ENERGY-WATER
April 27, 2010

Coordinator: Welcome and thank you for standing by for today's conference call. At this time, we're going to go ahead and place all participants on a listen-only mode. We will have a question-and-answer session today, at which time all parties will be asked to press star 1, to ask a question or make a comment. I need to remind all participants today's conference, it is being recorded. If you have any objections with this recording, now would be the time to disconnect.

We're going to go ahead and get today's conference call started. I'm going to turn the call over to Mr. Larry Flowers. Sir, you can begin.

Larry Flowers: Good afternoon -- please put your phone on mute, please?

Welcome everyone to this important topic that's being sponsored by Wind Powering America.

We have been working in the Energy-Water Nexus for a number of years (unintelligible). (There's) been several presentations made. (Unintelligible) at wind power.

And today I bring you two experts in the field. Brad Udall, from the University of Colorado -- will be talking about water and climate change impacts. And Stacy Tellinghuisen, from Western Resource Advocates will be talking about the value of water.

To get this started, I want to spend a couple of slides to give you the context. If you look at the USGS statistics, you can see that we use more water for cooling thermal power plants, than we use for agriculture. This is not well-

known fact outside the water business, but water for cooling fossil and nuclear power plants are a big use of our nation's limited water supply.

Furthermore, there's a lot of issues around water and drought, in the West, historically, and now we're also hearing these concerns around the Great Lakes, and Lake Superior, as well as recently in the Southeast, with water to cool thermal power plants. And of course, this is the way that Governor of Colorado and Kansas solve their interstate water problems. And then we hope, we hope we can get past that in the future, with good water policy.

If you look at the relative use of water for alternative electricity generation, you can see it varies quite greatly. The classic coal, pulverized coal, over here, uses about -- this is consumption now, as opposed to withdrawal -- consumption, a little over 500 gallons per megawatt hour. Nuclear will be over 600 gallons. And combined cycle gas, which is a very popular electricity form, is a little bit under 200 gallons per megawatt hour.

Now some of the advanced technologies we talk about with coal, CCS, carbon capture sequestration, dramatically increases the water use. And so as we go down that route, in research, we need to keep an eye on that.

Even so, our concentrated solar power that's being promoted in the Southwest is a significant water user, and we have to go to dry cooling, as you can see, which dramatically reduces the water use, but also increases (in efficiency).

You can see the wind -- we use basically no water for cooling, and that is where the basis for the interest in wind as a water mitigation strategy for electricity generation. We've calculated, based on average numbers for the various RTOs, what the water savings is currently, by state. We've installed

wind capacity. As you can see Texas and Iowa, of course, the two big wind states, currently are saving billions of gallons of water annually.

And in Texas in particular, that's very important, because the Ogallala Aquifer, which extends from Texas up through Nebraska, is being depleted unsustainably through irrigation.

If you look at the 20% wind report, where we're talking about 300,000 megawatts of wind by 2030. We've calculated the water savings, and you can see water is being saved in all the right places -- in the Desert Southwest, Lower Colorado River area, in the Bonneville area on the Columbia and the Snake River area in Idaho, the Ogallala Aquifer, Texas and Oklahoma, the Great Lakes region up in the Lake Superior region, and even in the Southeast Region with offshore wind dramatically reducing the stress in that region.

So you can see that a 20% wind future saves about 4 trillion gallons of water that can be used for other uses.

Well Secretary Chu, a Nobel Laureate, his summation of the issue is there's a 2/3 chance that there will be a water disaster, and that's the best scenario.

So given that background, as far as the water challenge, problems, and the wind mitigation strategy, I want to introduce Brad Udall, who's the director of the University of Colorado and the National Oceanographic Atmospheric Administration's Western Water Project. Brad, please take over.

Brad Udall: All right. Thanks.

This is Brad Udall, speaking to you from Boulder, Colorado today, where my office is actually in the single largest NOAA lab in the country, the Earth System Research Lab.

I want to chat with you about a report that I and 30 other coauthors produced last year. It was done by the US Global Change Research Program, and released by the White House in June 2009. And it covers a whole variety of impacts related to climate change, including of course, water.

The report was led by NOAA. It went through extensive review. It was designed for the general public, unlike many of the climate change reports that come out. It drew on every other previous assessment that's out there, including those from the IPCC and the US Climate Change Science Program, including 21, what are called Synthesis and Assessment Products, that the CCSP produced over the last five years.

There were ten key findings in the report, and the fourth finding after some really obvious ones like climate change is occurring now and it's going to be serious, was that climate change is going to stress water resources. And what's intriguing about these two images here are the projected changes in annual run-off, which you can see, especially dire in the Western United States, 20% to 40% reduction. And these hatch lines indicate very good global climate model agreement, and then wetter areas in the East.

And what's intriguing if you match this up against changes in population from 1970 to 2008, where are we growing the fastest? Well we're growing the fastest in the Southwestern portion of the United States, exactly where we expect to see the most reductions in future run-off.

One of the things you hear over and over again, with regard to water resources and climate change is that wet areas are going to get wetter and dry areas dryer. And you can, again, see this in these projections of the U.S., where the Midwest gets wetter, and the Southwest gets dryer.

I often say that changes in water resources will actually be some of the most serious impacts associated with climate change -- it's not heat. It's actually changes in water resources. And there's a whole variety of reasons why this is true.

The water cycle is the mechanism by which the earth redistributes heat from the equator, where there's too much, the poles, where there's not enough. And that heat moves in the water cycle in the form of big ocean currents, like the Gulf Stream, and actually in the form of what's called latent heat -- that is when you vaporize water from the equator, the energy that goes into that vaporization, that evaporization, is actually retained in the vapor, and when the water moves somewhere else and condenses, that energy is released. It's that energy that powers thunderstorms and tornadoes, and even hurricanes.

