FEMALE: I'm going to have a few introductory slides upfront, but luckily we've talked about a lot of what I had as, sort of, the introductory section already. So, I'm going to go through them fairly quickly.

So, scaling an IRP. I mean, part of this is really selecting the appropriate tool for an IRP. Part of it is designing the IRP to circumstances. That could be the staff that you have available to run the IRP. That could be the objectives that you want to achieve through an IRP. That could be the regulatory requirements necessary to achieve approval or acceptance of the IRP--there's a number of different things.

In terms of models, many of the models--we talked about the transmission, we talked about the DSM tools. Many of the models are complementary to each other. Some are really designed for a very detailed look at certain systems or certain elements of the power system. Others are designed more for long-term optimization. So, when we look at the scale, and this is not inclusive of everything, but when we look at

the scale, transmission models tend to be very detailed. You're looking at nodal congestion. You're looking at half-hourly, hourly points of time.

Planning models tend to be less detailed. There's a trade-off. You can't do everything in one tool. And you really probably shouldn't try to do everything in one tool. You want to have expertise that you can pull together among different staff who might be electrical engineers, who might be mechanical engineers developing systems, and economists or financial planners that are looking more at long-term strategies. Just as you want your staff to be complementary, you want your tools to be complementary to each other, as well.

Each is designed to look at a different element, as well as a different time period. So, if I were looking at the risk to, of congestion, in the short-term, I would want to look at a short-term modeling tool, a power-flow tool, or an hourly production-cost model. If I were looking at environmental compliance decisions over the long term, I want to have

something that can optimize resources. So, I'm looking at the mid- to long term, I'm looking more at a capacity expansion planning tool.

One part of our exercise, both in Ghana and Tanzania, was to look at different models that would be appropriate for the utilities themselves or the participants, the stakeholders, to utilize for IRP work. So, we introduced them to a number of models that they didn't necessarily have experience with, or some that they did. Some--on occasion, we had the question of, well, why can't we use, we know PSSE, why can't we use that? Well, it's not designed to look at capacity expansion in the long term. It's not designed to be long-term scenario driven. Our goals and objectives are not aligned with using simply PSSE. What we want to do is use PSSE as an input to our process, and even potentially an output, but the list on the far right, here, is really the list of tools--and it may not even be comprehensive, but you can see it's fairly long--list of tools that are appropriate for this long-term optimization modeling

that can consider multiple resources at a single time together and weigh those alternatives.

Some of them are pretty costly. ABB, AURORA, PLEXOS, these are all commercial tools that are fairly widely used, but they do have high annual license fees associated with them, of $100,000 plus, typically, for a model like that. LEAP is open source. It doesn’t have full optimization, but it does have good optimization capabilities, just recently introduced, actually. Some of these are--NEMS and REEDS were developed by the U.S. government, and NEMS is open source, but it’s an extremely complicated tool that you wouldn’t want to try and apply anywhere else but where it’s already been developed for in the U.S. WASP, you know, is a very low-cost tool. I actually think it’s available to all developing countries, but it doesn’t have strong optimization. So, there’s trade-offs, right? Some of them are well-developed and maintained because they’re from software companies that were trying to sell them, right? LEAP is from--LEAP is maintained, but it doesn’t have the user support that you would get from PLEXOS, for

example. So, you know, there's not only trade-offs in the capabilities, but in the support you can get for a tool.

FEMALE: Have we ever had success in trying to negotiate reduced cost for developing countries? It’s hard to get hooked on something that then requires fees for years and years.

FEMALE: Yeah. Juanita can speak to that.

FEMALE: So, we’ve done that. So, our model, you know, is costly as well. We’re not in the business of software licensing and maintenance. But we do license it to a handful of companies, and it’s priced along the same, you know, range that Maria just discussed. But we’ve offered it at a reduced cost to Tanzania and Ghana. For, you know, much reduced cost, I would say, so, because, you know, we’re interested in this work, you know. We don’t want to make a bundle on it. We just want to see it used well. But, otherwise, I don’t know. You know, South Africa uses PLEXOS, I believe, and I don’t know under what terms.

