FEMALE: Here in session two, what we're going to focus on, we're going to get into a fair amount of detail on the components of an IRRP. But we are covering a lot of components, so when I say a fair amount of detail, it's still going to be fairly high-level. We don't have enough--we could spend a week on each of these components, and here we are spending a few hours on them.

So, what we'd like to try and give you some examples as we're going through. In certain cases we'll just be focusing on some of the issues and elements associated with each of the components.

So, the components involve the demand forecast. We've already heard a lot about the issues with demand forecasting. Understanding where load is, as well as how it's going to grow, is an important aspect of the demand forecast.

Supply-side resource analysis--so, this includes your existing system. Which, in some cases, we're finding surprisingly little information available about exiting power plants and the maintenance and costs of those power

plants. As well as, what alternatives exist? You know, what is the wind potential? What's the solar potential? Is there gas supply? What supply-side resources can be developed? Including distributed resources, not just central station, but distributed-system analysis and distributed resources on that distribution system becoming a part of an IRRP. Again, there's scaling issues into how much you can do at once, but it is an important element and factor to consider.

Transmission networks--this could be as broad of a question as, will these two companies--countries--interconnect? You know, is there value? Do we see benefits from trade for a project connecting two countries? Or it could be a simple question along the lines of, should I build a gas power plant and a pipeline based off of what those cost expectations are? Or should I build my plant closer to resource availability and build a transmission line? Those questions can be addressed here. But basic transmission resource analysis to know what your capabilities are to move energy and peak conditions is critical, just to even be able to start to answer that type of question.

And then, demand-side resource. So, this is including energy efficiency. You know, the broad aspects of demand-side management is energy efficiency and demand response. So, we're not just looking at serving the megawatt-hour needs, but we also want to look at a reliable system for peak needs, and that's going to affect all of these categories.

So, that set of components goes into the simple--this is a simplified graphic of that big one we showed earlier, but it goes into the whole IRRP process. Basic question we want to solve is, given what our demand expectations, and the uncertainty around our demand expectations, are, how do we manage all of these other resources over time, such that we're serving our customers at a reasonable cost with reasonable risk levels?

That reasonable cost and reasonable risk level is going to be subject to the factors, not the components, in this case. The components is what we're calling, you know, what are we doing the analysis of? The factors are, how do we judge the IRRP in the end? How do we judge that we have a

successful plan? What's, you know, the economy? The economic growth and development and goals are going to be important in determining the IRRP analysis, but also in judging, potentially afterwards, how much of the unserved capacity will now be served, right? Have we reduced outages? Have we encouraged industry to actually connect with the grid and are helping grow the economy with our plan?

Political motivations--you know, this is the big uncertainty out there for every plan, whether it's in a developed country or not. Political motivations can affect IRRP planning. And it's one of those things that's very hard to actually assess and judge, but it is a factor that you do try and give credence to, where possible.

Regulatory structure--one might consider, after aspects of the IRRP, in designing the regulatory structure, in designing the ways to achieve your plan based off the regulatory structure. So, if regulators are approving contracts and approving self-builds, but they're not guaranteeing loans, you might, you know, it might have a

different path forward to achieve the IRRP goals, than not.

Environmental and climate goals--so, in certain countries--we saw Ghana had a 10 percent renewable target--that will be something that you can judge your IRRP plan against. Or, you can enforce it within your IRRP plan. We'll want to look at environmental goals, environmental impact.

Consumer willingness to pay--now, so, this comes back and also affects your load forecast. What is the cost of actually being able to serve customers--in align with what your political goals might be? That cost--through an IRRP you might determine that--that cost really is just going to be too high to actually serve all of the customers that we think we want to serve. And you come back and you look at the implications to your load forecast.

And technological process. What we don't know today, we don't know that we don't know that, right. So, what we can do is, try and assess some breakthrough events. Typically, what we're thinking of in an IRRP is more of an evolution than a complete revolution, right? We don't know what

those revolutionary technologies might be, but this is also why we want to repeat the IRRP. We want to repeat the planning process on a regular basis. We want the staff to--who's running it--to understand and to follow new technologies, and then be able to incorporate them into the analysis going forward.

This is also why IRRPs done 10 years ago often don’t realize themselves, right? Because you don’t know, at that point, what you don’t know. You’re going to have an actual plan that might be the next two, three, or four years. You’re going to have goals that will be five to 10 years. And, 10 years and beyond, you’re going to start investigating at this point. You’re not necessarily going to proceed on an individual project.

So, what are the steps to performing an IRRP? The first and foremost, getting data. Your plan is only as good as the information that you put into that plan. Data is a huge challenge in, you know, many of these countries that we’re talking about. Understanding where the load is, understanding who has the load, this is an area that can be, you know, we can spend a lot of time on developing.