As the atmosphere warms up, it'll hold a lot more moisture, not just a little bit, but a lot. Every 1 degree Fahrenheit means 4% more moisture holding. And so if you're looking at, for example, a 5 degree Fahrenheit increase by mid-century, which is certainly well within what the models show us. You've got 20% more moisture holding capacity.

One good analogy perhaps is think of the atmosphere as a big sponge. The sponge gets bigger under climate change, and not only can it hold more from evaporation, but when you wring it out, more comes out.

A warmer climate, globally, means more evaporation and more precipitation, but regionally there are going to be losers, and that includes those dry areas that I talked about before.

We expect storm tracks to change, and that's another reason why the Southwestern U.S. is going to get dryer.

And this diagram here, just talks about all the variety of changes we expect to see, and I don't think I'm going to spend much time on it.

The water cycle is already changing. We're seeing it from early peak stream flow, due to snowmelt driven runoff in the Western United States. The proportion of precipitation falling is snow, which is decreasing in most portions of the U.S. Mountain snow water equivalent, especially in the Pacific Northwest, annual precip we see increasing in most of the U.S., but decreasing in the Southwest.

Heavy precipitation events are increasing over almost all of the U.S. Mountain glaciers are receding in almost all parts of the world, especially in the U.S. western mountains and Alaska. We're seeing temperatures of water, increases in all water bodies; ice cover being reduced; longer periods of drought, and even thawing of permafrost in Alaska. And I'll walk you through a bunch of these changes.

These slides here talk about how heavy precipitation days have changed since 1958 to 2007. And even in places where we don't get much precipitation, like the American Southwest, we even see increases in heavier precipitation days.

When you look to the climate model future here, out to the 2090s, we're going to see the lightest kinds of days, the drizzle sort of days decrease, moderate

precipitation days not change much, and the heaviest days that these very high percentiles, 90th and 100th percentiles, the real flood-like days. And you can see both higher emissions where it's going to get perhaps as much as 9 Fahrenheit warmer at 2100, and more moderate emission scenarios here, where maybe it's only 6 Fahrenheit warmer.

One interesting corollary to this idea that floods and droughts become more common, and also these heavy precipitation days, is you get longer dry days. You get longer periods when it doesn't rain, and we see that this is worldwide in the climate models.

So here's another look at this whole idea that floods and droughts become more common. When you look at the data over the last 50 years, there's no clear national trend, but increasing temperatures have made many droughts more severe, and that's certainly the case in the ten-year drought that we're experiencing in the Colorado River system right now. Precipitation isn't necessarily a lot less than we've seen historically, but the runoff has been less, and the supposition here is that these increasing higher temperatures have caused problems or reductions in runoff.

As I mentioned before, the longer dry periods between precipitation events is something we're going to see. And again, this idea that storm tracks are going to shift in winter and spring. And the area that's particularly at risk in the United States, is the American Southwest, and you can these are precipitation changes in percent, with the darker colors include greater reductions in precipitation. Here's our lower emission scenario here, and then a higher emission scenario.

And the cross hatching, you know, indicates that many of these global climate models, or about 21 of them, consistently agree that you're going to see a problem in this area.

And I'll note, generally speaking, the areas we expect to dry in the United States are at about - or excuse me - in the world, are at about latitudes of 30 degrees; so 30 degrees North and 30 degrees South. When you look at the 30 degree North band, you see many of the world's great deserts sit there -- Northern Africa, American Southwest; 30 degrees South includes parts of South Africa and Australia, especially, and Australia, I'll note, has been seeing some very severe drought conditions over the last ten years, that most people believe are in fact climate change at work.

So I mentioned that precipitation and runoff are going to change, and precipitation especially increase globally, but recently you're going to see these changes. And the graph over to the left, we've already seen before.

Here's some other changes in the upper right, Spring, again you can see these declines in the American Southwest. You can see this band across the U.S., to the North, wet gets wetter, and dry gets dryer.

Summer -- our models aren't very good, I have to tell you, and very few changes, even though that's dark, those are fairly minor changes. But especially winter, you can see, and I'll note Mexico, is an area also at great risk for reductions in precipitation.

One thing where our models have showed us historically are consistent reductions in summer soil moisture. And when people think about climate, they sometimes don't much think about soil moisture and how important it is for buffering. Soil moisture is a very important feedback mechanism in our

climate system. When it's wet, and has been wet, that soil moisture actually keeps temperatures cooler than they would otherwise be. And when you dry out soil, then that's when the earth can heat up, and that's why almost all droughts are associated with extreme temperatures, because there's no soil moisture left, that buffer the sun's incoming solar radiation.

So another finding is that snow dominated areas are going to experience changes, and snow in the West is a natural reservoir for water. We're already seeing reductions, especially in the Northwest, the Pacific Northwest, and also the Northeast, at lower elevations. Not shown here is some interesting work that indicates below about 8200 feet in the Western U.S. where we've seen these reductions in winter snow pack.

And that corresponds in many parts of the West, areas where you have a difference in temperature between 31 and 33 degrees Fahrenheit. And of course, what was previously snowed, now turns into rain. In general, more rain and less snow in winter, and then advances in stream runoff timing in the West. We've seen 20 day advances already in parts, in the Northeast of 14 days. In the future we expect to see perhaps up to 60 day increases in runoff timing in the West and an additional 14 days in the East.

So these two graphs here on the left, this is observed trends from 1948 to 2002 and stream flow timing, and all these red dots here are areas where the streams are now running off earlier. And you especially see it in the Pacific Northwest where the mountains are lower, and hence it can get warmer. You don't see it as much in my home state of Colorado, and this historic period because our mountains are 14,000 feet, and if it goes from 10 degrees Fahrenheit to 11 degrees Fahrenheit, you still haven't changed the form of the snow.

