Wind and Water Nexus: Impacts of Wind Development on Water Use in the Energy Sector
March 20, 2013

Coordinator: Welcome and thank you for standing by. At this time all participants will be on a listen only line for the duration of today's conference call. Today's conference is being recorded. If you have any objections you may disconnect at the time.

Now I'd like to go ahead and turn the call over to your host for today, to Mr. Ian Baring-Gould, National Technical Director of the Wind Powering Initiative. You may begin.

Ian Baring-Gould: Great. Thank you, Jose. So welcome everybody to another Wednesday webinar series of the WPA webinar series. And today we're focusing on the wind and water nexus looking at the kind of drought that we have been seeing across the United States and clearly here in Colorado we feel it very closely. And everything is indicating that we're going to have yet another dry and warm year coming up. And so we thought this would be a good time to start talking and looking a little bit at the issues around water and the power sector.

And to this end we have two people that have been doing a great amount of work in the issues around water usage and then more specifically water usage in the energy sector. Stacy first, focusing more on the western parts of the country and then Paul focusing on the east or more on a national perspective of giving us the whole nation here.

As we always do, Q&A is done through your computer. So we don't do a live Q&A at the end. And to ask a question you go up to the top of your screen where it says "Q&A," hit that and it'll give a little screen that you can type in your questions. We will be doing questions at the end but please don't hesitate

to put a question in there and if you want it addressed to either Stacy or Paul do that or the question can be done at the end to either of them.

So without further adieu Stacy, are you back online? We were having a little bit of technical problems with Stacy's presentation. Are you here Stacy?

Stacy Tellinghuisen: Actually Ian I am having more technical difficulties right now. So if we could possibly switch and...

Ian Baring-Gould: Yes.

Stacy Tellinghuisen: ...Paul goes first that would be great.

Ian Baring-Gould: We can do that. Paul, are you ready?

Paul Faeth: Yes, sure.

Stacy Tellinghuisen: Thank you.

Ian Baring-Gould: So we're going to start off with Paul. Paul is the Director of Energy, Water and Climate in the Institute of Public Research for CNA where he is developing a program working and exploring the policy synergies between the kind of wind and water themes or wind and energy themes.

His current work is focused on energy and water nexuses in the power sector kind of focused in the United States but also bringing in lots of experience from China, France, and India but with a focus in Texas and looking at the environmental impacts of stuff like fracking and dam building programs. So, kind of a wide variety and usage of the different water uses that we're seeing in the energy sector here in the United States but also internationally.

Prior to his work at CNA Paul was the president of Global Water Challenges which is a coalition of 24 corporations, NGO foundations, universities, health agencies, working to promote and invest in safe drinking water and sanitation primarily for poor developing - for developing countries.

Paul has worked for many years at the World Resource Institute which is a global energy think tank and has led economic programs in quite a number of places. So Paul comes to us with vast experience both in the environmental and the water sector.

So without further adieu Paul is going to talk about water conservation primarily focused in ERCOT.

Paul Faeth: Great. Thank you very much, Ian. I appreciate the opportunity to speak to the group today. I want to start by acknowledging our partners in this work which include the Regulatory Assistance Project which is the project lead with funding from the ClimateWorks Foundation and also we're working with the Vermont law school on the case studies that we're doing.

So you will all be referring to Ian's opening remarks to the drought situation and, you know, in 2011 in Texas and in Oklahoma was the drought of record. The worst one-year drought that has ever been recorded. And so when we were getting this work started we were looking at opportunities to understand the connections between energy and water a little better and also between energy/water traditional pollutants and greenhouse gas emissions.

So what we've done in this study is we've developed a power sector model for Texas and as Ian suggested we're also applying that model to France, India and China for some work that's ongoing. And what we're looking at is that one

of the things that we see in energy models is that they don't include water. So in economical models for energy policy what's the typical thing—way to go about that is to just assume that energy is free and instantly available which of course is an assumption that we all know is not true.

So what we've done with this model—it's a fairly simple model—but the kind of the fundamental aspect of this that we're looking at is to build in water as a constraint. So we're looking at a whole wide variety of technical options to produce power in ERCOT which include coal, nukes, gas, wind, PV, and some hydro and looking at different options for doing that. So, you know, conventional coal with once-through cooling, conventional coal with recirculating or pond cooling, you know, gas with once-through—natural gas combined cycle, et cetera, et cetera. And wind is one of the options that we've looked at and included in the analysis.

So each of these have technical aspects to it which include cost which include things like capacity factors and include the environmental attributes such as sulfur to oxide emissions, NOx, particulates, greenhouse gas emissions, mercury, et cetera. And then also how much water that they withdraw per megawatt hour and how much water they actually consume.

So with that in the model what we've done is developed a projection for demand in Texas or we've taken from ERCOT and then run out a little bit farther. And then so we say well the model has to meet that demand and in the least expensive way possible subject to various constraints.

And so what I wanted to show you just to start with—and the first graphic shows the baseline fuel mix for ERCOT as we think it's going to roll out and I want to emphasize that these are possible futures. We're looking for things like, you know, big changes or little changes cause—is it up or down, big or

little? Is sort of what we're really interested in rather than, you know, kind of the relative minutiae of this thing because it, you know, it's a foresight tool as opposed to a forecasting tool.