FEMALE: So, I actually won't really spend much time on this, but associating the tool with the appropriate context is as important as associating--as developing the context and the goals and design upfront.

So, the first item here is FTR value, or hedging. This is really a financial instrument. You know, it's looking at financial value. The type of tool that we suggest is a nodal production-costing model, short term can identify congestion, goes node to node. The rest of the items on this list are long term, right? These are the types of questions that you want to answer in an IRP, or that you might be addressing in an IRP. So, a model--and we list IPM, which is our tool--but a model that does capacity expansion and optimization would be appropriate for the long-term decision-making.

However, just to point out again, these models are all interrelated. But they don't stand--you can use them stand-alone, but if you're really doing a full-scale IRP, you want to take advantage of all of

the potential information that you have available. Someone's gone and done a load survey, you don't want to ignore that in doing your demand forecast for an IRP. You want to include it.

Likewise, contingency analysis, TTT analysis that's done with a power-flow model, feeds information into the longer-term capacity expansion tools. When you run the long-term capacity tools, there's actually a loop that feeds back to these other models, too. The GE-MAPS is a production-cost software. It's a short-term, hourly, nodal pricing, nodal dispatch. It can't do capacity expansion, but if you want it to project nodal pricing 10 years into the future, you would need to link the outputs of a capacity expansion model to it. Ideally, you'd have an optimal result, in that case, that feeds back to your production costing and includes decisions about resources, decisions about demand-side programs. So, while we focus on a capacity expansion tool, there is value in an IRP to multiple types of analyses.

And one thing that I do want to emphasize is, the third point here. An IRP is a living document. This is why regulators require IRPs every few years. Typically, we see them between two and five years as far as a requirement goes, but it’s not just to update and refresh about information. It’s to learn from what might be missing, or might be identified, in prior IRPs. If we’re doing an analysis about gas versus a transmission system, you can use the IRP to first identify which makes more sense, a pipeline or a transmission line. Then you go use these other tools to really refine that analysis and bring that detail back to your next IRP.

If your--if in country--in Tanzania, we’ve identified lack of information to do an appropriate load forecast. When I say appropriate, one that we’d really like to get to that level of detail. So, a suggestion, coming from the IRP, is to do more load survey work. We also think, you know, appropriate training of staff will be required from that. So, we’ve already learned from this IRP process.

Ultimately, you want to take what you've learned from a prior IRP and include it in the next work.

So, living document. You don't have to accomplish everything with your first IRP. You want to stage it appropriately, both to the staff that you have available, to the information you have available, and to the tools. Make it repeatable. Learn as you go.

And I'm just going to give one example, and Sanjay is going to give another example of IRPs. My case, I'm giving an example of an IRP that happened. Sanjay's going to talk about the blank slate. How would you design an IRP from a blank slate? And we'd like to focus our discussion on your own experience and questions that you have, so we can talk about scoping around that.

So, the example I'll give is Puerto Rico. Puerto Rico has not traditionally done IRP analysis. And somewhat like we talked about earlier, crisis drives IRPs, right? California, the IRP-style analysis went away, energy crisis occurred, IRP-style analysis comes

back. Puerto Rico, we had crisis situation--both in country, but--PREPA, the electric authority in Puerto Rico, you know, has large debt issues and inappropriate planning toward managing that debt issues.

What was regulation passed in 2014--legislation, excuse me--passed in 2014, that required the regulator in Puerto Rico to design--to force the utility to do an IRP analysis. The regulators took about a year before they came up with the designs and objectives that they wanted to achieve through that IRP.

In May 2015--was it May? Yes, May 2015, they introduced the IRP regulation. Would have very detailed accounts of what the regulators wanted to see in the IRP. They were concerned about the cost implications, the risks, LNG supply versus renewable supply. They outlined, in a fair amount of detail, exactly what the IRP should look like. Specifically, they said we want optimization of resources using a capacity expansion model. They didn’t say what model.

