FEMALE: So, we've talked a lot about the components of the model, and we've started to talk about the risks and scenarios. We'll focus a bit more here, in session four, on the scenario modeling. Molly will also come and talk a bit more about how to incorporate the climate change into scenario modeling, as well.

So, this is just, you know, this graphic is really presenting the steps we saw earlier. Steps one, two, and three. Collect data, develop data, develop-- design the goals and metrics that you want to evaluate on the first step.

The second step is, you know, what portfolios can achieve those goals? What resources and combination of resources can help you achieve those goals? And that, at the end point, gives you optional resource plans. As we move on, we'll start to consider different scenarios.

So, now that I have a set of resource plans, or a resource plan, what happens if the assumptions that I made to develop that resource plan don't happen,

right? Don't occur. If the load growth is half of what I planned for. If the fuel prices or the fuel availability is much more or much less than what I planned for. If the cost of developing a new hydro resource or a transmission resource is much greater than what I was initially planning for. We evaluate that through scenarios.

What we can also use scenarios for, are examples that Augusta had brought up earlier about a resource--a renewable resource zone, right? We could look at a scenario of renewables versus a scenario of not. That will give us two different portfolio options that we'll start to consider under these same risks. One renewable portfolio, one nonrenewal. Well, it might still have renewables in it, but it's not going to be a resource renewable zone, for example.

So, under each of these scenarios, our outcomes are going to differ. And can anyone think of what outcomes? When I say outcomes, what am I talking about in an IRP? We've got portfolios. The scenarios might be different load levels, different fuel

prices. What are the outcomes that could vary in an IRP planning? What are the metrics that we'd evaluate with an IRP plan?

FEMALE: Costs?

FEMALE: Costs, yes. We want to know how much we're going to invest. What are the revenue requirements that a utility or an investor will face? How do those vary in these scenarios? Is one scenario more risky than another? Is the bandwidth of investment so wide that it doesn't make sense in a given portfolio?

Emissions, our goals might be related to emissions, the tonnage of $CO_2$ or $SO_2$ or NOx can vary in all of these portfolios and scenarios.

The energy not served, an odd characterization, right? But how much energy is actually--or demand, how much is not reaching consumers, right? Are we able to satisfy the needs that we anticipate? Is there loss of load? That's a metric, that's an evaluation tool. That's an output of our analysis.

The total expense of fuel, the total consumption of fuel, is an output of our analysis. Where that fuel's coming from, maybe we have one source, maybe we have multiple sources. Comes in output of our analysis.

These are all things that we want to consider in designing the metrics that we use to evaluate our plan. We have a wealth of information available once we perform this modeling. So to let it, you know, sort of sit there unused, uncompared, unevaluated, you know, defies the purpose of doing this full analysis. So, the outputs are going to be critical in evaluating which options make the most sense.

Scenarios that we might want to consider, and this is not an exhaustive list at all. This is actually a fairly simple list of three different scenarios. One with a reference load. Well, this is what I expect to happen to load growth. This is what I think the gas price will be. You know, based off of whatever analysis and resource availability you've used. There's an expected case.

This case, we've layered in a mild drought with it--in scenario one. So, rather than normal conditions, we think that there is several years of drought conditions that could occur. Another scenario could look at high load. A third could look at low load. You might look at high gas prices. You might look at increased gas availability. You might look at multiple fuel resources being developed, coal area, gas area. You could look at all of those through the IRP plan and vary the pricing. Not only the pricing, but the supply of the fuel that's available.

Severe drought, now, this might be something that you'd consider more on a particular time period. So, it might be, I have a 20-year plan. What happens if three of those years are drought condition? I've developed a--you know, imagine, my base portfolio was developing all hydro. Very little resource mix behind it. Now I have three years of drought scenario. I'm either going to have loss of load, or I'm going to need emergency power supply, which to develop that

quickly would typically be a diesel-type generation. Or to utilize existing diesel, instead.

So, our scenarios, we design them to help inform the information that we want to learn about at the end of the day, right? So, if we had questions about, is it better to build transmission or to build gas pipeline? Is it better to have a renewable zone or to have diverse resources? Is it better to build a microgrid here or to expand transmission? We design our scenarios to help answer all of those questions, right? We want to know the cost of all of those things. We want to know the impact to the environment. We want to know the impact to energy usage and utilization and raw input, fuel use and utilization.

So, we'll run all our scenarios. We'll get all our outputs. Now we have a lot of data. And what do we do with that data? We need to compare the performance of our portfolio options across those different scenarios. And, again, this is where our metrics become important.