But what we see is, you know, starting in 2010 is there's a mix, you know, of gas and coal are each about 45% with some amount coming from nukes and about 10% overall coming from wind. And so when we run that out there's a couple of assumptions based on the model. One is that you can't build new coal because of regulations but also really coming in more importantly is the price of shale gas. And with fracking, with current prices what we're seeing is that coal, basically, it isn't economic anyway even if it were allowed it wouldn't come in to the solution.

And we assume that for nukes that you're not going to build anymore because of policy exclusions and wind we assume that you will and that the price of wind we've assumed will come down about 25% over time from 2010 to 2040. And you actually will see kind of kinks where that starts to come into the model.

And so with the baseline fuel mix what we see there by the end is a lot of natural gas and a lot of wind and with a small amount of coal and small amount of nuke. And there are a lot of implications to that which I'll get into here.

The next graphic that I want to show you is we ran this model with a variety of scenarios and we actually said well okay, what if you limit the amount of water that can be consumed so that there's no more water in the power sector that can be used and what's actually being used right now in 2010? We also looked at well what if the price of wind doesn't come down? What if it stays where it is, you know, for the entire length of this scenario? What if there was

much more end use efficiency, an improvement of about, you know, 2/3rds of a percent annually in end us efficiency? And then the one you're looking at here is well what if there were a carbon cap put on?

And what's interesting to note about the various options is that with the exception of nuclear the greenhouse gas emissions and the water use are in pretty much locked step. So coal uses, after nuclear which uses the most water, but for these analyses we're assuming that we won't be building any more nukes so they're basically irrelevant. But we're saying okay, coal uses about twice as much water both withdrawals and consumption than natural gas does. It also emits twice the greenhouse gas emissions and it emits a whole variety of traditional air emissions.

You know gas, because its more efficient, doesn't need to reject as much heat into the environment so it uses less cooling water and releases half the greenhouse gas emissions. And of course wind doesn't put out any traditional pollutants or greenhouse gas emissions and there's no requirement for water for cooling. So it withdraws no water and it doesn't consume any water either. So what we assumed in this scenario was about a 40% drop in greenhouse gas emissions from 2010 to 2040.

And what I want to do next is show you a little bit about—well, for example, here's one with the high wind cost. And the difference between this is very important because what you see here, and this points to one of the sensitive aspects of the model and what is important in the true aspects of where wind is going in terms of pricing, et cetera, which from everything that we see in the studies that have been out—and this is something any input on this from anybody on the line either later through my contact information I'd be very interested in hearing.

But like I said we assume that there will be real prices in wind declines but if there were not the implication of that is that basically the fuel sector would move not exclusively but largely to natural gas with a lot of implications tied in for that. Excuse me, I'm waiting for the slide to switch. Okay.

This next slide which says "Demand Site Management"—this is where we assume that there would be increases in the efficiency and the end use. And the gray shaded area at the top shows the emissions—or, excuse me, the demand and generation that's avoided by going with a higher end use efficiency. And with that come, you know, a variety of benefits including less need for water, less need to develop more capacity, and, you know, fewer greenhouse gas emissions, air pollutants, et cetera because you don't have that demand.

And so you see, to the end though you still see a lot of wind coming in and I should add that right now at a—you guys probably know all this—but at an instantaneous measurement wind was at about 28% in the fall in ERCOT. And speaking with the strategic director of ERCOT they believe that wind can actually go quite high in the future and perhaps, you know, even 50% of the total mix in terms of the timeframe that we're looking at here with a whole variety of things that they're doing to manage a system in new ways that can accommodate wind.

Okay, one more slide here. Okay, so what we're seeing here. This slide shows the percentage of gas generation over the various scenarios. And, you know, on the right hand side of the various scenarios that we've tested here and again you can see from the last couple of slides back that if the wind price doesn't come down then natural gas is going to be dominant.

But you also see that with a carbon cap that it is much less dominant and it kind of comes up in the, you know, kind of late to early 2020s kind of reaching a peak and then it gradually comes down. I think, you know, in looking at this for a sub this is what we think people mean by a bridge and where, you know, for a while natural gas may be going up but as the price of renewables come back down basically see in most of the scenarios that then it kind of evens out.

It does bump up for a while though in some of the other scenarios and the reason where you see those kind of steps is because in the model we've built in the retirement of two big nuclear power plants. And that's why you see those step functions that are coming in there.

Now similarly I want to show you another graphic. This is wind generation. And under the various scenarios particularly what kind of jumps off the line there is when there's a carbon cap. And in the instance of a carbon cap wind ultimately could become, you know, very high percentages of the total generation in ERCOT over the long term.

And you see that comes in, you know, for the other scenarios like, eventually even in the baseline for example we see after about 2020 quite a bit of wind coming in. And what's an interesting factor—which again you guys probably know all of this—but there is a new transmission line being developed that's going to come online fairly soon in the next couple of years and will give ERCOT access to very high quality wind resources from the pan handle, et cetera to bring that back down to the southeastern part of the state.

And so, you know, where that becomes competitive is where you see kind of wind sort of taking off. And even in the baseline case—and I've talked with the strategic planning director for ERCOT they have said that they believe,

you know, within a few years actually that—the term that he used said that he thought that ERCOT would be overwhelmed with renewables which ends up being I think quite a good news story.