Oftentimes, with that demand, what we'll need to look at is reasonable growth expectations and ranges, just because we don't have the data about, you know, what's the population in this area. We don't even have that level of data to come up with, you know, a more detailed approach to looking at demand.

So, one of the things that we often come up with in a power sector master plan is actually a recommendation on how one would get better data, supply-side resources, the cost to develop new resources, the cost to continue operation of existing resources. We're looking at hydro plants, now, that we don't have any, you know, maintenance records on. We don't know what the conditions are. There's no current engineering studies of the physical plant condition. These hydro assets could be very long-lived. We don't know. They could be ready to fall down next week. We just don't have that information. Getting that information, managing that information, that's important for us in considering these plans going forward.

So, that’s going to factor into all the components, the data gathering, the data collection. The reasonableness of assumptions is also going to be an important element of creating data inputs to an IRRP.

But then there’s the design criteria, and I know it’s probably really hard to read this slide in the compact tree, but that bottom element in the first step is very important, too. How we design our IRRP is based off of information that we have available. How we judge our IRRP is based off of the decision criteria that’s important to us. We need to come up with metrics to evaluate whether these resource plans really are appropriate, whether they make sense, whether they achieve our goals. So, if we had climate goals, if we had renewable procurement goals, if we had fuel diversity goals, if we had goals about unserved energy, those would all become decision factors that we evaluate our plan against.

It’s important to try and understand those decisions, those decision factors upfront, because one of our steps is going to be to design--our third step is going to be--

consider risks that will affect those factors. So, data, and what the criteria to judge the IRRP, are step one.

Step two, create alternate resource mixes. What we want to do is based off of the information that we have. What resource mix, what mix of demand- and supply-side or distributed resources can effectively meet our needs going forward? And, we'll typically have a few different alternate portfolios that could meet those needs going forward.

Our third step is to judge those portfolios, given uncertainty. We know our data is not great. We know things aren't certain five, ten years out, either. We need to design our scenarios in order to consider multiple factors.

And the final step will be to evaluate the options. So, what we're going to create is a band of different options. And how do they perform if scenario A happens or if scenario B happens? How do they perform if markets don't materialize? Those will be considerations that need to occur and be evaluated in the fourth step of an IRRP.

Again, this is not going to the next step of power sector master plan. This is keeping it within that IRRP umbrella only.

So, what do metrics look like? An objective is to minimize cost. If that were our only objective, we would only be using a revenue requirement or a dollar-per-megawatt-hour criteria for our analysis. We might want rate stability. So, we don’t want to see rates go up and down as you invest in new alternatives. Or we don’t want to see rates incrementally increase too much based off of the resource mix that we have. What if fuel prices go up unexpectedly? What if fuel supply is cut short? So, rate stability could answer those questions or metrics would answer that type of question.

Resource adequacy--are we reducing loss of load events with this plan? Are we reducing the number of them, the frequency of them? Are we coming up with a way to balance them? That’s one metric that could be used for resource adequacy. Another is simply reserve margin. How much capacity do I have over and above that single peak hour, and is that adequate as a resource adequacy mechanism?

Environmental stewardship--this may or may not be a goal, but looking at the emissions would be a way to measure the environmental stewardship and the impact. Further ways might be to evaluate health impact over and above that. If you have X-number of emissions, what does that mean to the population? We've seen--the Delaware IRRP I mentioned actually does health impact.

Diversity--so, diversity here, as I've written it, is the concentration in any type of asset or fuel. Or, it could also be, how much am I reliant on any single power plant, right? So, there's a number of different things that could affect diversity. Diversity could also simply be a factor that affects your rates or that affects your loss of load frequency. We could have a separate metric or not. This is part of the design process. What we want to do is understand what's relevant and important for the decisionmakers who are going to move forward on this IRRP, and design these metrics in order to make that evaluation appropriately.

Land use, acres of land required. It could also be--this could be related to soil, or it could actually be looking at bird migration paths if you had wind. It could, you know, we could look at a number of different elements beyond simply what's here, but the criteria, again, is going to be critical upfront in order to really make a solid assessment going forward.

And the main criteria in all IRRPs, there's always a minimize cost. The question is, what else are you going to do beyond that?

A simple, you know, a simple diagram showing all these pieces interact. We showed them as bubbles before. But demand forecast is related to how you build your transmission system. It's related to how many distributed assets you need and where you need to have them placed. Again, but that's the point of the integrated analyses.

And I think we've got Molly. So, Molly will talk a bit about that extra R in IRRP and how to manage the climate risk within an IRRP process.

FEMALE: Good morning, everybody. Time to switch it up a little bit for those of you who are interested in learning more about resiliency and climate risk. I'm going to talk a little bit about why it's important to integrate climate risks into power systems planning and how we're doing it in the IRRP project.