They didn’t say much beyond that, but they did specifically call that out.

So, PREPA did a very, very detailed transmission analysis. They used a nodal-based production-cost tool. They did some very detailed engineering work. They submitted an IRP using all this very detailed analysis that they had done, but they didn’t optimize a single element of their plan. They assumed gas is coming in, this LNG will be available, we should convert to gas. They assumed information in their production-cost models rather than weigh the resources against each other.

You know, effectively, what I say, they put the cart before the horse. They did the detailed analysis before they did the optimization. They did great work. Honestly, I looked at some of their reports and their analysis, and the modeling that they did was good. They had great data collection, but they did not meet any of the objectives of their regulatory requirements. They did not do a long-term planning exercise. They really did much more of a short-term,

immediate-need exercise in their work. So that IRP has yet to close. PREPA is required to go back and start from scratch, effectively, before they can move forward with long-term resource planning.

So, this is an example where there really was no coordination between the regulator and the utility. Although there was a stakeholder process, it wasn't anything that the utility learned from. But they did their analysis. They continued with their traditional means of doing that analysis, rather than look at the objectives and design their IRP upfront to meet the objectives of that work.

So, we wanted to focus a bit more on, how would you go about designing an IRP if you had a blank slate to start from? Or, if you had specific objectives in mind as you're doing so. So, Sanjay will talk about some of his recent experience.

MALE: Thanks. Thank you. So, as Maria said, this is not an IRP. I don't know if an IRP is being considered or not, but this is a study that we did a very short

time ago, just a couple of weeks ago actually. Ken and I were in DRC looking at the power sector, and the objective was really to find solutions on improving access to power within the country. I'll give you a minute to go through this, and then I want you to tell me what are the two most striking things that you see here.

What's the first thing that strikes you?

FEMALE: The points highlighted in blue?

MALE: I gave that away, didn't I? Yeah, 9 percent electrified, and by some estimates that's a higher estimate. It's even lower than that. And the total installed capacity is about 2,600 megawatts, only half of which is available at any given time because there are frequent breakdowns.

So, the biggest source of power is right here at the mouth of the Congo River, which is the Inga dam. So, Inga 1 and Inga 2. Inga 1 is, I think, 1,400 megawatts. Inga 2 is 400 megawatts. OK. And then you

have a few scattered sources around the country that add up to 2,590. OK.

From Inga you have got one power line. It’s a 400-kilovolt HVDC line that goes all the way down southeast to the mining industries. This line is not tapped in-between. It transfers power from Inga all the way down here, to a place called Lubumbashi. There’s a power line that goes--an AC power line--going from Inga to the capital, Kinshasa, that supplies power to part of the city. Kinshasa is 11 million people strong. It’s only 40 percent electrified. OK.

Most of the country in the center is all forest, very rural. This is the high population corridor. So you have Kinshasa here, and then if you go down south, and just follow this line down, you’ve got a couple of cities here that are highly populated. This area is highly populated. And then this area, the mining part, is highly populated. But the point is that there is very little power here. The power sources here are what I call distributed. A combination of

diesel plus small hydro. Even here, you have diesel, one guy that's running a small power plant of 2.5 megawatts. There's a combination of diesel and the solar PB, and it supplies power to I think 1,000 households or something like that.

So, that's the challenge. And the challenge is to improve power access to, first of all, this populated corridor, which has got some of the major cities here, and then to the rest of the country. How do you do that with no accessibility, no transmission lines except for this one, which is just a single line from point A to point B, no tapping in-between?

So, we did a little demand analysis on this. And this demand analysis is only on that four-cities line going from west to southeast. And we found that using 250 kilowatt, per capita, per year, which is based on a World Bank tier zero to tier five energy-demand scale, the unmet demand was 4,500 megawatts. Huge.