The next graphic I want to show you is the coal generation over time and you see with all of the scenarios coal drops off quite a bit. And this is basically simply due to aging of the fleet and the fact that there's no more coal that can be brought into the system. It's being replaced by other things. And with a carbon cap it happens fastest. With the high efficiency it happens more slowly and the reason is because you're not building as much capacity. So as a percent it's a little bit higher in terms of the percent of total capacity.

Now for water withdrawals. And again, we looked at two things: water withdrawal as a consumption. And the difference there is basically the difference between your washer and your dryer. When you wash your clothes, you know, you withdraw water to do that and when you're done with the water, you know, you send it back to the treatment plant. So very little of that water actually is consumed. It goes back into the environment for a second round of use by someone else.

But when you consume water that's the dryer and, you know, the water that's attached to the clothes, it's all evaporated. And so there's a big difference there in terms of how water is accounted for. And for Texas the number that they look at primarily is water consumption.

But this shows withdrawals and those little step downs are where a big coal fire power plant retires. And so in all of the scenarios because of the replacement of coal by natural gas water withdrawals overall in the system we believe will go down.

Now the next on that I'd like to show you here is water consumption and similarly for all the scenarios except for the high wind cost scenario where you continue to run a lot of natural gas is there the water use goes up a little bit, but overall it's pretty much flat. The least amount of water use happens where you get with the carbon cap again because of the synergies that occur between the fossil fuel content and the efficiency and the use of water for cooling.

So the carbon cap gets you the largest reductions in water use over time and what you see with all of these scenarios is that basically the power sector over time is freeing up water for uses either to the rest of the economy or to the environment. And Texas right in the last ten years grew by about 4 million people a year. So there is a significant concern not just because of drought as I showed you or I spoke to a little earlier but the concerns about the growing demand for water withdrawals and consumption within the economy.

Now you do see something interesting here, too—the water limit. We assume that, you know, you can have the amount of water that's model calculated in 2010 and no more. That that keeps water levels flat, you know, out to about 2020 and then things gradually decline. And there's really not much difference between that and the baseline scenario.

And again the key here is the moving away from coal and moving to gas in the first place which frees up water consumption. And then secondly as wind becomes more competitive and its opportunity for use becomes more then the demand for water consumption also fades away.

But importantly, you know, where the baseline and the water limit gets you down by about 20% from the baseline—the beginning of the baseline, I

should say, you know, the efficiency in a carbon cap gets you quite a bit more in terms of potential savings for the economy.

So, let's see. Moving along. CO2 emissions. And again, these charts look fairly similar between the last one and this one with the exception of the high wind cost. And again there's this synergy that occurs in the drivers as they say for energy in the power system. And again we see here that our carbon cap not surprisingly reduces carbon emissions the most and then efficiency next.

But if not for wind and a gradually declining price for wind then we would expect that the carbon dioxide emissions from Texas would actually go up over time by about 1/7. And it would be a lot worse of course if coal were to continue to be used. So there is a benefit here from the move from coal to natural gas but a much larger benefit in all of the scenarios from that then following substitution of natural gas by wind.

And so that aspect to be able to achieve, you know, much lower targets for water use and for wind and also for air emissions then the application of wind and bringing that into the power sector for Texas is really critically important. And without renewables you basically can't the kind of progress that you might want to see in CO2 emissions or in consumption of water, water withdrawals and also the air emissions.

And speaking to air emissions just as one example again a traditional pollutant sulfur dioxide associated with carbon emissions that it comes down, the SO2 emissions come down pretty much no matter what you do because of the retirement of coal.

Now the last couple of slides I'm going to show you are, everybody of course asks, well, what will this cost? And what's interesting again is the assumption

in the model that we have applied of the declining price of wind over time is actually pretty important. And you see, you know, in the beginning prices go up a little bit with a carbon cap because you have to bring things on I would say a little bit early, just to strictly the economics.

But the least total system cost is for high efficiency and we do apply a $35 a megawatt hour cost to every megawatt hour of power that's not needed. And with the high wind prices where they're flat over time then the costs do go up. And the baseline and the water limit are kind of in the middle.

Now what's interesting is the difference between the fixed costs and the variable cost in the overall system. And what we find is that wind has the highest fixed costs over time in all of the scenarios, but of course it doesn't use any fuel so it also has the lowest variable cost. And you see a range of these, where efficiency basically the costs go up very little and the fixed cost aspects and you see the baseline kind of a little bit toward the high side but more or less in the middle of the range of the scenarios in showing that, you know, for those scenarios it increases for everything and the least for efficiency.

And then finally what I want to show you is the variable costs and the scenarios you see that for the carbon cap, so there's basically no fuel costs. So there's some variable operation and maintenance cost and as you use more fuel then you have higher variable costs across the scenarios.

And one thing that's interesting and important is from assistant operator's point of view with low variable costs and higher fixed costs you can actually lock in and get a better prediction of your costs for the total system operation over time. And so there are aspects to this that are also interesting from a planning point of view.

And so, let's see. Just in closing my contact information and I'd be happy to take questions. But like I said, just to sum up what we've shown, is that there is a lot of efficiency and a lot of synergy to be gained by looking at these things together.