So, essentially, the, you know, the rationale is--I mean, it's clear that reliable and cost-efficient energy services are critical components of growth and development. Those two aspects, reliability and cost-efficiency, can be impacted by climate risks. And so, and we've heard a lot about climate already, and Juanita brought it up at the beginning. If you're only concerned about the baseline climate, historical climate, you might not be capturing some of these increasing risks as a result of climate change.

In the baseline, even in the historical, we see big impacts on reliability and on cost as a result of droughts, for example, floods for example. So, this is something that stakeholders are familiar with already.

It’s the changing risks that we’re concerned about in an IRRP, which is looking forward.

Again, you’ve seen it in the slides today. Everybody here is an energy expert. A lot of emphasis on investments and renewable energy and on infrastructure. And, you know, renewable energy is a large emphasis, obviously, because of climate change mitigation, other reasons, as well. What’s not being taken into consideration with these renewable energy investments are the climate risks to renewable energy. So, I think there’s a lot of confusion when I talk in Ghana or Tanzania. Oh no, we’re managing climate, we’re investing in renewables. They are going to provide resilience. It’s going to be a diversification. But they’re not considering the very real risk to a natural resource-based energy resource. So, natural resources are very climate sensitive. So, biofuels depend on water. Hydro depends on water. So, there’s a lot of risks associated with these renewables that aren’t being taken into consideration.

Same thing with infrastructure, long-lived, often fixed assets. Climate is intensifying over time. Over time,

these impacts are going to grow. So, in recognition of that, the International Hydropower Association, in 2015, undertook a survey of hydropower utilities. And 40 percent of the hydropower utilities that were surveyed were actually taking into consideration climate change in their engineering and structural design measures to a large extent, or, you know, completely, probably about 5 percent there.

So, this is--the recognition that climate change and climate risk is important is something that's coming through in the private sector, in utilities. But it's also something that's increasingly coming through as part of due-diligence requirements, for example, for bilaterals, multilaterals. Particularly, you see it for climate risk screening of projects. You see that a lot in the World Bank screens, African development screens. And USAID requires climate risk screening and management in all new strategies and plans, which would include the power sector investments.

IRRP, the way that we implement it, would help to realize some of this due-diligence requirement, because we do do a

climate-risk screen of the power sector when we undertake the IRRP assessment. And we also do consider different types of risk-management strategies that could be applied to mitigate those risks.

So, what we're--one of the major things that we're trying to accomplish, and I'm leading the resiliency efforts in Tanzania and Ghana, is building basic capacity and understanding of the power sector stakeholders, of climate risk, the types of climate risk, and the potential impacts of these risks, across the entire power sector. In a place, like, you know, Ghana and Tanzania, where hydropower is, you know, their hydropower--there's a large hydropower dependency, there is some understanding of these climate risks, because they've faced droughts in the past.

But getting beyond that and looking at the risk to transmission and distribution, the risk to, you know--or even the impacts on demands--there isn't a large recognition of the broader suite of risks that can affect power systems.

Also, the types of climate risk management options, there isn't a large recognition of what can be done to manage or mitigate these risks. So, what we're doing at a very basic level is trying to build the capacity of power planners in these countries to understand the types of risks and the types of risk-management options. And then, bringing that into the power systems master plan. And that second R right there is, really, how do we bring in some of these direct impacts into our planning and strategic decision-making processes?

So, this is not comprehensive by any means, but I've outlined some of the direct climate change impacts. Utilities face operational and financial risks as a result of climate change. Some of the direct impacts include climate change impacts on resource availability. Again, changes in the quantity, in the timing of flow into hydropower, into reservoirs, can have a big impact. The efficiency--so increases in temperatures can reduce transmission and distribution efficiency, and that's something that's a factor in Tanzania. And the structural damage is usually, typically, what most people think about when they think about climate risks. And that's those,

sort of, big-impact events, whether it be droughts or floods that have a direct--cause direct damages or disruptions to the services.

And then, changes in electricity demands. So, in this case, one of the biggest impacts could actually be as a result of development in Tanzania as air conditioning becomes--the penetration of air conditioning increases as wealth increases, particularly in places like Dar. At the same time as you have increases in temperature, you could see large increases in electricity demand that are currently not being accounted for.

Indirect impacts of climate change. I'm not thinking, in this case, of like, for example, fire, which can be caused by drought, which is a secondary impact. But really, more, how do these direct impacts of climate change affect strategic and planning decisions? So, that's really what the IRRP is about. It's understanding what some of these climate change and other risks are, and what the implications of them are within a power systems planning framework. And then how do we actually--how can we

actually go about managing? How can utilities go about managing them?

So, some of the ways that climate change indirectly impacts on power systems is through strategic and planning processes. But it could include things like changes in energy, technology, research, and development investments. It could include things like changes in energy resource and technology choices, which is something that might come out of a least planning--or least-cost planning or least-regrets planning model assessment. It could include things like changing the risk-management investment or the business, the risk--changing the behavior of utilities and how they consider risk in incorporating climate change. And, actually, all of that really speaks to what we're looking at here with IRRP. And this is directly associated with the types of capacity building and activities that we're undertaking in Tanzania.