These are projections, and you can see in end of century Colorado is no longer immune, or our elevation no longer provides a buffer, and almost the entire West is seeing these rather larger, earlier increases -- substantial increases in runoff timing.

And this is a study that came out in 2007 showing over about the last 55 years how snowfall has changed, as a proportion of total winter precip. And wherever you see a red dot on this map is in a place where we've gotten less snow. And it's almost throughout the country, and there's almost no area. A few odd little exceptions here, but almost without exception, more rain and less snow in winter time.

Another change you're going to see on an annual basis in snow dominated area is in the hydrograph. That is the annual pattern of runoff. And what you see here on the black line is how typically a snow dominated basin runs off. It peaks in June, and then quickly declines in August, and you have this low flow period out the rest of the year.

At the end of the 21st century, this peak here is going to shift earlier, and it depends on exactly where you are in the West, how much that shift is. And you also tend to see lower flows later in the year here. And so you have this longer period where the water can heat up, and you can have the negative impacts associated with low flows.

In some parts of the country, like the Columbia River Basin, we expect the areas under these two curves to be the same, actually. The same amount of runoff will occur. It'll just shift earlier.

So water quality and ground water are also expected to change in the future. Higher air temperatures will translate into warmer water temperatures and this

graph here on the lower right shows some temperature increases in Lake Superior, both air and water, since 1979.

There's some interesting metabolic effects with higher temperatures in water -- for critters that live in water. Warmer water can hold less dissolved oxygen. And so some people say, or term, that organisms that live in water may face a potential metabolic squeeze. That is to say the warmer temperatures increase their metabolism, but the oxygen that's in the water is actually reduced. And so they get squeezed from both sides.

Lakes stratify during the year, where the top waters and the bottom waters don't mix. And they turn over at -- the term is turn over. That is they can mix twice a year, once in the spring and once in the fall, because will occur later and the spring earlier. The summer period when the lake doesn't mix oxygen in from the top down to the bottom will actually be longer, with some potentially harmful effects for, again, aquatic organisms.

In general, pollution is made worse by higher temperatures and lower flows. And also the notion that we will have heavier down pours to date has been associated with more sediments. For example, in coastal areas, beaches get closed during heavy precipitation events, and all the crude that runs off into the ocean, all these sediments. And we expect those events to become more common.

Water quality and ground water, as I mentioned, are issues in the case of ground water. A large proportion of Americans use ground water. It's close to, I want to say, 1/2 or maybe 40%. You know, we don't much understand how ground water recharge will change under climate change. In some parts of the country, these heavier events may in fact increase ground water recharge. Ground water recharge, typically, is episodic. It doesn't occur after every

event. You have to have soils that get fully saturated for ground water recharge to occur. And so in some parts of the country ground water recharge may in fact increase.

Salt water intrusion in coastal aquifers is a big deal, as sea level rises that sea level lens that sits inland of the ocean, can actually push up against existing coastal aquifers, which in some places are valuable water sources.

Climate change is not just about climate change. And I think the skeptics in the world that get tired -- the true skeptics, I guess I should say about climate change, not the deniers -- frequently you hear over and over again, people get tired of, the sky is falling, with respect to climate change. And I guess to those folks I always like it say the 21st century, it's not just about climate change, but it's about climate change in the intersection of a whole lot of other stresses that the planet is facing.

You know, in many cases it's population stress. It might be some other form of environmental stress. In the case of some social systems, with regard to water systems, our water systems are already under stress in many places in the country. And this map, which was done by the Department of Interior's Bureau of Reclamation, in about 2002, identified the areas where we're going to see large or highly likely future conflict potential.

You can see, for example, in the Rio Grande, where there are endangered species issues already; the Lower Colorado, where there's all kinds of issues going on with regard to Las Vegas and Central Arizona project deliveries in the Arizona and the water pipeline here into the Los Angeles area. I mean here is the Big Delta area. All these systems are already under stress, and if you add climate change and population growth, an aging water infrastructure, that

is very expensive to fix, and all kinds of water disputes around the country, you have a mix that's particularly volatile.

And that's, I think, in many cases what you will see with climate change. It's not just climate change. It's how it intersects with other existing stresses, where we're going to see real problems.

So there was an interesting article that came out in Science magazine in 2008, and effectively this article, I think the title was, "Stationarity Is Dead: Whither Water Management?" Climate scientists and water managers have always used the idea that you could plan for the future based on the past. And this particular article in Science talked about how that's no longer true. It's no longer true in part just because how we expect the water cycle to change in the 21st century, how the physics of it change.

And even when you look back using (paleo) climate studies -- so for example, tree rings, or lake sediments, or corals, to try and discern the climate of the past thousand years or so. You can see in the case of many parts of the U.S., especially the Southwestern U.S., that the 20th century was quite unusual. In the case of the Southwest, it was quite wet relative to what we've seen in past centuries.

And this graphic here shows, going back to 800, what the different kinds of things we've seen. It was very in this period, in the West. So from about 900 to 1300, in fact, in the Colorado River basin, we see 60-year periods where you see 20% declines in river flow. And those kind of declines right now, we're we to re-experience them would literally, I think, break all the existing water management agreements.

This is the 21st century over here on the right, and it was quite wet. In fact the Colorado River compact was signed right in this period -- one of the big (boo-boos) if you will, of Western water management.

And there are a lot of institutional barriers that change in the West. You know, all the laws and decrees, and compacts frequently have standing in law, and they're difficult, if not impossible to change without a major crisis.

The way we operate our reservoirs, they all have -- most of them have flood control rule curves that are subject to environmental impact statement process and are very expensive to change. In fact, most reservoirs have never had their flood control rule curves revisited once they were put in place, for example, in the 50s and 60s.