And even in a place like Texas which may not be, you know, totally gung-ho on climate policy nevertheless it appears that because of the synergy between fossil fuel content and greenhouse gas emissions and water which are favorable as you move away from coal and towards renewables that actually it looks… We think that the scenario for Texas with the use of renewables actually is more optimistic certainly than we would've though going in but that the energy water issues are an important aspect in terms of the total debate and we think an interesting place to actually have a conversation.

So I'll wrap up with that Ian, and, you know, when we're at the end I'll be happy to take any questions.

Ian Baring-Gould: Great. Thank you very much, Paul.

Our next speaker who got her Internet connection back and going. That has to be one of the worst nightmares on these kinds of webinars, is your Internet connection blows up on you as you're about to say hello to everybody.

But our next speaker is Stacy Tellinghuisen who is a Senior Energy and Water Policy Analyst for Western Resource Advocates. And for people who don't know Western Resources they're a non-profit conservation organization really directed at the west but looking at water, land, and air and protecting the combination of those three.

Stacy has worked for a very long time on the water and energy nexus, sometimes focused on water, sometimes focused on energy and then the combination of the two of them and spent this time looking at the impacts of energy development on water resources and vice versa. She's published quite a few reports and papers on this area as well as testified in front of utilities and regulators on issue around water and how that plays into energy choices.

Prior to joining western Resource Advocates Stacy worked on water issues for the California Sustainability Alliance and for the City of Moab, Utah. She also has taught natural and environmental sciences for school groups in California and Utah. She has a Masters of Environmental Science and Management from University of California at Santa Barbara. So Stacy, hopefully you're there.

Stacy Tellinghuisen: Yes I'm here and...

Ian Baring-Gould: Good.

Stacy Tellinghuisen: Hopefully our Internet connection will hold and I won't have any more technical difficulties. So sorry for the mix-up there at the beginning.

Thanks for the opportunity to present today. I'm excited to talk to this group about the energy-water nexus. I think it's an important issue and becoming increasingly important and I have a few statistics on the front slide here. In 2005 thermoelectric power plants in Arizona, Colorado, New Mexico, Nevada, and Utah consumed around 292 million gallons of water a day. That's a hard figure to conceptualize but it's approximately equal to the water demands of Albuquerque, Phoenix, and Denver combined. So, not inconsequential.

And then on the flip side of the energy-water nexus 13% of the nation's energy is used by the water sector, an estimate out of a group in Texas. And I think compounding this issue is the issue of drought and in the middle of the picture of Lake Powell in 2005 and around 2005 Lake Powell and Lake Mead on the Colorado River were about half of their average capacity.

So today I'm going to talk about these issues. I'll give a general background and then I'll talk more specifically about the impacts of drought using a couple of case studies focusing mostly on Texas. And then I'd like to address what we see as some of the best practices or management strategies for integrating drought and water issues into energy choices.

And again, as Ian mentioned, that western Resource Advocates is a group that works primarily in the interior west. So most of my presentation will focus on the west but I hope that the information and the sort of best practices and some of the takeaways are relevant in other parts of the country as well.

This is an image of the United States in the most recent U.S. drought monitor. Drought conditions were prevalent across the nation last fall. They've gotten a little bit better over the winter months but the majority of the country is still in some level of drought. And the Colorado River Basin in the southwestern states is almost entirely in drought with portions of the basin in severe drought.

And then I'll just highlight that in recent years we've seen water and energy conflicts throughout the nation. Back in the early 2000s we saw issues in the West particularly on Lake Powell with the Navajo Generating Station having issues with its cooling water supplies. Most recently in 2012 we saw news stories from around the nation where drought could potentially pose problems for power plants, or did pose problems for power plants. In many of these

cases we got off without too much of a problem but I think that with increasing drought in the future we're likely to see more challenges in the future.

And again today I'll focus on the interior west and this is just a map of the Colorado River Basin. It supplies water to approximately 30 million people across the seven states, 3 to 4 million acres of irrigated cropland, and numerous power plants. In recent years the Colorado River average basin water supply has been approximately equal to average basin water use if not below average basin water use. The recent projections of climate change look like it's likely to reduce water use by about 10% by mid-century—excuse me, reduce water availability by 10% by mid-century in the Colorado River Basin.

The Colorado, like many other river basins in the west, is a full allocated basin and is in many regards fully used. And why that's important for energy is that as we look at either developing new power plants or new power resources this is a fully used system. So any new demands will impact existing water users.

So I think that's the important background and context for water and energy issues in this region. Now I'm going to talk a little bit more specifically about the actual water used for energy.

This graph is just a comparative graph that shows how much water is used for electricity generation across different fuel sources and different technologies. And this is not comprehensive and these figures generally reflect water intensity rates from power plants in the interior west.

So I'll walk through the graph. On the Y axis is water intensity and gallons per megawatt hour. All of the bars are color coded so coal is gray, nuclear is purple, natural gas or oil is red. And on the left hand side of the graph are

conventional forms of generation. So a typical wet cooled coal plant would use around 550 gallons of water per megawatt hour of electricity. A nuclear or a conventional gas steam plant are a little bit more water intensive than a coal plant. And a combined cycle gas plant uses about 1/3rd as much water as a conventional coal plant.

