly accountable to the voters and have a direct tie with the voters.

And I guess the other thing that's important to note about the board governance is that this is not their full-time job, so they're not energy experts. That is until recently we've been joined by someone who, I guess, would be an energy expert in Director Picker.

So with that just covering our energy resources about 50 percent of our generation comes from natural gas combined-cycle plants primarily. We have four locations with combined-cycle plants totaling about 850 megawatts and an additional 150 megawatts of natural gas simple-cycle peaker plants.

We also have a substantial amount of hydro in our portfolio, about 25 percent of our energy comes from hydro and a big chunk of that comes from our Upper American River Project. That's a total of 688 megawatts going up the American River into the Sierra.

We also have substantial import ties to the northwest. We have about 1600 megawatts on the COTP transmission line. And we use that to bring down both hydro and biomass resources. We have a total of about 200 megawatts of biomass. A good chunk of that is up in the northwest. And on the wind and solar front we've just finished out our Solano Phase III to a total of 230 megawatts and a solar 50 and 100 megawatts of rooftop and ground mount respectively.

So I mentioned our board and the governance that they provide. And this was a few years ago now that they adopted this policy, but it was a policy to put us on a path to a 90 percent carbon reduction by 2050, called our Sustainable Energy Supply Strategic

Directive. And what it provided for us was kind of a midterm marker of a 2020 goal and then a long-term goal of a 90-percent reduction below our 1990 levels consistent with the state targets. And it allows for a fairly long-term planning horizon for planning for the kinds of resources that I showed on the previous page. And how those resources are going to need to change to fit within that window and provides one of the pieces of a set of long-term planning activities that Kathleen will go over as part of her presentation.

Just to give you a quick demonstration of how we're doing on achieving those goals, we're actually about 20 percent below our 1990 emissions level today, and expect to be about 30 percent below our 1990 levels by 2020 with the current set of policies that are in place primarily met through renewable portfolio standard in energy efficiency as well as some of our voluntary green pricing program. And this is despite about a 30 percent increase in electric sales since 1990 over this timeframe.

I mentioned the sustainable energy supply and goal and RPS energy efficiency, but also are working hard on energy electric transportation and smart grid as well as various greenhouse gas policy initiatives in trying to work with the state to create policies to allow a smoother pathway on the long-term planning horizon. And then lastly disaster recovery and emergency response coordination, which up to now has been effectively our adaptation approach and that's a fairly near-term planning window for specific disasters that could hit us.

We initially began looking at a climate impacts about 2008-2009. We commissioned our first study with SAIC to begin to look at effects of changing climate on our assets and operations. And we primarily were focused on temperature effects on peak demand, hydro impacts, flood risk and thermal limiting on power plants. And this work was summarized and presented to the board ahead of their adoption of the sustainable energy supply carbon reduction goals and to some extent influenced that along with the activities that are going on at the state in terms of long term planning.

So with that background I'm going to ask Kathleen to share with you our current work on adaptation planning, so Kathleen?

MS. AVE: Thanks Obadiah, hello everyone. So in terms of our current approach we're doing this work with SAIC who helped us on the prior work as well. But the intent here was to review the work that was done in 2008 and 2009, the summary of the fiscal impacts.

Investigate and summarize any new findings related to the topic areas that were looked at back then, but then review the best available science for areas that weren't addressed back then. And the main ones there are wind, which is extremely important for us and then wildfire, which may impact our upper-American River hydro project as well as our transmission assets and then to develop some very high level next steps for recommendation.

So this initial work was just to capture a snapshot of the current best available science from previously published sources. We weren't doing new original research here, but the approach was to just gather this information and then plan for subsequent work where we would dig a lot deeper into specific operations or processes that warrant further examination or data analysis.

So we're in the process right now of the final stages of completing our report and we're developing, you know, more specific recommendations for what we will be looking at in the future although we have some ideas of where that's going to go. And then we definitely want to pursue opportunities for collaborative research. This work identified some gaps; we talked about the gap of wind information earlier in the day. That's definitely one that popped up and we'll want to pursue potentially with the CEC or other partners.

So why prepare? The objectives of already in the strategy were really to assist our work for us and our community of owners to prepare for changes that are already happening and that are expected in our region. And to enable us to manage those changes, many of them are beyond our control even with our and the collective efforts of the State of California to prevent unnecessary risk. So we want to be able to plan and work with other local agencies in our region to best utilize our resources.