So, here is another implication of climate change, and that is, what do these risks mean in terms of, you know, how do we adapt to them? And what's that going to cost? And how is that going to change or affect our planning

processes? So, you know, some of the adaptations that we'll be certainly looking at within the IRRP are a lot of the demand-side measures that increase efficiency.

Some of the other ones that may not be explicitly included in our quantitative assessment may be things like raising vulnerable assets to higher ground. So, in Ghana, there's a big concern with transmission and distribution located on the coast that's subject to potential sea level rise. And they're already seeing impacts on some of the infrastructure in the coastal areas there.

So, those kind of costs are things that we can bring into the planning process and make recommendations on, but we're not going to be explicitly modeling, per se, within the integrated resources model.

So, I've just outlined, at a very high level, four steps that we're undertaking in Tanzania right now to bring in the risk and resiliency component. The first one is that we've developed a risk and resiliency assessment, and we should be finalizing that in the next couple weeks, actually. And we'll be presenting this assessment.

But the risk and resilience assessment takes a look at the country in a disaggregated way and looks at how climate is changing and how climate is projected to change. And what are the potential impacts of climate change on power systems components, for example, you know, the supply-side transmission and distribution and even on demand?

And it takes a look at, also, the potential adaptation measures that can be applied to mitigate some of these risks, and then provide some recommended climate scenarios.

So, here you can see we've broken Tanzania into five zones, and these five zones are roughly--roughly correlate with climate zones of Tanzania. But they're bounded by administrative boundaries in order to facilitate collecting some of the socioeconomic and power data to undertake the analysis. A lot of the statistics are at an administrative level.

So, the second step is to bring that assessment to the power sector stakeholders in a participatory workshop. And

we'll present the results in about a month's time, actually, I think, the end of April. And it's not just presenting the results. We'll be discussing the results with the stakeholders and getting an understanding of, from them, what do they think are their priority risks? What do they think, you know, what's most important to them? Have we captured those risks correctly? And what do we want to focus on when we undertake the resilience part of the power systems modeling?

So, that's going to help us--once we understand what these risks are--it's going to help us to develop climate scenarios with them. So, for instance, if they say, yes, we're very concerned about drought risk to hydropower, we're going to be looking at drought, or, you know, or drought risk in our modeling, in our efforts in Tanzania.

So, but it might be that some other novel risk that they haven't considered may come out because they haven't thought about some of the other risks to the system. And, you know, those are the kind of--that's what we're looking to capture in a participatory discussion with stakeholders when we present the risk and resiliency assessment.

And it should also be an opportunity, again, to build capacity and basic understanding of what some of these risks are, what the implication of these risks is to their financial and operational management. So, I think there's a broad opportunity. I think the biggest opportunity is really in building capacity to understand the risks and the resilience options.

And we'll be able to--when we do the power systems performance evaluation--we'll be able to bring explicitly some of these risks into consideration when we look at the power systems planning.

Now, this slide right here says power system performance evaluation. How do we integrate them into the IRRP? And there's, actually, much more to this than just these two points. And when we pulled together the slide deck for today, it was--I had laid out all these, like, beautiful slides that said risk and resilience to transmission and distribution, to--and the next thing you know, we put them together and the transmission and distribution specialist took one and put it in their deck. The generation

specialist took one and put it in her deck. And at first I was, like, hey, guys, what's going on? But then, you know, for the climate change specialists in the room here, that was a huge success. We work so hard at trying to get climate change integrated into transmission--energy planning--you know, water resources planning, whatever the sector is. And so, for me, you know, this is a little bit light right here, but you're going to be hearing more about risk and resiliency as we go through the slide decks of, you know, each of the specialists and each of the different power system components.

So, but here I just highlight the water evaluation and planning model that we're implementing in Tanzania with Stockholm Environment Institute, and in session four I'll talk a little bit more about that. I'm helping out with some of the power modeling there, or the hydropower modeling.

And then, Maria is going to talk about the IPM model and how we bring in the climate change scenarios into that. And then, again, within the other sections that are going to be covered today, you'll see some slides on how climate

risks and resiliency can be taken into consideration in each of those components, given the different climate scenarios, again, that will be defined together in a participatory workshop with stakeholders.

And another thing is, to highlight here, we will be undertaking a WEAP training for stakeholders in TANESCO who are responsible for hydropower. They're very, very interested in that. Also, we'll have stakeholders, I think from the Ministry of Water, in attendance, as well. So, there is an interactive element to the WEAP modeling. It's not, you know, black-box modeling. And some of the stakeholders that we've talked to already have familiarity with WEAP. So, I'm really looking forward to bringing that model and that capacity to the stakeholders there.