Agricultural water, which in the West is about 70% of consumptive use, everyone thinks will be a source, but it's particularly difficult and contentious to transfer it to other uses.

A whole area we know very little bit about is how water demands will change in the future under higher temperatures. A recent study here in the state of Colorado, on the Colorado River, indicates by mid century, perhaps 18 day increase in the growing season, with a 30% increase in water demand for crops. And by near end of century, almost a 30 day increase in growing season with significant, I want to say on the order of 50% increases in water demand.

So in the 21st century, water management is not going to be as simple as it previously was, where you just looked at the past and decided -- okay, those were the bounds of what I need to plan for, and I will just do that.

It's far more complicated than that, and to be honest, the water managers I work with right now are scratching their heads trying to figure out -- okay, how do we deal with this new system, this new client system, with so much uncertainty? Do we need to look at other tools and techniques to help us plan for the future, aside from just looking at hydrology? Are there other ways, for example, to share the risk?

When we wrote this report, Global Climate Change Impacts in the United States, we picked, I want to say, roughly six or seven sectors, energy, biodiversity, health, agriculture, water of course -- I probably missed a couple.

And then we also covered, I want to say, roughly six regions, or seven regions of the country. And it was very clear during the initial drafting of this document that water was quite special. That it was unlike all these other sectors.

And this slide here speaks to the interconnection between water and almost everything else we do. You can see human health and the connection to heavy downpours and waterborne disease.

I'll speak about the connection between water and energy use in the next slide. But specifically speaking, you know, you can see reductions in hydropower in certain areas. And with fossil fuel and nuclear plants, if increased water temperatures occur in some places, plants may have to shut down.

Transportation is often times affected by floods and droughts. In the Great Lakes you can actually reduce cargo capacity significantly, when the lakes go down and floods have obvious impacts on transportation.

You know, agriculture and forestry, obviously connected to water.

And ecosystems, you know, one of the biggest issues associated with climate change because of the adaptive capacity that plants and animals have, given the rate of change, is not nearly great enough.

So I would say over the last three or four, maybe five years, people have become very aware of this idea that water and energy are linked. Energy systems use tremendous amounts of water, and water systems use large amounts of energy.

Let me talk about the water sector first, because that's the area in which I specifically work. Major water providers in the West use huge amounts of energy. Central Arizona projects water 300 miles and 3000 vertical feet in Arizona, and needs 400 megawatts to move that water around. This is hydropower in reverse, right? It's 1.6 million acre feet of water a year. It's a huge amount of water being move to Phoenix and Tucson, and has a corresponding, very high energy utilizations that state water project in California uses 2% of all electricity in that state, the single largest user.

In Las Vegas, they have to pump water out of Lake Mead a thousand vertical feet, and to supply 2 million folks there, they use about 100 megawatts to get it up and over the hill.

We think something like 4% of the nation's electricity goes to pumping heat and treating water and wastewater. When you look to the future and decide what sources of water to utilize, those sources have vastly different energy profiles, desal. being the classic energy pig -- conserving water, actually having no energy associated with it. And all kinds of things in between, and I think the water management community now is beginning to look very much at their energy footprint associated with new water supplies.

The energy sector use of water is in large part, what -- well Stacy is going to talk a little bit about that, and Larry talked about the withdrawals and how cooling water withdrawals are very large, almost equal to agriculture. It was interesting to note that just a couple of weeks ago the State of New York decided to not renew the Indian Point Nuclear plant, (once through) cooling water permit, which was a large amount of water. I want to say it was over 1000 cubic feet per second, which is a very large river. And when that permit expires sometime in the next several years, they're not going to renew it.

These kinds of issues, I think, are going to come up in the future, and they're going to be direct and center as we deal on a carbon constrained and a warming world and we're going to need to pay attention to them.

So these are the -- this is my last slide. These are the key findings. We're already seeing changes in the water cycle. And those changes affect where, when, and how much water is available for all uses. Floods and droughts are likely to become more common and more intense, as regional and seasonal precipitation patterns change, and rainfall becomes concentrated near heavy events.

We're going to see precipitation and runoff likely to increase in the Northeast and Midwest, and decrease in the West, especially in the Southwest. In areas where snowpack is a dominant source of water, the timing of runoff will continue to shift to earlier in the spring, and you'll see lower flows in late summer.

Service water quality and ground water quantity will be affected by changing climate. We're going to additionally stress our water systems with climate

change, and of course, the past century is no longer a reasonable guide to the future.

And with that Larry, I'm done.

Larry Flowers: Brad, thank you very much -- very interesting and intriguing set of slides and certainly something to reflect upon as we plan for the future and we'll come back to you with questions.

But now I want to turn to Stacy Tellinghuisen. Stacy is an analyst at Western Resource Advocates, one of the leading authorities on water management and conservation, and law in the Intermountain West. And Stacy came from the University of California, Santa Barbara, under Professor Bob Wilkinson, where I (got) to know her.

And we have funded, we being Wind Powering America, has funded Western Resource Advocates to do a series of studies on this area of energy and water. And the most recent has been trying to value water. So in the value proposition when we talk about wind energy versus alternative generation, new generation, we look at a lot of impacts and benefits. And one of them, of course, is water.

And so the question is how do we value the water that is saved? And so we've asked Stacy and Bart Miller, at Western Resource Advocates to look into that issue and she will report on that at this time. Stacy?

Stacy Tellinghuisen: All right. Thank you, Larry.

And thanks, Brad, for that great presentation.

I think when we think about the water and climate challenging in the Southwest, it can feel a little bit daunting. I think that's increasingly becoming true throughout the country. But I think here in the Southwest we at least have some tools for thinking about energy and water planning together. And I'm going to talk about one of those tools today, and that is, you know, how do we think about the economic value of water when we're thinking about electric resource plans. How should a utility and how should regulators really value that water?