The supply source is hydropower. This country is probably the second richest after China in

hydropower. It’s got about an estimated 100,000 megawatts of hydropower potential. There is solar, but, again, the resource is scattered. And then there is diesel that is currently being used.

So, how would you go about designing a study for this? What would you start looking at? One thing I should add, this map--OK, so, this map--this is one of the cities. Let me go back for a second. This is a city that’s right here, this one, OK.

The UNDP atlas, which was published about two years ago, they identified these small hydro sources. And these hydro sources are scattered around the country, around the city in different regions. They range anywhere from a few kilowatts to a few megawatts, but they are not developed. They’re not operating. They’re not producing anything, but they are identified. We don’t know if any feasibility study was done or not. On what basis are they identified? Why is this 240 kilowatt, for example? What’s the technical basis for it? We don’t know.

So, this is what I call--earlier called a white sheet of paper or blank slate. Do you go for large-scale hydro because it is so abundant in the country? Or do you go for mini- and microhydro because it's also very remote and inaccessible? What kind of solar do you do? Are you grid connected, or do you do a lot of off-grid or a combination? How do you expand your transmission and distribution system, given that right now you only have this one line? And then you have one line going here, as well, which is the eastern part of the country next to Rwanda, which is also populated. The rest of the country is blank. Maybe you can do microgrids. One thing that is being considered is privatization.

I'm going to open it up to discussion. What do you think? What's the best way to proceed on the analysis for this? Yes?

FEMALE: Why is only half of the generation capacity available?

MALE: Because stuff is breaking down. Transformers are breaking down, machines are breaking down. The transmission lines are not operational. The World Bank has given millions of dollars in loans in the past five years or so for refurbishment and it's still ongoing.

MALE: What's the government's plan? What do they say?

MALE: Good point. So, the government, we met with the energy advisor to the Ministry of Energy. OK. The minister changed about three months ago, and he was the advisor to the previous minister. Now, he doesn't know if he's going to have a job or not in the next month or so.

We asked for data from different departments across the government. Everybody gave us a different set of data. Even the population, for example, for this city, one source said 300,000, another source said 1.3 million.

Somebody said that we have a solar plan that is one megawatt in capacity that's operating in the east, somebody said it's two and a half. I mean, you see the discrepancy here, and it's just a lack of information, the lack of coordination.

One percent said--so, this is a hydropower plant. It's a 10-megawatt plant that is actually under development with aid from a foreign country. And they have planned to build transmission lines from here to the city. Nothing has been built. Nothing has been designed or developed, but there are plans. It's going to be a 66-kV line. So, when we mentioned that in our out-brief to the government, one department stood up and said why are we building 66-kV lines? We phased that out 20 years ago. And another department said well, they just threw their hands up. This is what we did. This is what we designed. So, there is no, sort of, coordination in the government to speak of. There is no plan, as such.

There is one state utility called SNEL. The whole thing is in French, so I'm not going to pronounce it,

but that has a monopoly. They have been running the electricity sector for years and years and years. They own all the generation of the transmission lines. Obviously, very reluctant to give up control. And that's--they hold a lot of the information, which sometimes they share, sometimes they don't share.

FEMALE: I imagine there's an awful lot of conflicting ideas about what they want to do to promote economic growth or whatever. What are those things that the government is interested in? And then you want to push someone to come up, the stakeholders, to say what are the questions they need to ask? What are the questions they want answers for, in order to make those decisions?

And then, seems like, that kind of a frame of reference could generate whether it's a theory of change or logic, too. Then asking the questions that you'd want to ask of the power sector to then start to shape a plan. But that's real long term, and I can imagine a country as complex as this, as diverse,

that it would be hard to kind of corral all of that in one place.

But, and I imagine the Ministry of Planning, or whatever it might be there, they might have an awful lot of different ideas about where they want to go or what they want to do. And is USAID working with that?