And why are we calling this readiness? So adaptation is a term that is not particularly well understood among the general public; those that do understand it or know what it is associate it with the natural selection, which is a long, slow, different kind of process. So we saw some research that was presented at the Behavior, Energy and Climate Change Conference here in Sacramento last fall. And then also have kind of heard through the grapevine that the state is considering changing the way it presents this kind of information getting away from the term adaptation. So we went with readiness. Preparedness was actually the term that tested best among the public in the study that we saw, so we may end up changing it. But readiness was what we were told the state was headed for, so we went with that one.

MR. BARTHOLOMY: I would fly that the federal government is going towards preparedness now.

MS. AVE: Preparedness? Okay, well we'll have to change that. And, you know, this seems like in a way a little bit of a fussy thing to talk about, but because we are in a position where we're going to need to be conveying this information to our customers and to get them to buy in to changes in the way they behave and/or how they pay for electricity it's really important that it be something that they understand.

So just getting into the summaries of the physical impacts that we have gathered this is actually an older slide from our original study. And it looks at high-emission scenario or middle-high or business as usual and then a low emissions scenario, which is starting to feel like it's not even worth talking about. But we do continue to include it.

And this shows, summarizes the state-wide temperature rise and it shows increased temperatures, reduction in Sierra snowpack and increased risk of flooding in the Sacramento and then also the potential reduced air quality. All of which will have impacts in Sacramento. There are, you know, I'll focus on the medium-high emissions scenario, a 79 to 80 percent projected loss in Sierra snowpack obviously will have a big impact on our hydro system down the road if certain other trends occur. Two and a half to four times as many heat wave days and then also an increase in the heat-related deaths projected for urban centers and the number of critically dry years all driving an 11 percent increase in electricity demand.

So this summary includes some additional data, newer data in some cases, for focusing on Sacramento and again, by mid-Century looking at a one to four-degree Fahrenheit increase and then 2.7 to 8.1 degrees by the end of the century. Extreme heat days, we're looking at an average of 44 by 2050 and 85 by the end of the century. And the most current period that we looked at for current observations of extreme heat days is that it's around 13 per year, so this is a really big increase. And I think we saw some of that in Dan Cayan's expected number of heat waves even by 2020.

So and there's also data that we looked at for precipitation against snowpack and wildfire. The precipitation line is of note and we've been having some dialogue with CEC staff over this one, because we are in Sacramento right between NOAA's California climate regions 2 and 5, almost right on the border. So we're in this sort of fringe zone location. And you also may not remember, I'm not sure if he's still here from PG&E when he presented the increase in precipitation that they experienced. The fulcrum in that graph was Folsom in the upper American River and so precipitation is definitely going to be a tricky one for us to call here in this region, because we are kind of right in the middle of two zones that will have differing or are expected to have different patterns. So how that affects our UARP, you know, and then how we experience life here in Sacramento will be things we definitely want to watch.

Move on, we can summarize some of these. So the potential concerns that we have that we are kind of going through and looking at, well what specific projects might we want to charter in these areas? Changes in the overall ambient temperature, but particularly the peak temperatures that we have to plan for, the extreme temperatures are the ones that we have to have load serving capability to meet. So they're extremely important and being able to project, you know, really on a daily basis what are those going to look like and how might that differ from what they look like today is really. And then the nighttime temperature, so this was also something that Dan talked about earlier in the day in the observed data of the increase in nighttime temperatures. And for those of who live in Sacramento the cooling at night is important for our livability, but it's also important for our ability to get our equipment cool enough to be able to generate effectively and distribute electricity effectively on the following day. So that's a really compounding item for us.

Chances in the frequency of extreme events, obviously that one because that could affect a number of these different vectors and looks like that's a pretty solid trend. How it pulls in temperature and wind and precipitation all still a little bit unclear, but the frequency is expected to increase.

Efficiency, reliability and life cycle of our power plants, the previous presentation gave kind of a summary of some of those impacts and then, you know, the ability to cool down at night. And the assumptions that go into the life cycle for that equipment and maintenance schedules for the equipment all are kind of questioned if the basic ambient temperatures really start to shift over time.