Looking at some of the emerging technologies in the center of the graph an IGCC coal plant would be a little bit more water—excuse me, water efficient than a conventional coal plant. But tachyon carbon capture and storage typically has a energy penalty and so accordingly a water penalty. Retrofitting a conventional coal plant with carbon capture and storages—the tall bar in the center of the graph—that could potentially triple water use at that site.

And then water use for renewables is really variable. It depends to a great extent on the cooling technology employed particularly with solar thermal plants. We have two figures here: one for a solar thermal plant using wet cooling and one for a solar thermal plant using dry cooling. And then I'll just highlight again that solar PV and wind generally use no water.

So looking across the region this is a map that just shows power plants and their water use. And the figures here are estimated based on electricity generation data from EIA and water intensity data that was generated by NREL. And this is the same color coding scheme so the gray circles are coal plants, the purple is nuclear and red are oil and gas. And you can see the biggest water users in the region are the Palo Verde plant in Arizona, several of the plants in the Four Corners region, the Navajo Generating Station, Four Corners in San Juan, and then several plants in Utah and Wyoming.

So, moving on to the potential impacts of drought. I'd like to first present a couple of case studies of where drought has impacted power plants and then

we'll talk about management strategies. This slide demonstrates the results of a study from NETL from several years ago that looked at a model drought across the western region and how that would impact power generation.

And what NETL found was that electricity generated at coal plants generally declined because of the drought. Electricity generated at gas plants increased. Generation at hydroelectric facilities decreased and there was no change in electricity generated by renewable facilities. These changes in the generation mix had some secondary impacts. The first was that energy not served—or ENS—increased. The second was that prices increased and the third was that carbon dioxide emissions increased.

And again this is was a model study so I think there are couple of important caveats. One is that the actual impacts of a drought in the region would depend on water rights and a number of other factors. And the second is that long term or technology choices can act as a hedge against this risk of drought.

So there's a couple examples of where drought and water quality issues have actually affected power plants. One is the Laramie River Station in Wyoming. In early 2008, their cooling water reservoir was at about 10% of capacity. That was following about eight years of drought. And the power plant managers took a couple of actions: they purchased agricultural water from nearby and conveyed it by way of a 17-mile pipeline. That water then required some additional treatment and of course all of this had a cost. It's hard to estimate what that actual cost was.

I think the drought in Texas in 2011 is perhaps the most interesting and astounding example of where drought has impacted the power sector. In 2011, Texas saw their worst one-year drought on record. They saw both reduced

water supplies and increased temperatures and those increased temperatures led to record electricity demands particularly in late summer. Because of reduced water levels Texas reported that they had 11,000 megawatts of power plants that had record low cooling water levels and 3,000 megawatts of those power plants were at risk of potentially being curtailed if the drought continued.

That was in the fall of 2011 and fortunately the drought broke and they had some unusual rainstorms. So those power plants—about 3,000 megawatts was not actually impacted in the end. In the end only 200 four—excuse me, 24 megawatts of power plants were actually curtained. But Texas utilities also brought 470 megawatts of gas units online that had been mothballed and I think perhaps most interestingly the state curtailed 1,200 water rights that were in priority. These were senior agricultural rights for the most part and they were curtailed in favor of allowing water to continue flowing to power plants and to cities. As a result of all of this electricity prices skyrocketed.

And I should note those agricultural water rights that were curtailed some of the farmers actually sued the state of Texas in December. So that's an ongoing saga. And the drought this year is looking as bad as it was in 2011.

There's a couple of factors that potentially exacerbated or mitigated the drought in Texas. The first is that Texas has 10,000 or more megawatts of wind. Some of that was operating during the height of the drought and certainly long term having those wind turbines operating reduces the water use by the electricity sector in Texas.

Perhaps exacerbating the drought impacts was Texas transmission. It's a fairly small geographic area and the weather patterns affected the entire state. In parts of the interior west it's rare that we would see a drought in both the

southwest and the Pacific Northwest at the same time. And so having transmissions that links those two regions which are geographically and weather-wise fairly different may provide some insulation from impacts of drought.

So looking at these case studies I think the important question is moving forward how do we manage these water related risks? And how do we plan for future water scarcity? Particularly as power plants that are going in today will likely be in the ground for 30 or 40 or 50 years and as I mentioned earlier with climate change we are likely to see more severe droughts at least in the Southwest.

I think there's three key steps. The first is having good information that informs the decisions. The second is valuing water along with other externalities and the third is recognizing the risk of drought and the value of water efficient resources. And I'll talk more about each of these and give some examples of best practices from western utilities.

So the first is managing risk and having good information in our planning processes. And there's a couple of good example from the west. I think Arizona Public Service is probably leading the region in terms of how they're addressing water in their energy planning. They began reporting water use in 2009 in their 2009 resource plan and it's played a role in past sighting decisions at the Arizona Corporation Commission.

In Colorado utilities began reporting water use and water intensity in 2011. And water and the value of water was a factor in the 2010 Clean Air Clean Jobs Act hearings.

So just a few examples from Arizona Public Service and I apologize you can't see all of the graphs at once. The first graph in the upper left hand corner just shows water use in 2027. This is from Arizona Public Service's 2012 resource plan. So they are looking out over the next 15 years at how water demands might change over time.