And can you see the second slide?

Brad Udall: Stacy, this is Brad. No.

Larry Flowers: We can -- I can see it, Stacy.

Stacy Tellinghuisen: You can see it?

Larry Flowers: Water (intensity) electricity?

There we go.

Stacy Tellinghuisen: Okay, good.

Okay, so this is the slide that Larry showed earlier, so I won't spend any extra time on this. But I just want to emphasize, again, that these are values for typical Western power plants. And it's water consumption. So it's gallons per megawatt hour for electricity generation. And again, as Larry highlighted earlier, wind here, uses no water for electricity generation.

One point I wanted to make, the numbers here for geothermal generation look very high. Most geothermal power plants actually use geothermal fluid for their cooling sources. So they don't actually compete with other fresh water demands like agriculture or cities.

So what does this mean for the Southwest? I think it's important to put this in context. And I should say throughout this presentation I'm going to focus really on just the Southwestern states, the Colorado River basin states, with the exception of California; so Nevada, Utah, Wyoming, Colorado, Arizona, New Mexico.

There are about a dozen large thermo electric power plants in the basin that rely directly on water from the Colorado River or its tributaries. Most of those power plants are large thermoelectric coal plants, and this map shows us power plants. The circles are color coded based on the future. And they are also sized accordingly. So the large power plants in the Four Corners region, the Navajo, Four Corners, and San Juan generating stations, they all use between (20,000) and 30,000 acre feet of water per year.

And just for reference, an acre foot is around 326,000 gallons of water. It's enough water to sustain about households for a year. That's consumptive needs.

And the Colorado River basin, I guess, is an important basin for us to think about, and the reason why we're focusing on it is because water is fully allocate in the basin, and today water really is fully being used in the basin as well. So any new water demands for power generation, or to sustain municipal growth, those new demands are going to impact existing users. And in most cases that's going to be agricultural users.

I think we could think also about the benefits of, you know, removing some of these big users from the system. Can we replace some of these big water users with wind or other water efficient resources, and have some benefits.

I also want to know if there's a handful of power plants that are in the Basin, that don't use Colorado River water. So for example, the Palo Verde nuclear plant is located down in Southern Arizona. It relies on recycled water, about (60,000) to 70,000 acre feet per year. That water, at least in theory, could also be made available to meet municipal demands.

So thinking about these water uses, we wanted to look at what is the value of this water. If it weren't used for thermoelectric generation; if it could be used to meet urban demands or be used for agriculture, or for environmental needs. Those are sort of the three primary categories of uses that compete with electric generation.

So, the first one of those is the municipal value of water. We looked at water transfers, permanent sales from farming or other entities, to cities. We looked at new municipal proposed water supply projects. And then we also looked at municipal tap fees. And most Western cities will charge a tap fee to a new house, or usually the developer pays it. And that tap fee represents a volume of water 1/2 an acre foot for a year or so.

Those tap fees vary considerably from city to city, and to some extent they're function of political factors. So a city that's really encouraging growth might have a lower tap fee. But at least in theory, a tap fee should reflect the cost of developing a new water supply or upgrading a treatment plant.

So what we found is not surprisingly the value of water varies considerably throughout the region, from state to state, and also depending on which metric

you look at. So states like Colorado and Arizona and Nevada, which really are facing the biggest challenges in terms of water, those are the states where the value of water is highest.

And the values for all states range from $50 per acre foot per year, to around $1600 per acre foot per year. It depends a lot on location and scarcity. And as I mentioned before, other political factors.

Thinking about location, it's interesting, the City of Denver might charge a tap fee that's around $5000 per acre foot, but just ten miles away, in the neighboring town of Broomfield, the cost of that water might be ten times as high. And that's just that fact that Denver has pretty robust, reliable water supplies, and Broomfield is looking for new water supply projects.

This is just a map of those tap fees and these values aren't annualized, but they are on a common metric. And you can really see the diversity. So I think this is Flagstaff down here in Central Arizona. The cost of a tap fee there is over $45,000 per tap, per acre foot.

Here in the front range of Colorado the cost of water is all over the place.

And so I think when we started this project, we thought, well maybe we'll be able to come up with a value for water that's similar to a dollar per ton of carbon emitted. And what we have realized is that because water is so heterogeneous, you can't really come up with a dollar per acre foot value. But you can come up with a pretty good range.

I want to make a couple of applications of this data.

Most new thermoelectric power plants are probably going to be located in rural areas, where they can purchase water from farming communities for pretty cheap. But there are a handful of aging power plants in urban areas where if those power plants were retired that water could be transferred to a nearby city.

One of those examples is the Cherokee plant in Downtown Denver. And there is legislation just passed this winter in Colorado that's going to encourage (accel) to retire, three of its aging coal plants, Cherokee being one of them. And if we look at the value of the water used for Cherokee on an annual basis, it's almost $5 million per year. So if we think about retiring Cherokee five years early, the total value, economic value of that water could be as much as $25 million.

Reid Gardner in Southern Nevada located pretty close to Las Vegas -- if that plant were retired, that water could be transferred to the Southern Nevada Water Authority, which serves Las Vegas. And the value of that water, it would also be around $5 million per year.

The three big coal plants in the Four Corners region -- Four Corners, Navajo, and San Juan -- they're all using water from the Colorado River. And I think if those plants are retired you could conceivably move that water from those power plants to urban areas, like Phoenix, Tucson, and Albuquerque.

As I mentioned, before though, most new power plants are probably going to be (sited) in agricultural areas, where they're going to purchase water from farmers for fairly cheap. And so we also -- it was really important for us to look at the cost of water and the value of water for agriculture.