So timing of snowmelt and the volume of precipitation, I mentioned this a little bit earlier. And our experience so far, our actual data suggests that we are seeing an earlier runoff, but so far we have not experienced any change in the overall precipitation in the system. So and, you know, again being right in the middle of those two zones so far we're not seeing it in the data, but that doesn't mean that that won't emerge at some point in the future and we'll be watching it really closely.

Localized and Bay Delta flood risk, it's no secret that there are issues like swimming pools impacting the levies here in Sacramento. And lots of concerns about what's been built in the flood plain, so this affects us and our infrastructure definitely. We have substations that are at risk of flooding and other assets, so that's something that we're definitely going to be looking closely at. Some of the maps that exist for the area that show specific levee breaks and the times of inundation and the areas of inundation are of critical importance to us for planning.

And then wind patterns and speed, we as Obadiah mentioned we operate a large wind facility in Solano County. So what will happen to the output of that plant is of critical importance. And then the

Delta Breeze, it's a huge factor in our ability to cool in the summer and anybody who lives in Sacramento knows that no matter what you're doing on a hot day, by the end of the afternoon you're pretty much just waiting for the Delta Breeze to kick in, so that you can cool down. And that's of huge importance to us, so what will happen to it is a big, big question. And we'd like to gather as much data as we can and potentially do some new research. We actually, Obadiah had a chance meeting or found a retired meritorious professor at Sac State who had done his original dissertation on the Delta Breeze. So we've located him and he's dug out his work and anyway we're sure going to grab anything that we can get and then build from there to get a better understanding of this.

And then of course wildfire frequency and intensity, the impact to our transmission assets as well as some of our out of district sources of energy supply Obadiah mentioned in the Northwest. That's a big one and then just our UARP as well.

Am I running out of time? Very good, okay I better go fast. Okay, so like any utility, water or electricity or whatever, we have short and long-range planning horizons and the assets that we own have in some cases very long life cycles. All of which is to say that in the short-term, you know, our real-time, hour ahead, day ahead trading activities definitely could be affected by extreme events. Our budget, all the load forecasts, commodity forecasts, they go into the development of a budget over time where we would expect to be affected as some of these metrics start to shift.

And then, you know, climate and these impacts on our physical infrastructure are definitely things that will be what we do and will continue to incorporate into our integrated resource planning process, which looks at a longer horizon as well as decision making around some of these longer-term assets.

This is just a snapshot of our current enterprise risk dashboard and I highlighted with circles some of the areas that will -- that already exist here. They're risks that our board looks at monthly and those are some of the places where we expect adaptation-related work to potentially affect the ratings.

So additional research, I mentioned wind and the impact on the patterns and speed at Solano as well as the Delta Breeze are real large priorities. And then better granularity around temperature, the certainty of daytime peak versus the annual average temperature projections really important for the ability to plan and to decide when and if we make changes in the way we forecast temperature upload.

The increase in nighttime temperature, we would definitely like as much information as we can about that. That's very local to Sacramento and some of the information that was presented earlier today is helpful in that regard. And then the relationship between extreme in our normal peak demand, since today we do plan for peak events, but how that might need to change is still a little uncertain.

Wildfire here, really the impacts of post-fire debris and sediment flows are things we're not sure if this might have an impact on the hydro system and how we operate it. And so yeah, in terms of erosion, additional erosion and other issues, so that's something that we would also like to look at and then again, just focusing on better data for our edge location.

So the next things we're going to do, I mentioned this is a phased effort, so we're going to be recommending to our board -- we haven't actually taken this to them yet. So this is all just recommendations at this point, incorporate these scenarios and our readiness findings into any long-term planning process at SMUD that looks beyond five years. And then that we participate in a new regional adaptation collaborative that is being formed here in Sacramento, support and help fund new research. And then we think we want to be doing this at least every four years. It seems like things are changing fairly quickly in terms of the development of new methodologies and new studies. Five years feels too long, every year or other year too short, so we'll see. But this will change depending on what comes out and whether or not there's really a reason to revise our findings sooner rather than later.

So that's what we have, thank you.

CHAIRMAN WEISENMILLER: Yeah, thanks. I was just going to note that the last year the Energy Commission adopted its demand forecast and included climate change in that.

MS. AVE: Yes.