Under their base case scenario they expect water use to increase and the two scenarios that I don't believe you can see on your screen: one is a high renewable scenario, one is a coal retirement scenario, and once is an enhanced renewable scenario. Or excuse me, one is their Four Corners contingency. So I think this is the first important step is just estimating how much water is going to be used under these different portfolios in the future and how does that compare to water use today.

The middle graph here APS also looks at how total water usage will change over time and how the water intensity of the electricity they provide over time changes.

And then in the bottom right hand corner, the third graph that was in this resource plan they looked at sensitivity. So how does water use change if we have a carbon price or if natural gas prices are high or if the production tax credit does or does not exist? So they looked at some of these sensitivities and the potential range of water use. And in this graph the green dots are the estimated water use under the base case and the blue bar is the sensitivity.

Xcel Energy here in Colorado also provides a good example: their 2011 resource plan. They began reporting the water intensity of their different power plants. So on the X axis of this is a list of their power plants and on the Y axis in gallons per megawatt hour the water intensity. They also note whether they own those water supplies or are under contract for them.

And then Public Service Company of New Mexico also lists water sources, water intensity and use. And they actually modeled a drought scenario in their 2011 IRP.

I think the second key piece to managing drought and energy water uses in the future is to look at valuing water. I think this is a tricky proposition because the value of water varies considerably depending on where you are in the west, what the potential use is if it's agricultural, urban or environmental uses, and how scarce water is in that place.

This map just illustrates one example of how variable water values can be. This is a map of municipal tap fees across the region and the red large circles are more expensive, the blue small circles are cheaper. Even two cities that are very close by like for example Denver, Colorado and Broomfield, Colorado are about ten miles apart but their tap fees vary by a factor of 10. And so that makes it really hard to estimate what the actual value of water is especially if you're looking out into the future.

This is a graph from Colorado. It reflects water sales to municipalities and I think the numbers here are less important. The trend is what's important. The orange line reflects the average price of water over time between 1987 and 2008 and the price spiked in 2002 and 2003 in part due to population growth and growing demands but also because of severe drought here in Colorado in 2002. I think this is the trend that we're likely to see in the future with ongoing drought and with climate change.

And just a couple of examples of how utilities are valuing water. NV Energy looks at the current opportunity cost of using water for power generation and Arizona Public Service models the cost of recycled water. The cost of

recycled water for APS is probably more expensive than what they're actually paying for water today but I think over the long term it's probably less than the value of water.

And the final step I think in managing for energy and water issues is to really recognize how water efficient energy supplies act as a hedge against the risk of drought. And there's a couple of ways to do this; one I mentioned earlier. Public Service Company of New Mexico or PNM is now modeling a drought scenario in their resource plan—or they did in their 2011 resource plan. The other is for electric utilities to include some kind of qualitative description of how a resource plan or an actual resource helps to mitigate against the risk of drought or helps to mitigate against water shortages. And we haven't seen any utilities in the region doing that to my knowledge at least.

So again, just to summarize, the three pieces that we think are essential to managing energy and water issues: better information, really valuing water, and recognizing the risk of drought. And with that I'll note that there are I think a few opportunities for managing our water particularly in the energy sector. Those opportunities really are aggressively pursuing energy efficiency, pursuing water efficient renewables, and looking at a smart transition of some of our more water intensive facilities to cleaner more water efficient forms of generation.

And with that I'll highlight a couple of pieces of sort of good news. This is some of western Resource Advocates recent research looking at estimated water use for power plants in the—or excuse me, power generation in the interior west. This is in the six-state mountain/west region. And what we have found is that water use appears to be at least declining in that region. It peaked in 2007 or 2008 and has been on the decline since then.

And there's a number of factors that contribute to this. The economy certainly contributes, the price of natural gas contributes but a portion of this is also attributable to clean energy policies. So this graph just quantifies how much of those water savings are due to clean energy events in the interior west. And the biggest savings are this white bar; those were in 2006 the retirement of the Mojave coal plant in Nevada. But each year there have also been incremental water savings due to renewable energy—the sort of orange rainbow bar—and also due to energy efficiency.

And our analyses goes up until 2010 right now I but I expect that we'd see a similar trend if we extended this out to 2011 and 2012. And I should note that these water savings due to renewable energy are almost entirely from wind power.

So to summarize, as we look for it again we expect to see less water available in the Colorado River Basin and the Southwest in general. And there's a couple key strategies to dealing with these water changes. The first is recognizing the risk of droughts and their impacts and the second is really making robust no regrets investments today. And again those investments should we believe be in water efficient and I believe carbon efficient resources.

So I'll wrap up there. I'll just note that on our website we have a few reports that include a lot of the information that I presented and my contact information is here too. And we're starting a new project now actually looking at agriculture and water and energy issues and if folks on the call are interested in that I would love to touch base with you offline.

So thank you and thank you again Ian, for putting this webinar together and giving us an opportunity to present.

Ian Baring-Gould: No, my pleasure. Thank you very much for both of your presentations. A number of questions have come in, and there are more coming in. So just for everybody else, if you don't remember how to do it go up to the Q&A tab on the top of your screen, hit that and you can type in a question there that will pop up and then we'll direct them from here.

So the first one to Paul: was your work done by ERCOT? Or funded I guess by ERCOT or NREL? And then was it consistent with what ERCOT and IEA estimates are and where do they differ from those?