We looked just at permanent water transfers, and again, we annualized these permanent -- the cost of these transfers over a 30-year term at a 4.75% discount rate.

And this graph on the side just shows all of the transfers that have occurred over the last 20 years. And the blue squares are Colorado. Colorado has one of the only well-functioning water markets in the West, and that's in the South Platte Basin. And then the light-blue diamonds are all of the other transfers in the other five states.

One thing that I think is an important trend is to look at how the price of water has changed over time in Colorado. I think this is a story that we're likely to see replicated throughout the West, with population growth, and especially if climate change decreases available water supplies. Colorado experienced a major drought in 2002 and 2003 and that combined with population growth caused the price of ag. water to spike. And most of those transfers were to cities.

And then finally, the value of water for environmental use, as we looked at in stream flows, willingness to pay studies and revenue generated by white water parks and recreation. And again, as with the other values of water, it's kind of all over the map, but the value is pretty high in Colorado, where we have a very robust in stream flow program. It's also high in Nevada for various political factors.

And then it's quite a bit lower in Utah. And I'm not sure if Utah has any in stream flow rights. And so they don't necessarily have the political infrastructure set up to sell water to environmental uses.

So just to compare the value of water for all of these different needs, you see from this graph the different types of uses are broken out by color. So, municipal uses are red, environmental, green, and ag. transfers, blue. The highest values in every state is really a municipal use.

And then environmental and ag. uses are a lower value use. I think one issue is that the value of water for environmental uses is not necessarily very well-represented by the price people pay for it. There's a lot of factors, like the fact that keeping water in the stream helps to dilute waste water treatment plant discharges. And those values really are not accurately reflective here.

So I guess I want to talk a little bit about some of the good examples that we're seeing in the Southwest, and I hope that these may be replicable in other states. There are two states, Arizona and Colorado, that are starting to do a better job of integrating energy and water.

And first, I'll talk about Arizona.

The Arizona Corporation Commission has a proposed rule-making right now to figure out how to value water when it evaluates electric utilities resource planning processes. The Corporation Commission has a history of thinking about water in terms of evaluating power plants. They rejected two merchant power plants earlier this decade, based on water impacts. And then in one of their dockets they noted that generation -- this in particulars with regards to a solar project -- but would result in environmental benefits and lower energy specific water usage.

So they are aware of the benefits of certain technologies in terms of water usage. We didn't find -- interestingly, we didn't find any examples of where the Arizona Corporation Commission had evaluated the water savings

associated with wind. So that seems to be one gaps today in their resource evaluation.

Not surprisingly, Arizona Public Service also thinks about water in their electric planning, and I would say APS is probably the most progressive utility in the West in terms of integrating energy and water today. And their resource plans, they report water use in gallons per megawatt hour, for both their current and future resource plans. The company also assumes that any new gas plant would be dry cooled. But they don't have similar assumptions for new base load power plants.

And I think at a minimum we'd like to see other utilities around the region reporting water use for their current and future resource plans. It's sort of a very basic and important piece of information that I think regulators and decision-makers need in order to evaluate different plans.

In Colorado, voters enacted Amendment 37 earlier this decade, which was our first renewable portfolio standard. And a part of that amendment noted that adopting the RPS would help minimize water use for electricity generation.

The Public Utility Commission has also invoked those same sentiments, and in fact, in 2007, they noted that evaluating water savings and other environmental benefits through their costs being embedded in resource generation bids was an important step in factor externalities in resource planning. So I think that is really significant progress on integrating energy and water.

In terms of the utilities here in Colorado, Xcel Energy, our public service company of Colorado, recently selected a dry-cooled, solar thermal plant in the San Luis Valley, in part because of the water savings. And to our

knowledge they didn't do a sort of quantitative analysis of the value of that water, but it was just qualitative.

Interestingly, Xcel has been really progressive on adopting wind, also, as a part of their resource planning efforts, but they have never noted the water savings associated with wind. So I think that's another gap that we should look at in the near-term.

Tristate generation and transmissions, there's a lot of the rural co-ops in Colorado. They have a new resource planning process. And in that process they will report water use for both existing and proposed facilities.

And we have some data from both New Mexico and Nevada. And I don't have slides on those here today, but if people on the phone are interested, I'll be happy to share that information.

So just to summarize a few (of) for the take-home points, we heard from Brad earlier about the water strains, particularly in the Southwest. I think we could say that water is incredibly valuable today, but if climate change advances and population continues to grow, water is only going to become scarcer and more valuable.

And new thermoelectric power plants in the West would lock up water supplies for 40 to 50 years. And I think that lifespan of those power plants have to be considered when we're thinking about committing our water to those uses.

I think there's some key opportunities for us. When you look at this map here on the left, this is a map that's from the Western Governors Association, from their Transmission Planning Authority, and you look at the really windy

regions in the front range of Colorado, parts of New Mexico, and parts of Arizona, these are all places that are facing real water scarcity issues. And so I think to the extent we promote wind and replace water thirsty facilities with wind and other water efficient resources, it can help us meet our water needs in the future.

There's other technologies other than wind, that also have important water benefits, energy efficiency, certain forms of combined heat and power, microturbines that use biogas generated at landfills or wastewater treatment plants, solar photovoltaics, geothermal, and certain types of solar thermal systems, if they're dry-cooled, those can all also have water benefits.

So, just a couple of key recommendations that I've touched on throughout.

First is for utilities, I think an important first step, again, is for utilities to evaluate and project water use for their future resource plans, and also evaluate water use at existing facilities. That's a really important piece of information that most regulators don't have today.

The second key recommendation is to regulators, and that is that they consider the value of water today, and in the future. And I think we need to be assessing the opportunity costs of locking up water in a power plant for the lifetime of that power plant. Whether that opportunity cost is lost, agricultural revenues, or forgone opportunity to use water for urban or environmental needs. There is a real value to that water.