CHAIRMAN WEISENMILLER: And this year we're taking more of a look at that issue, particularly have that in mind if extreme events may affect our peak planning also.

MS. AVE: Right, I've seen the sections in the most recent reports that deal with peak temperature forecasting. And so we're aware of that work and definitely plan to incorporate it into this.

CHAIRMAN WEISENMILLER: Yeah, it seemed like one thing, which is sort of an indirect effect of climate change is the whole Bay Delta plan and that impacts on your hydro system?

MS. AVE: On our hydro system?

CHAIRMAN WEISENMILLER: Yeah.

MS. AVE: In terms of demand for the water?

CHAIRMAN WEISENMILLER: Oh, in terms of demand for the water or what altered flow patterns might mean.

MS. AVE: Well, there's a pretty dedicated crew within SMUD that's watching that very closely, because certainly any change in our access to the water that we use is it's a big concern. As I mentioned it's a big part of our portfolio.

CHAIRMAN WEISENMILLER: Okay, thank you.

MS. AVE: Thank you.

MS. KORESEC: Do we have any questions from the audience? All right, thank you. Our next speaker is Andrew Petrow from ICF.

MR. PETROW: Good afternoon, my name's Andy Petrow. I work for ICF International. My firm was hired by the California Energy Commission to help design and implement the California Local Energy

Assurance Planning or what we affectionately call CaLEAP. My presentation today will give you a little bit of an overview of the CaLEAP project, but also demonstrate how CaLEAP can help and in fact is helping, right now respond to -- I mean, I should say prepare for, respond to and mitigate against the impacts from climate action changes at this point.

CaLEAP, this is the main goal, but what I want to point out is that CaLEAP is a planning process. It's a comprehensive planning process, which we'll go over the methodology a little bit, but it's to -- some of the speakers earlier mentioned that planning is the key to some of the solutions or things that we're working with the climate change right now. We support that and say that planning is a step, not the only step in moving forward. Our process is focused on local governments, we're working with a lot of cities and counties to make sure that they understand the comprehensive planning process moving forward.

The main goal of our project is to ensure that the key assets within their communities have energy after major disruptions. We know that a lot of events, we focus on the effects of the hazard, not the hazard itself. I know this afternoon we've talked a little bit about the science behind a lot of the hazards. We're really looking at the impacts. We're really saying that no matter whether it's a flood, fire, earthquake or cyber attack that you can have disruptions to your energy within your communities. So we're really looking at in your key assets will they have energy after those type of events and what can you do to prevent that or ensure that there's power after?

We also look at climate action change. I'm sorry, we look at the wildfires, we look at all hazards in our events, so we work with a lot of mitigation planning that looks at different types of hazards. We look at the impacts from those and we also look at how the communities can respond to those moving forward.

The objectives of CaLEAP, the main thing is to demonstrate how you can build a stand-alone energy assurance plan that addresses these concerns as well as to incorporate energy into existing planning efforts. So we are not looking to build siloed plans here, we're really trying to figure out how we can work with communities to go with their existing planning efforts. So we are working with cities, updating their general plans. We're working with their emergency operations plans. We are working with their haz mitigation plans as well as their climate change plans and greenhouse gas plans as well, so there's different plans that the communities are currently doing. We're leveraging that information to try to see how we can kind of grow that and consider or emphasize energy moving forward.

We also want to present new and evolving technologies. That's something that a lot of communities have kind of avoided or don't properly understand, where do they need to be in the future. So it's not about jus throwing backup generators on my key assets, but really understanding where's technology moving in the future? We bring that technical expertise to the locals, so that they can start making better decisions moving forward.

We talk about awareness. Our planning process is a comprehensive planning process. We really want you to understand your communities, what's happening there, are you growing as a community? Are you aging as a community, where are your needs kind of moving down the line? Do you see more industrial, commercial kind of moving, what are those impacts on energy? What does that mean to your community? Not only from a response but also a recovery standpoint, so you start understanding how the energy kind of come into play there. It's key for communities to bounce back immediately after disasters, so that you can get business back to normal. Energy is the key factor there. It ripples through everything from your recovery, from your commercial, your economy as well as your communications to your responses.