I think I'm going to skip ahead a lot because--nope, sorry. I don't have the slide that I thought I had. So, we'll just go right to this one.

So, we'll have different portfolios. We run each of them through alternate scenarios, and then we have our results. We have to select the best portfolio strategy. This is where we start to weigh portfolios, similar to what Bill described earlier, of assigning values one through five and assessing the DSM programs.

Our selection process is going to be quite similar. We will rank our priorities. Are our goals being achieved? How close are they to being achieved? Can this be financed? Is there enough capital to support this plan going forward? Does it achieve the goals that we're working toward? And that's where we'll end up selecting the best portfolio strategy.

So, again, our metrics are, what are the marginal costs? What are the total costs? What are the

production costs? What are the capital investment costs? Is load being served? Is all load being served? Is only industrial load being served?

Does my pattern of builds affect my capital budgeting? So, am I concentrating all of my investment decisions in a particular year to try and serve the most load by having an incredibly high rate impact and not necessarily taking advantage of technology improvements that could happen in a few years?

The resource plan that we're going to select at the end of the day--and I do have slides more towards this at the end--will be that plan that performs, I'll say the best, you know, the plan that gives us the highest performance under each of our metrics, on a combined basis, under all of those different scenarios that we're stress testing.

Scenarios are risks. Could be climate change risks. Could be fuel supply risk. Any risk that we think is

appropriate to consider will vary by the country or the area that we're looking at.

At the U.S., the climate--the CPP, the Clean Power Plan, for Virginia was an example of a risk that we spoke of earlier that those IRPs were designed around evaluating. Our goal is not a least cost. It's a least regrets.

That's the key difference, here, in looking at all the scenarios, including the resiliency scenarios. Understand that, yes, we want to have investments. We want them to be smart investments, ones that will be used and useful for the life of those assets.

And, I think we've talked about most of this other slide. We're going to talk a bit more about building the climate scenarios and then jump into the IPM tool and how we're evaluating those scenarios for Ghana and Tanzania in the IRP work that we're doing today.

FEMALE: Hello. Everybody's surviving quite well? Sort of? Need coffee? No? All right. So, actually, I'm

actually just going to speak to one slide. In the sheet with bios, if you have any questions or you want to learn more about this, my email address is in there. We're kind of short on time, but a lot of the information in here we've kind of covered.

So, specifically--I'll speak with two slides, if that's all right. Specifically, I'll--I'm going to talk a little bit about the hydropower modeling that we're doing. We're working with the Stockholm--that should say Environment Institute, SEI. And we're using SEI's WEAP model, which is the Water Evaluation and Planning model. And that's specifically for hydropower modeling. And the outputs of WEAP are going to feed into the IPM model.

So here, essentially, we're applying this in Tanzania. There's also potential for us to apply it in Ghana. There is a existing group in Ghana that has already developed the WEAP model. So, we're looking to expand the efforts that they've undertaken to be able to get it up and running so that it would feed into the IRRP in Ghana.

But, basically, the--with the WEAP hydropower modeling--this is Tanzania--this is the two primary river basins where hydropower is currently located for the country. And these little triangles are potential hydropower plants. I didn’t color code for existing versus potential, but we've already begun to start modeling the hydropower plants. And we'll be doing both. And the IPM model will actually determine when or if new builds should come online for these hydropower models. But we're building them up, anyway, in the event that we can test them or want to test them in the IPM model.

So, the WEAP model is a--it's a hydrologic model. And it also has water resources management in it, so it can model the hydrology of a river basin or river basins. And it is--you can consider climate change because it's driven by climatological parameters, like rainfall and temperature.

A lot of hydrologic models, actually, the starting point is runoff. So, it's a physically based,

watershed model that includes, basically, like I said, water supply and demand.

So, one of the things that we're doing is--or we will be doing once we've identified what the climate scenarios are--is looking at a range of different climate scenarios. And looking at how water supply changes underneath those scenarios. And how that translates into changes in hydropower generation.

The other thing that we're doing is looking at changes. So, you can't really model water supply and demand in insolation. It's not just that you're looking at a climate scenario. You have to look at development scenarios as well. So how might irrigation change? How might population change? So, how do domestic and industrial water uses change?

And some of the demands, like, for example, the agricultural demands will also be impacted or influenced by climate change. So, we're also modeling the competing water demands. So, we get a better understanding of resource constraints over time,

given competing water uses and how they may change as well.

So--and then, not only can you model the potential impacts and changes in hydropower generation using the WEAP model, but you can also--we will also be modeling adaptation measures.