And I think I will stop there, and I think, Larry, we have time for a few questions.

Larry Flowers: Yes. Thank you, Stacy. Thank you, Brad.

Stacy Tellinghuisen: Thank you.

Larry Flowers: We're now going to open up the lines to questions. The operator will facilitate this.

But as we're doing that, I wanted to ask you, Brad, what's the significance of a change in timing of runoff? What's the significance of that in sort of practical terms?

Brad Udall: (I think) it depends on where you are in the West and what your issue of concern is. You know, in the case of environmental systems, that shift in timing can be quite significant, especially those with lower flows, lower, warmer flows later in the year, where trout, for example, in many parts of the West are expected to become stressed because of dissolved oxygen levels falling to levels where they can't live.

For human systems, it depends. You know, in many parts of the West we have these big reservoir systems, and it may be that there isn't really much change in the human operation of these systems.

Although, in some cases, for example, in California, Larry, there's some worry that this earlier runoff will coincide with the potential for storms in the Sierras and they're going to have to change their rule curves. That is to say they're going to have to release more water out of these reservoirs to plan for flooding, but then they won't be able to capture it when it runs off.

So (I mean) there's a lot of complexities associated with this, depending on exactly where you are.

Coordinator: Excuse me. This is operator. Can I go ahead and give parties instructions on how to queue up for questions?

Larry Flowers: Yes, please.

Coordinator: Anyone wishing to ask a question at this time, we're going to ask you to press star 1, now. Please remember names were not taken as you joined today's conference. So it's very important at the prompting to be able to make sure your line is unmuted and you state your name loudly and clearly at the prompting. Once again, it is star1, to ask a question. If you need withdraw a request, it is star 2. Star 1, to ask a question, and standby for the first question, please.

(Ron Lehrer), your line is open. Go ahead, sir.

(Ron Lehrer): Yes. I wondered if Brad has any information about the role of forest fires. The Denver Water Department found out that the water doesn't really come out of the stream. It comes out of the forest.

If the forest burns down and then the hillside slides into the reservoir it ruins your day. And I wondered if you'd take a look at that and had any ideas about it?

Brad Udall: Yes, Ron. How are you doing?

(Ron Lehrer): (Unintelligible)...

Brad Udall: So, yes, in the case of Denver, you're right. It's had two major forest fires in I want to say the last ten years, and both have led to large increases in sediment

in their reservoirs. And some very expensive dredging to get sediment out or work to mitigate potential future soil losses into rivers and streams.

You know, the fire question is fascinating. There is a great piece in Science -- front cover piece in Science a couple of years ago by Tony Westerling. And effectively since about 1986 we're seeing a large increase in the number in fires, and the number of very large fires. The fire season is actually getting longer on both the beginning and the ending portion of the season. And it seems to be very tightly correlated with increased temperatures.

So going forward, fires are certainly something that we have to be worried about, both with regard to natural systems, and our human systems that deliver water.

(Ron Lehrer): Thanks.

Coordinator: And this is the operator. At this time, I have no one else standing by with a question.

Larry Flowers: I'll answer...Brad, I'll ask a question. This is Larry.

I've seen graphics on evapotranspiration, and the big driver of that of course is increased temperature. Evapotranspiration increases by mid century in the West, of 25% to 30%. How does that impact agriculture and other water uses?

Brad Udall: You know, Larry, this is actually, you know, like a lot of the science, it's interesting and complicated. And people hate to hear that word, but...

So there is a thing called the CO2 fertilization effect. As CO2 levels rise in the atmosphere, it turns out that plants are more efficient and effective at pulling

CO2 out of the atmosphere. And at the same time, believe it or not, they're more efficient at evapotranspirating. That is to say they use less water. The little openings in which they take CO2 out and release water vapor, they do this, they're called stomata. And those things actually can tighten up and function more effectively.

So there's a period of time under warming where it actually looks like plants maybe do okay. But at some certain point, and depending on exactly how warm it gets and what mission scenario is driving that warming, those gains, if you will on efficiency are quickly negated. And the numbers I had for you out of that State of Colorado study on the Colorado River were quite stunning. You know, the 18 day increase in growing season and 30% increase in water demand by 2050. I'm not sure how much that particular study dealt with this very interesting question of increased plant efficiency and it's something that's actively under study.

But I think you're going to see, potentially, some movements in agriculture in where crops are grown. Again, winners and losers, the Canadian Great Plains, for example, may become a better place to grow crops because it's going to be warmer for longer periods of the year. And our mid-continent may, in fact, be less favorable, because it's going to get warmer and dryer.

Coordinator: I do have one more person standing by with a question.

(Victoria Pebbles), your line is open. Go ahead, ma'am.

(Victoria Pebbles): Thank you.

I guess I have two questions.

One is I would love to see this kind of webinar repeated with the focus on our region. I'm with the Great Lakes Commission, and I work in the eight state, two province, Great Lakes area. I found on the type of work that you're doing, very, very interesting.

We have -- I'm wondering if there's any intention, either Brad or Stacy, in looking at the impact of tradeoffs with 316(b) changes in regulation looking at moving to closed loop withdrawal systems. You mostly have closed loop I think in the West, but looking at that on a national or either on a regional scale.

Brad Udall: Stacy, do you have any thoughts?

Stacy Tellinghuisen: Yes. My understanding, we are mostly on closed loop systems out here. So, most of the water use is consumptive.

I think (metal) did some research on this a couple of years ago about the increased water demands by shifting to closed loop systems. And I think there is substantially more water consumed for power generation in the East and in the Midwest -- other parts of the country when that shift occurs. But I think that's something like 1% of the amount of water that's withdrawn today.