We talk about energy profile, something that's different in most planning processes. We're kind of focusing on the energy side, our planning process. We're talking to communities about understanding their local supply and demand. Where are they getting their supplies from? When we talk about energy we're talking about both electricity, natural gas transportation fuels, as well as petroleum, I mean propane, and other types of fuels looking into communities. Trying to understand where those sources are coming from, where are your peak demands? Is it in the summer, the winter, is it for heating and cooling? Is it coming in off peak hours? So understanding that if you do have these disruptions and you need to keep those buildings or those functions working what type of supply are you really looking at? You really don't want to have to build a supply or demand, or excuse me, you don't want to supply a building that you need a larger demand for. You want those buildings to be efficient as possible, kind of moving forward.

And we talk about hazards, extreme weather events. We mention that we talk about all different hazards. We are leveraging a lot of work that's currently being done through Cal EMA and other emergency management agencies looking at different hazard stuff that communities are faced with. We are implementing that to start looking at the vulnerabilities of these things as well as the exposure. We are looking at extreme weather events, we're tying in, we're brining those members to the table, start looking at what does this mean? You know, is it 1,000 people displaced or 2,000 people displaced and for how long and what do we need?

We are looking at dependencies and interdependencies. That's something that's very key as we're working with the locals to start understanding what does it mean to my water system to not have electricity or my electricity not to have water? What are those interdependencies, how well are they working together moving through this whole system?

And again, the last part is the key assets, where is my key assets? A lot of communities have gone to identify critical assets, we're looking at key assets here, which is a little bit different. It's a subset, so we're not talking about within your community things that are important to you as parks and maybe amusement parks and other such kinds of things that have been normally or traditionally put on the list. We're talking about key assets, things that you cannot be without energy in your community such as a hospital, 911 center, maybe a heating and cooling center or a staging area or a school that you may use as a shelter; things that you really cannot be without power without moving forward.

And the last bullet we want to talk about is the building of partnerships. One thing that we are stressing in our planning process is about building these partnerships before the disaster, not after. It's really understanding who my utility contacts are, who do I need to contact moving forward? And trying to develop those relationships after a disaster is impossible. You have communications down, you have other obstacles, you have other challenges that you're faced as well as your partners are faced. That if you understand these partnerships before and their roles and responsibilities things are getting done more efficiently through the planning process.

CaLEAP methodology itself, we have vetted this methodology through the 43 cities that have done this nationally and paid by DOE to build these local energy assurance plans as well as we've vetted this by some large cities in the State of California as well.

We've started to understand how they go through their local planning process. We didn't want to create a parallel effort, we wanted to see how we can blend this into their existing planning efforts. We leveraged a lot of the work that was done through DOE initially at the national level, they have some guidance out there to local governments on how they could build and incorporate or actually more build local energy assurance plans.

We've also leveraged some of the work that was done by FEMA, so we've looked at the Comprehensive Planning Guide 101 that looks at a strategic approach on how you go through tackling a comprehensive planning process. We've blended those two processes together. We've worked with the locals to vet this buy-in and understand does this meet their needs, is this what they're looking for? Again, what we're proposing here is a solution, not the solution on how to move through this. So if they have a better way that they go through their process, go through a better analytical process, we're encouraging them to continue down that road. We're not saying they need to switch and meet all of the criteria underneath CaLEAP at this point.

We are talking about local awareness. We've talked about some of the things I'd like to point out about the methodology; it's a four-step process. One is dealing with the building of my forming of a planning team. The difference here that we've done traditionally in other planning efforts is that we're encouraging the expansion outside of local government. There was a discussion earlier about the police and fire not cooperating or talking, you know, underneath disaster scenarios. The State of California is pretty good at the blending of those two, but we're encouraging those people to be brought to the table as well as expanding outside your local government. Look at the local utilities, look at some of the larger businesses in your communities. We are working with Google, we are working with Cisco and a few other companies to understand what their needs are.

A lot of those communities, even the agriculture industry, their recovery also reflects how well the governments respond and recover from those disasters as well. So understanding what their energy needs are in those communities, how they will need to come back up on line or keep energy in their communities. We talked to the agriculture industry and they have indicated that it if they don't properly shut down the dairy industry or keep certain power into that dairy industry they start losing the cattle and which creates a ripple effect or secondary effect where you start having public health risk issues. And you start dealing with other issues. Now, if they had some semblance of energy or backup energy, alternative energy dealing with the dairy out there they may avoid some of those cascading effects that come from impacts.