And then, finally, at the end of the day, and this is, again, you know, focusing on risk and resiliency, we'll be bringing in a range of risks based on, both on the qualitative and on the quantitative assessments that we're undertaking in this process. Some of the impacts will be modeled, some of them won't. But at the end of the day, you know, something--some of the more intuitive adaptation

measures, I think, will be incorporated and will be modeled. But then there are some that are already ongoing that Tanzania is already incorporating that we'll be sure to reflect, as well.

So, you know, we're moving forward, and we haven't--I'm looking forward to going in a month's time and talking with stakeholders about the types of risks that they face and the types of resiliency options and measures, and getting an understanding from them what they think priority risks are, maybe, outside of, you know, drought risks to hydropower. That's it for me, and, Maria, you're up again.

FEMALE: I'm going to go fairly quickly through this section and the traditional supply section, as well. Still, any questions, please feel free to ask.

So, demand forecasting--demand, itself, can be influenced by a number of factors. Most basic is weather. So, looking at, you know, how hot, how cold it is, and what our heating or cooling needs are. Those two are often utilized together in demand forecasting tools.

Electrification--we spent an amount of time this morning talking about the electrification implications to regional demand levels. And what does that mean? Or subregional demand levels. And also, the extent and the financial ability to develop the resources for electrification would affect a demand resource.

The economy--you know, big example, the recent recession and the impact, particularly to industrial demand in the U.S. We saw sharp declines in demand, actual drops in demand levels, particularly for the industrial sector. And we've seen slower growth since that point, as well, somewhat due to modification strategies, others just simply due to changes in the structural development.

Rates--so, how much am I willing to pay will also affect what the ultimate demand is. You know, how many consumers will want to actually connect to the system? Or, will I conserve? Just--not through a DSM program--but, will I voluntarily conserve as my rates go too high?

Time of day. Peak, off peak. Hot, hot day for many hours in a row, or many days in a row, that will affect our electric consumption. It’s not just that single-point time of day but also the factors leading up to that time of day for peak, in particular.

Off-system load--so, we see in the U.S. today, part of the decline in demand has been solar generation on the distributed system taking load off of the system. But what we also have is a number of cogeneration-type loads serving loads off the main system and actually moving to those alternate sources of power.

And time of year--so, the Northwest Power Council, they’re planning for a winter peak condition. Their highest load is typically 7 to 9 a.m. in the morning on a winter day. Versus here in the D.C. area, where we’re looking at a late July, early August peak in the summer, probably later in the day. So, time of day becomes an important factor in your load forecasts, themselves, as well as how you use resources to meet those needs.

How do you actually forecast load? Simplest--how this is organized is simplest to most complex. Simplest is a time series. Oh yeah, the load has been growing at 1 percent per year for the last 20 years. It’s going to grow at 1 percent per year for the next 20 years, as well.

Why would you do that? Because you don’t have any other way to forecast demand. You don’t have any of this other information readily available to you. Or, you have data that conflicts, right? You might have measures of the economy that show growth for 10 years, and then suddenly there's, you know, it drops and it’s growing from the same source. You can’t explain the input data. So, it’s important to look, not just at collecting your data, but looking at the quality of your data as you’re forecasting.

There are means to do better than just 1 percent in a time-series data. You don’t, necessarily, just need to take that trend and extrapolate it forward. You can use time-series statistical approaches to better evaluate, even with limited quality data, and we’ve seen some success with that.

But, typically, what we want to do is move to an econometric forecast. An econometric forecast takes trend information on what sales are, and then incorporates these other factors into it. What's the relationship between macroeconomic development and demand? That, you know, how much personal income is, will drive my willingness to pay, will drive my demand level. So, economic growth and demand using econometric modeling--the statistical modeling. What you're testing, the individual parameters for their causal impact to, ultimately, what we want, a demand forecast.

So, econometric is data intensive, but not nearly as data intensive as these later two items that we're looking at. It's fairly straightforward. It does require someone who can understand some statistical measurements and manipulate and manage and collect data, but it's a fairly easy approach to implement. Anyone with Excel or a like-spreadsheet can do an econometric model.

When we get to end use, now we're talking about very complex data collection. So, this is looking at building usage. This is looking at residences-- residential and communities and understanding what the population is.

And, not only what the population in those communities is, but the how they're using their buildings. How--are they supplying power through other off-grid systems? Do they have those solar converters that Bill talked about earlier? Are they using their residence also as a commercial establishment? So, perhaps they have a freezer in their building, which they use for, you know, commercial sales. They're using that for something that they are selling out of their house. Perhaps they have people coming into their house during the day. How you count those establishments as commercial or residential?

This is where we're talking about that survey where you really have to go on-site and get this type of information. And not all populations are representative of other populations. And that's the hard part, particularly as you're getting to residences where they're counting--where they have a single meter. Where they're really a commercial business as well as a residential area.

How many people are in the home? How will the cooking utensils change over time? Will they move to electric?