Paul Faeth: The work was not done or sponsored by ERCOT. We connected with them, you know, for some information and we briefed ERCOT about the project and the results. You know, in terms of what's different we used ERCOT projections for demand over the period. So they make projections that go out to 2022 and we extended those projections.

But what's different is the, you know, for example the EIA, the model that they use—the (NIMS) model—does not account for water. So you can't run that model and say, you know, water will be limited or run scenarios that will tell you how much water savings that there might be. They do do carbon dioxide savings or changes and traditional kind of pollutant savings.

We have seen though ERCOT has done some studies about water use and they are concerned with that. I've also had a chance to speak with and brief the Texas Water Development Board and they are looking at opportunities, you know, to create more water and enhance their water supplies.

But the one area where I think it's similar is that because of this new transmission line as I mentioned earlier the ERCOT believes that, you know,

they said they're going to have a lot of wind coming in fairly quickly in the near future. And the scenarios the baseline and other scenarios kind of show a similar thing probably even later than ERCOT is saying. So the benefits are announced probably somewhat later than actually is probably going to happen.

Ian Baring-Gould: Great, thank you, Paul. Another question for you Paul from Larry Flowers and then I'll expand on this a little bit. But did you look at the efficiencies of dry or hybrid cooling scenarios in the work that you did? And then my kind of tack on to both of you is, do you see the wider use of hybrid or dry cooling which clearly has a cost impact on the power generation but is clearly a hedge against future drought conditions?

Paul Faeth: Yes. We looked at that and the data that we got, actually our data for water withdrawals and consumption actually, came from an NREL study done by a guy named Jordan Macknick. And in their analysis they show the possibility of using dry cooling for natural gas. And so we looked at it and we did include it as an option but with the declining price of natural gas in the future - or excuse me, of wind in the future the dry was less competitive than wind in the long run.

And the key element of all this too in terms of, you know, one of the questions that we struggled with was well how much wind is reasonable to assume that could be actually on the grid? And, you know, kind of conventional numbers that people have kind of have told me in a rule of thumb, you know, 20%. But, you know, ERKOT's at 28% momentarily and they've made changes to get to that level and they thought that it could be quite a bit higher. In other analyses by NREL for example show that you can go as high as 80% with renewables.

So we didn't let that be a limitation in terms of the overall penetration of wind into the power sector. And the dry cooling pretty much it wasn't cost competitive.

Ian Baring-Gould: Stacy, do you have any thoughts about the shift to dry or hybrid cooling in this sector?

Stacy Tellinghuisen: Well I'll just give a couple of examples of what we've seen in the west and that is that, you know, most of the new gas plants that have been built in Arizona and Nevada in recent years have used dry cooling. The coal plants that were proposed up until a few years ago in the interior west I think all proposed to use hybrid cooling of some sort and the new Comanche Unit 3 here in Colorado uses hybrid cooling.

My understanding of solar thermal is that it's really variable, that it's cost effective to use dry cooling if you're in a place like the San Luis Valley that's high elevation and cooler temperatures on average may be less cost effective if you're in Southern Arizona. But I think some of the proposals that have come in recently for solar thermal—it's been variable. Some of them have used water and some are dry cooled.

So that tells me that it's cost effective certainly in some places and depending on the utility and what I've heard from utilities too is that it depends on their regulator's perspective and maybe less on the cost effectiveness and more on some of the political issues around getting water for a new power plant.

Ian Baring-Gould: Great. Kind of a follow on question you had: why is water use in the Arizona Public Service enhanced renewable scenario high? Is it because of CSP?

Stacy Tellinghuisen: Yes, it is and that's a function of Arizona Public Service's model that they were using for their resource plan. So I think, in my mind I would question that whether that makes sense that all future solar thermal plants would use water. I think APS's current solar thermal plant—concentrating solar plant—is wet cooled. It's using water from, or replacing the water use at an agricultural area and actually using considerably less water than the old farming operation used. But I don't know if that's realistic to expect that all of the future solar thermal plants in Arizona would use wet cooling or not.

Ian Baring-Gould: Okay, great. Another question for you Paul, from (Richard Stellar). Why was solar not included in the analysis that you did?

Paul Faeth: We did include solar and we assumed that over the long term of the 30 years of the run that solar, the price of solar would drop by 50%. But it didn't, it was still not even at the end of the run cost competitive with gas or with wind. So it didn't really come into the solution. And right now even in Texas, you know, solar is a very small amount of the overall use. So, you know, what we relied upon… We did not assume things like, you know, cost breaks or whatever for the different technologies. And so, you know, as solar was one of the options that they choose from but again for economic reasons it just wasn't cost competitive.

Ian Baring-Gould: Great, thank you. Question that probably either one of you could ask that came in during Stacy's presentation. And it gets to the definition again of consumptive use by power plants. Is this water that evaporates and so is that water complete—when you say consumptive use is that water that's really taken out of the water chain?

Paul Faeth: Stacy, you want to take that?

Stacy Tellinghuisen: Yes. When I talk about consumptive use I do mean water that's evaporated. So most of the water is used to— in a thermoelectric facility is used to cool and condense steam so you'll see it in the wet cooling towers. And most of that water is used at least in western plants.