The second part of step 2 is the energy assurance plan itself. We talk about three steps underneath that. One is dealing with understanding your existing condition. The big point there is looking at energy profile. It's really looking at what are my energy supply and demand look like, excuse me do I understand what my backup supply looks like? Do I understand, do I have backup generators in my community? Will I be able to move them, are they portable, stationary? What does that backup look like, do I have add 100 gallons on to that storage tank or 50 gallons?

We were recently in San Diego where they indicated that because of the local economics, they don't keep their tanks full now at 100 percent capacity. So they had 100 gallons on their backup generator. Now they keep 50 gallons on their backup generators, which means that their supply is a lot less, which means their run time is a lot less. And if they haven't made energy efficiency buildings they're running out of time quicker now. They won't be able to keep their businesses going.

Underneath Step 2B is dealing with vulnerability. We look at both exposure and vulnerability. We look at not only are you exposed to a flood, earthquake, high winds, any of these changes that we're looking at, but are you vulnerable to it? You know, you're not always vulnerable to a certain type of event: sometimes you are, sometimes you're not. We're asking them to explore both exposure and vulnerability in your key assets and understanding what the impact will be there.

And then the last step is dealing assembling of projects and actions. We're helping local governments understand what type of actions can they take? Not only brick and mortar types of projects, but what kind of actions? That could be reaching out to the local utility a little bit more and trying to get them to partner in moving forward as well as policy decisions that the cities can make. Things that they could help, maybe asking CEC to help with the air quality boards, dealing with the backup generators, how often can they test them, how often can they run them and what's happening that way? So there's policy-types of issues that can be done too, so our projects and actions are really looking at the challenges faced by the local governments in keeping energy available too. Whether that is like I said from a cyber attack, an earthquake or anything else we're really looking at all the different events and saying, "What do you need as a local community and how can we get you there?"

The last two steps are dealing with the finalizing of the plan. There is no approval process, so what we're working with the local government is really their planning process. So if they have a planning process that they go through for approval that's what we work with. We don't add another layer of approval.

And the last step is step 4, which is the implementation and maintenance. We don't require any maintenance, but we encourage an annual maintenance of their plan to actually go back and look at their projects. Reassess and look at their homework so to speak, and look at what they've considered as part of their issues to come up with their answers or actions and projects. We're asking them to go back through and validate those as they go through the process. To continue to see is that the right alternative? Is that the right option that I want to move forward with looking for that backup energy?

The blue box at the bottom I just wanted to point out, I forgot to, is that it's talking about how we leveraged plans. So we're not asking them to go through this process in a vacuum. We're saying, "That if you have existing information you can leverage that information into your current plan or you can go through this process and also incorporate that information into your other plans as well." We're having a lot of success right now working with local governments incorporating this information into their hazard mitigation plans. They receive some grants right now to go through and look at the hazards in their community, look at what those impacts are. We're asking them now to emphasize on the energy aspects of those communities and incorporate that into their planning process.

Many communities are updating their hazard mitigation plans today and incorporating this energy focus into it right now. We've also developed a planning tool. It's important to point out that the planning tool is not a turbo-taxed type of tool. It's not you put data in, press a button, out spits a plan. It's really helping someone walk through the process organizing their thoughts, allowing them to collect information and also allowing them to share information as a virtual office with outside members.

Again, to kind of refresh we talked about expanding our planning team, going outside the local government, bringing in some private sector people. This allows them to actually have a common place where they can share information, where they can go in and update the information and they can all see the same information at the same time.

It also allows you to export information, which can be put into your plans. So we've seen a lot of communities actually give access to a lot of the private sector industry right now to talk about their backup generators: some of the caterpillar industries and things that are out there, moving industries that have backup generators. That they're partnering with these local communities and starting to list what information's available to some of these local communities. So they're able to go through this planning tool and start listing that information in there, start categorizing some of this, so the locals start understanding what's in their backyard, what they have, what their needs are and coming together as a partnership to try to come to these solutions.

So the planning tool is available to all local governments. They have separate pages for each one of the cities that have control over people and members on their page, so that they can decide who has edit rights to that page. Who has view rights or who doesn't have rights for that matter. So other cities can see each other's page only if given approval by that local city on the planning tool itself.