Will they move to gas? Will they move to something else? Those factors all become part of the end-use forecast if you're doing it to the full degree. This is a bottom-up level forecasting. Econometric is top-down. I've got general statistics I'm using to balance end use. I'm building from the very bottom and trying to go top-up.

What we will see in the U.S., most often, is a hybrid of these two. So, they're not necessarily trying to count their population, but they know how many customers they have, and they know how the customers have changed over time. They'll use econometric trends for that. But they also know what load is dependent on weather. So, they'll normalize for weather-sensitive load. They know what load is not dependent on weather. They'll do large-area forecasts rather than go and do detailed surveys, occasionally doing surveys but not terribly often.

Learning algorithms get to time of day. This is next hour, next half hour, next five minutes. These are, you know, AI-type programs, very valuable for ISOs, for grid operators, for persons that are doing the dispatch of individual systems. Is it necessary for an IRP? No. You

can do long-term learning algorithms, but this is fairly extreme for an IRP-type analysis. The most common will be the econometric, the end-use, or a hybrid approach which combines the two. You might do an end-use industrial, for example, but an econometric for everything else.

And coming to Molly's point on integrating our resiliency aspects into the different components of our forecast. Load forecasting clearly, you know, temperature, weather conditions, climate resiliency is going to be relevant. But some of the adaptation measures that need to be accounted for, whether in a load forecast or in the demand-side resource development, would be looking at the adaptation measures to deal with climate change over time.

So, if I were doing an econometric forecast, weather conditions, cooling degree days, heating degree days, actual peak temperatures, become inputs to my forecast. I'll want to utilize that to forecast my peak condition. That will affect what my heating and cooling needs are. And my resources, as I evaluate against them, my demand may change, and the value of those resources may change as my demand changes.

So, on supply side, here we're talking about, not distributed resources, but central station generation resources. Traditional utility, or merchant development stations that are connected to the transmission system. Natural gas, hydro, fossil resources, renewable resources, biomass, biogas resources will all largely be central station resources.

The first step is identification of the resource options that are available. The second step is to characterize them. So, what are their costs? How can they operate? Is fuel supply available for them? What are the environmental impacts? Will the performance change based off of weather conditions or climate conditions?

And then, inputting all of those parameters into the analysis, you know, factoring performance over time, time of day, time of year, and cost will be a key driver of our cost minimization function.

We also want to look at what stage of development are these different types of resources in. Are they well-

known, mature technologies that we can really have trust and confidence in the cost and performance factor that we're estimating? Or are they, you know, nascent technologies that are in the conceptual or in the R&D stage that we think could have significant value to the resource, to the country, that we're considering going forward?

Mature technologies, when we're doing our scenario analysis, probably won't have scenario variations around them. They'll have a very small bandwidth of uncertainty around their performance and cost. These nascent technologies will have much more uncertainty. We'll want to look at them in different scenarios differently, right? What if solar costs don't decline as they're expected to? What if the solar performance is only 20 percent versus 30 percent? You know, what are the impacts of time-of-day use of these resources? We'll want to consider those, as well as the pure base-performance aspects.

And we'll also, in some cases, just want to identify whether it even makes sense to consider some of the nascent technologies in the IRP today, or just flag it for

continuing tracking for the next analysis as it goes forward.

Some of the detail that we'll typically try and understand, particularly for renewable assets, but it, actually, is important for all assets, is, where can we develop them? The performance and output of a renewable, in particular, is going to vary based off of the conditions at the location at which it's placed.

So, this map is a solar PV, where we're looking at green as the highest radiation and red as the lowest radiation. So, that will affect how we characterize the resources in our analysis. Molly showed you the administrative zones. What we have is the resilience zones. Our modeling zones, and how we characterize where a new power plant can be placed, needs to also factor in the information that we have about the location. So, the performance, the output, the capacity factor, as well as the output at time of day will vary for a solar resource based off its location.

The more information we have, the better on this type of information. Sometimes we--all we have is a map like this,

and we'll have to, you know, use estimating techniques to come up with what a profile might look like based off the radiation. There are other tools and models that we use for that, that become inputs to the IRP.

And I think this is the same map that we saw earlier. So, and we've talked about a few of these items already, flood damage, hydropower, competing water use. That's been one of the key things that we'll want to take a look at, as, sort of, as some of the supply resources, in particular biogas, biomass, and the large hydro facilities that we have in place in our--as new potential resources in Tanzania are.

The hardening measures can be looked at from a cost perspective. We see a handful of them here. And, I think, we can turn it over and talk about some of the other technologies. Sanjay will talk about the distributed energy resources.

MALE: Distributed energy resources, DER, you might as well call them disruptive energy sources, because that's what they are coming out to be, very quickly. Solar, wind,

electric vehicles, battery storage, CHP, thermal storage, all of those things are considered to be distributed energy source. They're making planning more complex because they're coming on pretty quickly. They're coming on in multiple locations at the same time, whether it's policy driven, through incentives or an auction programs. Or they're organic, where utilities are moving towards the prize, more greener organization than doing these things on their own, sometimes.