So, one of the things--I've seen some studies that have already been undertaken on hydropower and climate change, actually, for Tanzania. And one of the key issues there is whether this--resource constraints are driven by drought. You know, are these power rationing driven by drought, or is it an operational failure, if you will?

So, we'll be able to look at changes in how--changes in operations, and whether or not they might want to modify how they choose to generate. We can look at changes in rule curves, which is, kind of, prioritization of water given the amount of water that's dammed.

So, where do you send your water? Right now, water flows towards money. So, you have farmers who are stealing water upstream, but generally, when push comes to shove, hydropower gets prioritized. The--so, there's a range of different things. It's a very powerful, powerful modeling tool.

Here is just--I just put up a--some initial results. Which is just--I was going to--in some of the earlier slides, I was going to make the point about--and it's a very obvious point, actually, but just how runoff, the amount of runoff, or the amount of water flow that you have, is correlated to how much hydroelectricity you can generate. So, you can just see the lower the runoff, the higher potential for hydroelectricity generated.

So, one of the things that we'll be looking at is this--as climate changes, are we going to end up down here or up here. And what does that mean in terms of the resource over time. In terms of how the power system develops over time?

In Tanzania, in 2002, they were 90 percent dependent on hydropower. And, since then, they've begun to diversify. And now I think they're closer to only, you know, only 35 percent dependent on hydropower for electricity. So, they are diversifying. But they're still are power rationing, frequent power rationing, which occurs when there's not enough water in the dam.

I think that the way that we've been helping USAID develop the, sort of, risk screening is to--it's, like, kind of a triage in a sense, right? How--getting to know, in a sense, is one way you could put it. Like, do we need to take this into consideration, some basic considerations, X, Y, Z, no exit. Or yes. And you can kind of filter in and decide, you know, how much attention needs to be paid to this issue, and whether or not it makes sense.

So, I think that there's some efficiencies in the process that have been implemented and are being implemented. But, clearly, in a case like hydropower, where there's such a large dependence upon water as a

fuel, it's very important. But some of the, you know, some of the studies I've seen, the impacts on demand, particularly, again, with increasing air conditioning capacity, that can have a really large effect.

And some of the other, you know, even some of the transmission and distribution. I have--I didn’t put up a lot of figures and, you know, shocking statistics. I could also do that, but I get--to your point, I think one of the largest lessons that we could impart would be just to have sort of build-in flexibility in terms of, you know, in terms of the way that power systems are managed.

Like, in the Dominican Republic, we were working with them, and they said, well, we have this huge drought. Focus, focus, focus, focus on drought. And now, this year, they have so much water that they're afraid that the dam is going to burst and they're going to have impacts downstream. So, it's really about, you know, developing management systems.

And this gets to the operations, maybe less. Also to the planning, but, you know, building into your planning and operations a sense of flexibility and understanding of this, you know, these impacts.

And maybe demystifying it a little bit. Like, you know, I used to always use this example, but it's not that great. It is just, you take into consideration like you take into consideration changing economics and demographics. That's kind of how we should be considering climate change. It's an additional uncertainty, right?

And so, if we could, kind of, start to get it to be more of a business as usual, that climate is changing, and we can't rely on a historical climate. I think that'll also get us to a better space instead of it feeling like this additional kind of burden, if you will.

FEMALE: A little bit again with the models. I'll go quite quickly. Here's some of this. Start with this pictorial, which is really pulling together all the

things that we've been talking about today. The components, our supply, our demand, our transmission, the factors, what are the air policy specifications that we want to consider? What are the--we didn’t put it on this slide, but what are the capital limitations that we have? What are the economic and goals and incentives? What are the regulatory goals and incentives to consider?

These all are the components and factors, and they're in the blueish, grayish area of this graphic. The optimization is the key part of evaluating these resources against each other in order to meet those objectives and factors.

And what we end up with--we started to talk about this before--were the outputs. Here are the projections. What are the costs, the power prices, the fuel prices, the fuel costs? If we were trying to enforce a renewable generation policy or enforce carbon limitations, what would be the cost of those policies and programs versus not having them in place

or versus some alternative of those policies and programs?

All come out of our optimization routine. And our long--all of--the graphic that we looked at earlier with that long list of models--most of those models are going to have this type of optimization available from it. Some will do more on air policy. Some will do more on capital budget limitations. Some will do more on figuring how that works into rates. But they're all trying to ultimately optimize a number of different resources against each other in order to comply with our stated objectives and goals, which are, one, serve the demand. And, you know, two, might be, you know, two could be anything else, really. It could be minimize emissions. It could be maximize renewable integration. It could be diversify fuel sources to the extent possible.