In power plants in the east that are located on big rivers or on the coasts even oftentimes those power plants will use once through cooling systems. And those systems withdraw a huge amount of water and put almost all of that water back into the stream at a higher temperature. But in the west most of our power plants use wet recirculating systems that do consume most if not all of the water that they withdraw. So that's net consumptive use for the figures that I referred to.

Ian Baring-Gould: And so gross would be water withdrawals and that's water that is taken out but could be put back into the system. But that's what the plant needs to be able to operate.

Stacy Tellinghuisen: Mm-hm.

Ian Baring-Gould: Okay.

Stacy Tellinghuisen: Yes.

Ian Baring-Gould: Great. Question from (Francisco Flores). Stacy, you say the natural gas use goes up during droughts. Why is that?

Stacy Tellinghuisen: I think you're referring to the NETL study and I think their analysis found that because electricity generated at coal plants and hydroelectric facilities was curtailed during a drought utilities made up for that by generating more power at gas plants, which are more water efficient. They use about 1/3 as

much water per megawatt hour as a coal unit. So that's why electricity generated at gas plants went up. And also I think that's a big part of why the cost of electricity under their model draw also went up.

Ian Baring-Gould: Great. Thank you. A question for Paul from (Trey Gibbs). Where did you get your water consumption numbers for nuclear and gas fired plants? He cites an NREL technical report in 2001 that says there's no kind of public database that talks about water consumption facilities. And to a degree Stacy, you could answer the same question about how where you were able to obtain these numbers.

Paul Faeth: Where we got most of our information was from an NREL study by Jordan Macknick that came out in 2011. And there are numbers in there that they culled from a variety of sources and put together which I think that's currently the best available single resource in terms of numbers for withdrawal and consumption.

There's a follow on study in a database that's scientist supported that also involved Jordan but also (Christian Averett). And that study—they took EIA data plant by plant for 2008 and they updated that information. They actually looked, using satellite imagery, looked at what power plants reported and what kind of power systems or the cooling systems they actually had and they made corrections to the EIA data. And that is a very solid database.

But since then EIA has also… so as recently as 2011, they've improved their data collection efforts. And so both of these now—and the UCS data is downloadable from the UCS website and they're searchable. So you can actually look by county or by state or by region, et cetera and get estimates for even for individual power plants that have been updated or, you know, for

regional water use. And that information is much better than it was a decade or a dozen years ago.

Ian Baring-Gould: Great, thank you. Stacy?

Stacy Tellinghuisen: Yes, and I would...

Ian Baring-Gould: Other sources that are out there?

Stacy Tellinghuisen: I would agree with that, that that information is getting better. There were a lot of errors in the EIA database up until a couple of years ago and I think slowly some of those errors are getting fixed.

We've used data from EIA, looking through it and trying to pick out sort of the data points that look egregiously off. And then also use data in the recent years from utilities that have started reporting water use in their resource plans. And, I mean, I think this really gets to the issue that this water use information is not always readily accessible or collected for all facilities. It still— as far as I know still limited to only to larger facilities. I think the cutoff is 100 megawatts and I'm not sure that nuclear plants are included in the EIA data collection yet but I could be wrong about that.

And so I think that's partly why we think it's really important that this data is in utilities' resource plans because it needs to be used in the decision making at some point. And there's a number of utilities in the west at least that still aren't reporting water use in their resource plans.

Ian Baring-Gould: Great. One last question. Has there been any analysis looking at impingement and entrainment and its kind of relation to renewable energy implementation?

Paul Faeth: Well I know, I mean, EPA is working on, you know, 316b which deals directly with that. But the rule hasn't been completed so far as I'm aware. And, you know, what that generally is calling for is… It'll basically mean that there won't be any new once through cooling technology and instead there'll be more of a focus on recirculating.

But the implications for renewables I can't speak to… I'm trying to think what that generally would mean in terms of cost comparisons. But it would be moving towards more efficient water use, more consumption but less withdrawals in conventional thermal cooling.

Ian Baring-Gould: Great, thank you. And again thanks to both of you for your presentations.

Just want to highlight the upcoming webinars. Our next one is on April 17th. It's going to be on offshore wind energy. I have tentative there because we're still trying to line up speakers for this one but feel pretty confident.

On May 9th we're going to have the WPA All States Summit webcast. And for those who haven't been involved in previous years we have the WPA Summit after WINDPOWER. But for the morning sessions where most of the presentations happen we do that on webcasts so people can phone into that and we'll be providing more information in regards to that.

And then we're kind of skipping the webinar—our standard format webinar series because of the summit for May. But in place of that we're going to do a Wind Energy 101. So it'll be different than what we've done here but an introduction to offshore wind energy for those people that have interest.

And then I do want to state again that the recordings of the webinars including PowerPoints will be posted on the Wind Powering America website in about

seven business days. If you actually want copies of the webinars, encourage you to contact Stacy or Paul and I'm sure they'd be more than willing to provide those to you if you actually need PowerPoints that you could use for other activities.

Lastly, just thanks to the U.S. Department of Energy that funds this work and we have listed our contact information there for Jonathan Bartlett at DOE and then both myself and Suzanne Tegen here at NREL. So if you have any comments about the webinar series, have other webinars that you would like to see please don't hesitate to contact us.

So until next month thanks again and thanks again to both of our speakers, to Paul and Stacy for the work that they're doing and then for the time in sharing it with us. So until next month thanks all and have a good day. Bye bye.