But what makes it challenging is the lack of information, and every speaker has alluded to that, where there is very little information about where the DER is coming on, and what amount? How fast is it going to come? We have that problem in the U.S., in developed countries. Think about places like Tanzania and Ghana and DRC, where there is no information, but, still, you are getting these distributed resources in some way, shape, or form coming up, and the lack of resources makes it harder.

When we analyze these DERs, we not only look at just the plan from a generation of supply standpoint, but we also look at the impact that it's going to create. So, if it's

solar or wind, it’s going to be intermittent generation. How is that going to affect the grid operation, the grid stability? Or, even if you go down to the feeder level, how is that going to affect the distribution system?

Traditionally, grid planning has been focused towards the left half of this diagram, where it starts at generation, goes to transmission, and maybe a little bit into distribution. Now we are seeing more and more planning because of the DER penetration going into the distribution side of things, commercial systems, industrial systems, and certainly residential distribution.

These--the DER technologies, coupled with storage, control, communication, what they’re doing is, they are making these things into what they call grid assets. So, they’re not just generation, they’re not just supply solutions, but they are being thought of in terms of assets to the grid.

How many of you have used Uber, right? Airbnb, right? Does Uber own any vehicles? No. Does Airbnb own any real estate properties? No. What they have done is they have created a

platform, essentially a software-based platform, where buyers and sellers can come and interact and exchange goods and services.

The grid of tomorrow, Grid 2.0, sometimes as it is called, moving towards the same--in the same direction. New York State’s REV program, Reforming the Energy Vision, for example, what that program is trying to do is to create a platform where generators, suppliers, buyers, both commercial, industrial, as well as residential, come onto that platform and start interacting in the energy marketplace, not just as a supplier to utility or to a large industry, but also peer to peer.

So, when you’re networking that way, you’re supplying not only to a large consumer, but you may be supplying to your neighbor 10 streets down the road. Where your network, if you’re producing excess energy, you are into that network. So assets--that's how they are called assets. So, you know, Uber has all these cars that we own, but for them they are revenue assets. In the same way, distributed energy resource is a great asset to utility.

So, what DER planning can do, if you start early and you start thinking in those terms, is you can leapfrog the traditional planning process and really start thinking in those granular terms, as to what does the solar system do at this point in the grid. Or what does a wind system do if it’s variable, intermittent, and I still need to use it for something. Or how can I use--maximize--the attributes of battery storage?

I’m not going to go through all of this, but we all know why changes are occurring. Costs are going down, for both PV, wind, as well as some of the other technologies. Battery--the holy grail is $100 per kilowatt hour. We are slowly approaching that. Other considerations, emissions, environmental, siting concerns for conventional power plants, they are dictating that we go towards cleaner options.

And then, as I alluded to earlier, if you combine DERs with advanced controls, communication systems, you’ll transform them into grid assets, where you can use them for managing your grid operations as well.

So, let’s look at how we would analyze a distributed energy resource. We’re working--ICF is working for a California--large California-based utility, where we are supporting them in preparation of their distributed resource plan. DRP as it is called. And we are going through all of these different steps with them.

So, the first step is scenario-based distribution planning. Where this is the very basic level of looking at a DER in a geospatial way. Where is the DER going to come, in what quantity, and at what point in time? So, we do a geospatial analysis. We’ve overlaid on the grid map and see how the DER map is going to look like.

The next step is what we call hosting capacity. Very, I guess, curious term, but what it does is, it looks really at the feeder level. What is the capacity of that system to host a distributed energy resource, whether that’s solar or it’s battery storage or any other. And there are several different things that are looked at. One is thermal capacity. Is it going to burn up the wires, for example? Is it going to mess up the voltage control or the frequency control? Is it going to burn up my relays or

exceed my protection limits? So, this is what's meant by hosting capacity. So, you do this analysis at the feeder level to understand how much DER that particular location can take.

And talking about location, one of the important aspects--I think Monica referred to that earlier in the morning--locational value of DER. So, it's not just that you put DER anywhere in the grid and it's going to be useful. If you put it at the end of a feeder system, at the end of a dinky little road where it's feeding, you know, a house and a small community, that's all it's doing. But if you can move that, if you can do a little analysis as to, if I put it in this location in the grid, is it going to give me more leverage in terms of managing my grid operations? Is it going to help me stabilize my grid in a better way? That's what's called locational value.

So, when you do a DER analysis, it's important that we look at not just how much DER is going in or who is going to be using it, but also where in the grid it is going to be, so that you can maximize the benefits that come out of DERs.