So, those are the evaluation metrics that would come out from the projections. Just got a couple of screenshots. I won't spend any time on these. They're in your package. So, you can see all of that. And I

think we have a couple duplicated slides. But all of that type of information are accounted for here.

Stream forcing--we talked about model regions for these long-term tools. You know, rather than looking at the node to node, we're looking at the area to area for these long-term tools. So, the transmission models and long-term planning models complement each other. They're not doing the same sort of analysis, but they are useful to use together.

Our load--load is going to be a critical input. Not only how much energy do we need to serve, what is the peak demand? But at what time of day is all of this load occurring? And how is that load shape changing over time? If I have--Northwest Power council--if my peak is 7 to 9 in the morning on a winter day, am I going to look to solar to serve that need?

You know, what are the best resources, based off not only what my peak demand is, but what my load shape is. I need the resources available to serve the supply needs.

How it's changing over time? Again, these are just focused on the actual generation resources. So we have dispatchable units, which can serve that 7 to 9 a.m. demand, provided that the raw input material is available. But then we have renewables that might not be able to, such as solar. Now the wind profile might look completely different than the solar profile, and that type of renewable resource will be available.

What we end up with--and this is a sample of the types of outputs that are available. I think we'll also touch--Juanita will touch on this in session five, as well. What we end up with, costs, what are my annual investment expenses?

Not only do we know what the costs are, but we know what type of resource I want to put it in. And here I'm calling everything a potential build to combined cycle. I want to add a lot of scrubbed coal in this example. I want to have a ton of wind built by 2050 in this example. So, it's a broad mix of resources

that are going to serve. And I think this was a North America example pulled from a few years ago.

How is my capacity mix changing over time? That's the question, ultimately, that we want to try and answer, right? So, how will it change? What are the costs of those change? And what will be the cost to our consumers? Whether it be through marginal energy costs or through average energy pricing, that output is going to be available to us.

Now, how do we actually evaluate the different alternatives that we've considered? If you've all gone through a finance 101 course, this will probably remind you of an efficient portfolio frontier, right?

So, if we're above that frontier curve, we don't want that. We're high risk. We're high cost, right? So, this curve is representing, for any situation of risk versus costs, right? What is--where do we want to end up? What is the most efficient place for us, as investors--you know, a utility trying to serve the power demand--to fall?

And here I've got three different portfolios that actually fall on my efficient frontier. One is a high-risk portfolio. Maybe that's my hydro, and I'm afraid-of-drought situation. Yeah, it could--it has a lower level as cost but got a very high risk. Then I have one with--actually, it's probably reverse.

But then I might have one that's a very high cost but a low risk. Now this might be a gas supply resource, where not only do I have to build the power plant infrastructure, but now I have a lot of pipeline supply issues--or pipeline development and supply issue and contingency with supply--to also consider in my total portfolio costs. And my cost of actually purchasing gas is going to be very high, but it's going to be there. Right? It's going to be available. It's dispatchable. It doesn't have as high a risk with it. And then something that might be a little bit more balanced.

The rest of these portfolios end up being either too costly or too risky, right? So, those are ones that

we would throw out from our analyses. Or we might end up with portfolios that are not risky at all and have low cost. Typically, what we're going to find on our frontier curve are going to be the portfolio options that are the ones that we'll want to consider and evaluate and compare.

Again, it could be a scored approach. It could be a more detailed metric analysis. To simplify, I've just shown what a scorecard might look like if I'm evaluating a resource, or a set of resources, against each other.

In this case, I've got costs. I've got what I've called risks, you know, general category of risk, and then environmental stewardship. Those are the three categories that I'm considering. The status quo is a very unfavorable high investment. I have nine portfolios that I'm comparing. They're either green--good; red--bad; or neutral. And this scorecard has given me a visual that, you know, portfolio nine looks pretty good. Portfolio five looks really good.

Portfolio two is one that I would likely want to consider.

And, hopefully, I picked the right ones to go with my graph, portfolio one, six, and five. So, let's go back and look at six. Six has some red in it. I think I inverted my six and my nine. So--but that's it. Our scorecard is going to help us identify the appropriate portfolios and how we want to consider the risks.

If cost is our leading factor, portfolio five wins out. If environmental stewardship was our leading factor, portfolio nine would win out. That's a simple scorecard approach, but it's fairly effective and visual, so that you can really see what the impacts are in each of the risk areas. And I think that actually takes us through this session.

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