So, you know, I'm less familiar with the East, but my sense is that the pressures and the challenges are very different between the West and East, whereas out here, our focus, our concern, is really around consumptive use. In the East, the bigger issue today might be water quality and temperature impacts.

Brad, do you have something to add to that?

Brad Udall: Yes, you know, (Victoria), we obviously did focus on the American Southwest, in part, because that's where we're based. But I think no matter where you look in the country there are water problems. You know, you see the Southeast, for example, Georgia, Alabama, and Florida going at it, with the Governors literally leading negotiations on some of these river systems that feed Atlanta its water.

And in the Great Lakes, a lot of interest there and as you well know, the new compact is fascinating, and a lot of long-term concern on the health of that system. Chesapeake Bay is another area; the Everglades. Almost everywhere you turn, there are water issues.

And in large part, I think it's because the population has grown and our demands have grown to meet the supply. When you look at USGS figures on total water consumption in the United States, it plateaued around 1980. And the big question is well why did it plateau? And I think it plateaued for a bunch of reasons that deal with environmental issues. There actually wasn't that much more water to take by gosh. And that's why it plateaued. And at that point in time, at least we began to think about how to better operate these systems.

Larry Flowers: And (Victoria), this is Larry. You know that closed loop cooling actually consumes more water than once through cooling?

(Victoria Pebbles): Yes, I'm really well aware of that, and we're struggling with that because most of our plants in our system here, at present, are on open loop systems. Although when the 316(b) rules are finalized, new power plants will have to convert.

But I know that Brad mentioned the denial -- the New York decision recently, and sort of thinking about how that's going to impact our region.

We are mostly, as Stacy mentioned, concerned -- moving beyond the quantity issue, which looking at the quality impacts and the thermal impacts of great concern for our region as well as complying with the conservation provisions of the Great Lakes water resources compact.

And so, like for example, Ontario is ramping up its hydro. and trying to take off coal fired power plants. But in light of climate change, as you noted Brad, what is the ramping up of hydro. look like in a carbon constrained world, or with increased droughts and floods as you mentioned, and the reliability of that feeding into the entire Great Lakes regional energy system. We don't have a regional energy, or regional power authority. It's kind of done on a jurisdiction by jurisdiction basis, and more than one of our states doesn't even have integrated resource planning or regulated electric utility systems.

Brad Udall: Yes, (Victoria), one of the interesting things about what you just said is, what I've noted in the West here is, in this state in particular, a movement from local planning about water, to a realization, three or four years ago that we can't do this locally. It's all connected, and it needs statewide effort.

And it's a little bit -- it's almost as contentious as, for example, doing education stuff, not locally. It has required many people in this state to rethink how we are going to use our resources and to begin to cooperate and communicate in ways they haven't previously.

Stacy Tellinghuisen: And I would just actually add one other thing to that, Brad, and (Victoria), and everyone. You know, I think we're starting to see more regional planning on energy and transmission issues too. And I think when we look forward to

the future, we have to evaluate a lot of these different energy scenarios under the lens of climate change and what are the potential scenarios. And so how do we plan for reliability and avoid risk of water shortages, whether it's water shortages for hydropower, or for thermoelectric generation, whether renewable or fossil fuel.

So I think, Brad, your point, that you made in your presentation about stationarity is dead and the way we planned for water in the past is not going to work for the future. I think that's also true for energy resources.

Larry Flowers: (Unintelligible) this is Larry.

Do you see an increased dialogue and seriousness between the water managers and the energy planners?

Brad Udall: Are you asking me, Larry?

Larry Flowers: Yes. Because I went to a Western Governors Association Water Managers meeting several years ago, and it didn't seem to me that there was a very active dialogue between electric utility planners for new power plants and thermal cooling, and the water managers, in other words, the municipal water managers and planners.

Brad Udall: I think that's changing. It still has a long ways to go.

You know, there are a few utilities in the West that are both water and power, and those are very interesting entities, like Colorado Springs, Salt River project in Phoenix, Imperial Irrigation District -- and the Central Arizona Project, which owns a large chunk of the Navajo generating station. And those folks, I think, begin -- already understand this connection.

The rest of the water utilities in the West that have no direct connection to energy, maybe have a ways to go, and I'll bet it's really regional. Like in this state -- and again, I'm sorry I'm so parochial, but it's where I live and work -- gravity has been our friend. Those mountains, everything flows downhill and it's great. But almost all the new water projects in this state involve large amounts of pumping, hence energy, and that's forcing people to rethink things.

Coordinator: And I do have someone else standing by with a question.

(Ron Lehrer), your line is open. Go ahead.

(Ron Lehrer): Yes, Larry, I just wanted to mention that the renewable -- I mean the regional transmission expansion planning process at the Western Electricity coordinating council has a water component. And I was with those people last week and told them about the work you've done, trying to bring these two things together. So I think you'll see some interest at the regional level; (that's) the level at the grid, the Western grid planning process. And maybe we can make some progress there.

Larry Flowers: Okay, folks, I want to thank you for hanging on here. We had almost 50 people at one point. I want to thank Brad and Stacy, not only for this presentation, but for the great work they're doing, and the important work they're doing.

For those of you who are still on the phone, who will be at Wind Power, I'll be delivering a podium presentation on the wind-water nexus with local, or emphasis on the wind aspect of this. This is an important area, a growing area, an area that Wind Powering America wants to continue to keep in the forefront, because of its not only importance, but also because of the

important role that wind can play in mitigating this issue, especially in the face of climate.

And so thank you again, Brad and Stacy, and thank you folks for joining us. This has been recorded, and will be on the Wind Powering America Web site for further review.

So thank you, and good afternoon.

Coordinator: And at this time, all parties may disconnect from the today's conference. At this time, all parties may disconnect from today's call. We thank you for joining and have a great day.

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