I have a feeling that the CDCS is actually focused on particular things, like--I don't know what the E3 portfolio looks like in DRC. But I imagine--I want to start with what are the questions you want to ask? What are the questions you want to answer? And what are you going to do with this? And can that help shape setting up what you need to know to then begin planning?

MALE: Right. Absolutely right. So, what are the priorities for the government, for the country, right? So, one priority is that this mining sector, here, that is running about 300 megawatts short in energy. OK. So they're using a lot of diesel and their own sources

to power their operations. So, one priority is to fill that shortfall. OK.

Another one is, again, powering these intermediate cities that lie in this path that have no power, or very little power, and very few sources of power. That's another priority.

A third priority could be, so, this is the Inga 1 and Inga 2, the two plants. They are part of a grand Inga project, which consists of seven phases. So, Inga 3 was going to be the next phase, which was going to be about 4,800 megawatts in size. That was under planning until the World Bank pulled its funding for feasibility studies last September because they weren't happy with how the government was handling the project.

FEMALE: Is that the one that ESCON had agreed to buy power from?

MALE: Yes. So, power from that was going to go down to Zambia and on down to South Africa. And the grand

plan was to transfer power to North Africa to Egypt and parts of there. But that is in limbo right now.

And then you have this part in the country, which is far removed from Kinshasa, the capital. The infrastructure in the country is so bad that you really cannot travel from one city to another easily. OK. People who want to go to the eastern part, they actually fly into Kigali, Rwanda, and cross the border west into DRC, then go into Kinshasa and flying or taking a road trip.

FEMALE: And isn't that area very geothermally active, like, there's a volcano?

MALE: There is geothermal, yes, yes. There is geothermal there. Any other thoughts? I'm not asking for solutions, just thoughts, brainstorming. Yes?

MALE: I wonder--you mentioned you have a blank slate, but also, you integrated all of the--

MALE: Yeah. Let's say you are the president, Kevin.

MALE: Right. But you mentioned it's a blank slate, but at the same time, it's not a blank slate at all. I mean it's--

MALE: In a way, yeah.

MALE: --charged with all the regional and cultural specificities. And I wonder--the integrated aspect of this, maybe, I wonder if that's almost--what I'm trying to say is, I wonder if you go region by region, rather than going to the capital and trying to decide everything for the whole country when, probably, Kinshasa is not the one calling the shots in the region.

MALE: That's a great point, and that's exactly how we started thinking about it. So, what we did in this study was, we decided to create five distinct projects that we could then present to the investment community. And say, these are potential projects that you guys can look at and think about investing.

So, we said one project is to link the output from all of these plans that are developed, including this one, and build a collector system. OK. Rather than build transmission lines from each individual plan down to the city, here, which is the city of Kikwit, we would build a collector system that would collect output from these plans and bring it down to a central point, here. And same thing from here to here. OK.

Once you get the power to this central location, the next project we created was a distribution concession system. So, this is where we get into privatization. We told the government, look, you guys have to think about privatizing. So, that was a second project that we created. It’s come down to this.

We would build an AC, what we call backbone, from this point on. Well, let me go up to this figure, here. From this point on down to this point. OK. A 220-kV, AC-backbone system. So, now you have a distribution system around each city. OK. So, you

could do the distribution concession system around each of these big cities, four cities, right?

Then you have a collector systems that’s bringing power from all of the hydropower sources. OK. But, so far, you are addressing the needs of each individual city. Once you create an AC backbone from here to here, you’ve now got a network. OK. So all the four cities are connected to each other in that power network. And they can then start to share power. OK. So, that’s the third project that we created.

The fourth project that we conceptualized was, we assumed that that big Inga 3 project would be developed at some point. And we said we would build a second HVDC line in parallel to the existing one. From here, all the way down here. To first supply power to the mining industry, but also build a couple of converter stations along the way, so they could be tapped into for those four cities. Make sense?