The next thing we do is called probabilistic engineering analysis. And that gets into more generation. So, somebody talked about forecasting, load forecasting. Well, in the same way, you do generation forecasting, right? So, you look at the solar resource. You look at the wind resource. And you do time-series analysis of how that solar resource is going to behave at that location, or the wind resource is going to behave at that location. And you do a probabilistic analysis, and say, okay, my plant is going to behave in this way over a certain period of time because of these probabilities or this probabilistic analysis that I have created. So, that defines how that DER is going to behave.

And, finally, when you put all these things together, you can start to formulate a plan for your T&D system. When you have mapped out the DERs in a geospatial way, you have done your hosting capacity analysis at the feeder level, and the locational value analysis, and the time-series probabilistic analysis, then you can start to think in bigger terms, in T&D terms.

And, just, the developing country context, more and more the paradigm now--this is referring to T&D in general--is moving towards--that transmission drives development. It’s not the other way around. It's not that, you know, we thought that, well, if people, a certain number of people start living here, we have to give them power, and we have to build a transmission line.

When you talk about scaling up renewable energy, for example, and talk about renewable energy zones, right? You intersect the renewable resource, and then you start thinking about, well, if I bring the transmission system here, is that going to develop that part or not? Are the developers going to come and start developing solar plants and wind plants in that location or not? That’s the analysis that is, I think, going to happen more and more, now. Where we look at the transmission system also as a driver of development for that particular resource.

So, we are going through these steps with this California utility where we have done this analysis. We have looked at the DER systems that are coming online in the future, and we are calculating what’s the value of each DER. And

then we overlay that onto what are the anticipated needs of that utility into the future, in terms of generation, in terms of supply, in terms of what kind of grid operations, grid stability will they need at that point in time?

So, we are looking at not just can a DER provide an engineering solution, but also, how it can--are the levels of DER adoption going to be sufficient to provide some potential solutions, potential stabilizing solutions for the grid? So, that’s the kind of analysis that we are currently doing for utilities.

Again, these are five different steps, but they can be done separately. They can be done in sequence or in isolation depending on where things are for your system. We are talking pretty high level here, and we are also talking about countries like Tanzania and Ghana. So, you may be starting in those countries with just a scenario-based DER planning where you think about, okay, this country is planning so many auctions, and here is where the resources are, let me do some geospatial planning first and map the DERs before I go to some other steps.

And that, so, again, mix and match according to your needs as to what you're doing. Yes?

FEMALE: The previous slide when you're talking about things like the hosting capacity and other variables in the DER--

MALE: Right.

FEMALE: --and it being deployable. Are those things that in the analysis, through the IRRP, that you're coming out with recommendations that it would be cost-effective to increase capacity for DER X-Y-Z location? Is that something that comes out of it?

MALE: I'm not sure that we would do a costing analysis at this point. And the Ghana and Tanzania people can speak to that to what extent are we integrating DERs into the analysis. We're not looking at costing, really, are we?

FEMALE: Yeah, some analysis--

MALE: Right, right, right. Any other questions? This is the end for me for this session.

Oh, a last slide. Again, I'm not going through all this, but we've talked about this. Why should we integrate it in planning? Well, it's something that's growing. It's coming up, it's got benefits. Why not leverage it?

And, it's like the utilities for a long time resisted looking at this. But now, because the penetration is getting so high, we have identified it as an asset, not just as a supply source or as a liability that the utility needs to manage. Leveraging is increasing.

And avoided costs is another term. So, when you look at-- do your DER planning, the utility can avoid costs of transmission of generation if you define your DER mapping accurately enough that you can say, okay, this is coming up online. I don't need to provide these. I don't need to plan for these future assets or future operations in my budget, because the DER is going to do it for me. I just have to leverage it.

FEMALE: I mean it’s an interesting question to me of why wouldn't, if you’re doing this analysis, how is it different for it, to not consider off-grid and on-grid--

MALE: I would. I would. Absolutely. Absolutely I would. Again, depending on the DER itself, if it’s a small solar system, obviously, it’s not going to have an impact. But if it’s a microgrid for example, yes, you should definitely consider it. Yeah, absolutely.

FEMALE: I think the thing about scoping, too, that'll come out is, it’s not just whether you should. So, in this session, we're trying to show everything that you could do under an IRRP. But as Juanita and Maria were saying, it comes down to what data you have available and then what the stakeholders want to do.

FEMALE: Right.

FEMALE: So, you know, it’s this process. If they don’t want to do it, then it doesn’t get--it can't--it doesn't get done.

FEMALE: It’s also just the scale of the project. So, for Ghana, I think we had talked about doing it streamline. So it's just, how big a project do you want to tackle?

Female: No, right.

MALE: Yeah. And ideally, if you have a white sheet of paper, you can, I agree. DRC, for example, is a sort of white sheet of paper, right now. Where nothing’s been done, you could look at all of these things, right.

FEMALE: Okay. So, my job today is not technical. It’s people management. And I’m looking at all of you, and this is really dense material. And I think we’re going to take a break.

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