We also offer technical support. That's a big piece to the CaLEAP Project at this point. We go out to communities and work with the local communities. We bring different levels of expertise at this point. We bring everything from project management to emergency management to the energy sector. So we bring a lot of new and evolving technologies. We're talking to a lot of communities about the challenges of smart grids. You know, does it make sense, does it not make sense? When do you switch over to different types of technologies? What's the best time to start over? Is there a vision down there? What does solar look like in 20 years from now? Do I start down that road now, do I wait? When do I invest? Do I throw all of my eggs in that basket?

We're talking with a lot of communities right now who are switching over to electric vehicles. We say that they're doing a very good job of reducing their demand, but they're doing a very poor job right now of really securing their supply. We're trying to get that balance between the two, so they understand that in an emergency if you switch over to all electric vehicles what happens in disaster is your vehicle will go 100 miles, stop and you have a paperweight in the middle of the road.

So we're trying to let them understand that what is the solution in a disruption? Where is the backup, is there a better way of going? Don't put all your eggs in one basket or if you do, understand those vulnerabilities and risks. Don't trade one risk for another without that understanding moving forward.

Current status of the project, actually this is a little outdated believe or not since the printing of this slide. We now have 45 cities, local governments that have signed up, 4 more have just joined us. There seems to be an increased interest the more this message gets out to the locals, the more that the individual cities and counties start hearing about this program and the project and the process. It starts growing with their neighboring communities. We were just in San Clemente the other day, they signed up and they're encouraging us to reach out now to Dana Point and San Juan Capistrano saying that they have these strong partnerships in the region and would like them to go through the similar process as well. So it growing and it is continuing.

We are looking at exploring funding options for projects. One of the big things that we want to say about CaLEAP is that it's not just another plan that sits on the shelf, you identify projects and it's off to the side. We're really looking for funding sources, so we are working with FEMA, we are working with Cal EMA, we're looking at other agencies that are out there, CDFA, that have opportunities where we can start leveraging some of these funds to start implementing some of these projects.

Really the goal is to try to get projects into the local communities to make them more resilient, more resilient to these changes in our hazards, the increase in these hazards. So we are working both within CEC looking at different programs that are out there. We do see this as a way of kind of centering some of the programs that are out there, your energy efficiency programs. Local governments start understanding when does that come into play, when do I start looking at energy efficiency into the building versus backup generators on those buildings as well? So it's really leveraging both programs and going hand in hand, not just going down one single road, but really figuring out what's the strategic approach? It's kind of making my community more resilient kind of moving forward.

This is a list of our participating local governments. As I've mentioned we've added four more communities since we've published this list. We can definitely update that list before it goes out, so that you have the most up-to-date list. But we have over seven counties that are kind of working, some are building regional types of energy plans at this point where they're either one, leading the effort with the local governments and the local government's building their own local energy assurance plans.

And in some cases the county's actually building a single regional energy assurance plan and having the locals as their stakeholders in understanding what their key assets are and what are some of the challenges they're facing to start building a regional approach to how they're going to respond to some of these disasters and hazards.

With that, that's the end of my presentation and I have some contact information. I'll take any questions or...

CHAIRMAN WEISENMILLER: Thanks.

MS. KORESEC: Do we have any questions from the audience? All right, in that case I think this has come to the time where we have a final opportunity for any public comments anybody cares to make before we adjourn for the day.

Lynette, do we have anybody on WebEx? Can we open the phone lines and see if there's anybody on the phone who'd like to make any final comments? Okay, well we have one stalwart phone person, your line is open, is there any question or comments you'd like to make? All right, hearing none I think we are finished for the day.

I want to thank all of our presenters. We had an excellent day, a lot of really good information. And want to remind folks of when the public comments are due, I believe it's June 18th, thank you. And I'll put up a sign in a moment here that explains how to submit the comments to the docket. And with that Commissioner, do you have any closing comments?

CHAIRMAN WEISENMILLER: Well, again I wanted to thank everyone for their participation. Obviously climate change is one of the defining issues of the time and certainly one of the things the state has really focused on is doing a science-based analysis of these issues in trying to determine how both to mitigate and to be prepared, so thanks again.

(Adjourned at 4:20 p.m.)

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