Finally, the final project was--remember that AC backbone we created from here to here? We said that

we'd extend that in both directions. So, we'll extend that from here, down here. And from here, westward, here. So, now we have got an AC backbone for the country running from the Inga dam, all the way down southeast, to here. And that's an AC system, so it's easily tappable as opposed to a DC system. And you can have a number of tapping points, converter stations along the way.

Those are the five projects that we conceptualized. We wanted to address the eastern part of the country, as well, but we didn't have that in the scope because of time constraints.

So, I will say one more thing about the eastern part of the country. Here, the Howard Buffett Foundation, Howard Buffett, the son of Warren Buffett, he is putting in $100 million into the development of this area. And he has invested in a company that has developed a 13.8-megawatt hydropower plant, and he's developing another 23-megawatt hydropower plant. And that person, that company, is selling power to this region. And Howard Buffett has made a $20 million

investment in that company. And he's investing more in similar resources.

To your point, Kevin, on a regional basis--or somebody else made that point--the regional basis, that's the regional focus where entrepreneurs are coming in and serving a region far away from Kinshasa's control. Yes?

FEMALE: I'm wondering if there's much interest in financing from the Chinese. Are they--are the Chinese involved in financing any infrastructure works in the country?

MALE: The Chinese are involved. They are trying to finance roads, no power projects just yet. This project, the 10-megawatt, and there's another one east here in this city, which is a 64-megawatt project, those two are being financed by the Exim Bank of the government of India. OK. The smaller one, the 10-megawatt is complete, but the transmission system is not built. The second one is half complete, and because of some issues with the contractor, he got fired. So, it's in

limbo, and they are doing a new procurement to find a new contractor to build, to complete this system and build the transmission lines to the cities. So, that's the status of that. So, yeah, the Chinese are there, but I haven't seen anything connecting them to the power sector just yet.

FEMALE: Can you explain the transmission that you--the transmission projects and--because some of them, kind of, look redundant to the transmission lines that are already there. What is it that's new about the lines?

MALE: OK, yes, sure. So this, the existing line, it's a 400-kilovolt HVDC line, OK. It's taking power from those two Inga 1 and Inga 2 projects. So, we assume that Inga 3, the bigger one, 4.8 gigawatts, that would come into the picture, that would be developed. If that is developed, that's a whole lot of power. And, you know, 4,800 is the nameplate on that. People say it could go from 5,000 to 11,000 megawatts. If that comes online, we need to augment that line in a big way. So, we proposed that we would build a

parallel 1,000-kilovolt HVDC line just to be able to handle that much power.

So, that was one, and the second one was an AC line. OK. So, AC line--the difference between AC and DC, I'm sure you know that, I mean, DC doesn't--you know, AC has too many losses. DC, you can carry long distances, so that's why you do DC. But if you have to supply power to short distances, it doesn't make sense to do DC, because tapping DC is also a little challenging. So, then you build AC lines. So, that's why we proposed that we will build an AC line from here to here, just so that you can then tap into it along the points and power places in-between. Yes?

FEMALE: I think that also in the projects you're proposing, you could make a very compelling reason for the focus and the actual locations of that. Because you could make a pretty compelling argument about value chains and economic development and health resources, health care access, and population. Because, I believe, Kikwit is where there's a large regional hospital.

MALE: Absolutely.

FEMALE: So, you've got those other--that's what I was thinking about, kind of, higher-level planning, or focus, or how does that fit in, kind of, that much larger picture? I think you could make a compelling reason to do this.

MALE: Absolutely. So, I mean, this was a very basic study, but, yeah, that--we would take that into account. For example, some of these sources are so small they're not economically feasible to even develop. OK. So, we would build the best possible sources, and, you know, look at what's--optimize the process, really. OK, and then do a follow-up analysis. And then see, OK, what is the unmet demand? And where is the demand coming from? And what are some of these higher-level issues that we can address, in terms of economic impacts and social impacts, and, sort of, bring all that together. So, I would certainly put that into the scope.

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