CLEAN ENERGY SOLUTIONS CENTER
ASSISTING COUNTRIES WITH CLEAN ENERGY POLICY

Tools to Facilitate Mini-grid Deployment

—Transcript of a webinar offered by the Clean Energy Solutions Center on 17 November 2015—
For more information, see the clean energy policy trainings offered by the Solutions Center.

Webinar Panelists

Tripta Singh	Director for Energy Access, UN Foundation
Peter Lilienthal	President/CEO, Homer Energy
Bozhil Kondev	Energy Advisor, GIZ (Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH)
Pierre Telep	Energy Advisor, GIZ

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Sean Esterly — Hello, everyone. I'm Sean Esterly with the National Renewable Energy Laboratory and welcome to today's webinar, which is hosted by the Clean Energy Solution Center in partnership with the United Nations foundation's Energy Access Practitioner Network. Today's webinar will discuss mini-grids, tools, and resources that can be useful for practitioners during the planning, design, and operation of mini-grid projects. And one important notes of mention before we begin our presentations is that the Clean Energy Solution Center does not endorse or recommend specific products or services. Information provided in this webinar is featured in the Solution Center's resource library as one of many best practices resources reviewed and selected by technical experts.

And also, just before we begin, just want to go over some of the webinar features. For audio, you have two options. You may either listen through your computer or over your telephone. If you choose to listen through your computer, please select the "Mic and Speakers" option in the audio pane. Doing that will just help eliminate the possibility of feedback and echo.

And if you choose to dial in by phone, please select the "Telephone" option, and a box on the right side will display the telephone number and audio pin that you should use to dial in. If anyone's have technical difficulties with the webinar, you may contact the go-to-webinar's help desk at 888-259-3826, and they can help you there. And if you'd like to ask a question during the webinar— and we encourage everyone to do so— we ask that you use the

"Questions" pane where you can type in your question and we will receive those through there. If you're having difficultly viewing the materials _____, we will posting PDF copies of the presentations to cleanenergysolutions.org/training, and you may follow along. Or, also an audio recording of the presentations will be posted to the Solution Center training page within a few days of today's broadcast.

Just a reminder, we're also now adding Solution Center webinar recordings to the YouTube channel where you'll find other informative webinars, as well as video interviews with thought leaders on clean energy policy topics. So, today's webinar agenda is centered around the presentations from our guest panelists, Tripta Singh, Bozhil Kondev, Peter Lilienthal, and Pierre Telep. These expert panelists have been kind enough to join us to showcase a catalog of tools relevant for mini-grid practitioners. And panelists and participants will discuss selected tools and their uses in details. Before our speakers begin their presentations, I'll provide a short, informative of the Clean Energy Center initiative, and then following the presentations, we'll have a question and answer session where the panelists will address questions submitted by the audience.

So, this slide provides a bit of background in terms of how the Solution Center came to be formed. The Solution Center's one of 13 initiatives that the Clean Energy Ministerial that was launched in April of 2011 and is primarily led by Australia, the United States, and other CEM partners. Some outcomes of this unique initiative include support of developing countries and emerging economies through enhancement of resources and policies relating to energy access, no-cost expert policy assistance, and peer-to-peer learning and training tools, such as the webinar you are now attending. And there's four primary goals for the Solution Center. First is to serve as a clearinghouse of clean energy policy resources.

Second is to share policy best practices, data, and analysis tools specific to clean energy policies and programs. Third— they strive to deliver dynamic services that enable expert assistance, learning, and peer-to-peer sharing of experiences. And then lastly, the center fosters dialogue on emerging policy issues in innovation from around the globe. And the primary audience for the Solution Center is typically energy policy makers and analysts from governments and technical organizations in all countries, but we do also strive to engage with the private sector NGOs and civil society as well. So, this slide shows one of the marquee features that the Solution Center provides, which is the no-cost expert policy assistance known as "Ask an Expert".

The Ask an Expert program has established a broad team of over 30 experts from around the globe who are each available to provide remote policy advice and analysis to all countries at no cost. So, for example, in the area of rural electrification, we're very pleased to have Abraham Raymond— director of the Social Transformation division at the Energy and Resources Institute— serving as one of our experts. So, if you have a need for policy assistance in rural electrification or any other clean energy sector, we do encourage you to use this valuable service. And again— it's provided to you free of charge. So,

if you have a question for experts, please feel free to just submit it through our online form at cleanenergysolutions.org/expert.

Or, to find out how the Ask an Expert service can benefit your work, please contact me directly at Sean.Esterly@NREL.gov or give me a call at 303-384-7436. And we do also invite you to spread the word about this service to those in your networks and organizations. So, now, I'd like to provide brief introductions for today's panelists. Our first speaker we'll be hearing from is Tripta Singh. Tripta is the director for energy access at the UN Foundation.

She leads the Energy Access Practitioner Networks' activities on mini-grids and manages its engagement in Asia. Prior to joining the foundation, she worked at World Neighbors, where she helped managed community health and environment programs in several developing countries. And then following Tripta, we will hear from Bozhil Kondev, an energy advisor at GIZ in Germany. His responsibilities include strategic and technical advisory to a portfolio of GIZ projects on rural electrification in both Africa and Asia. He is also involved in the liaison with partners in his national initiatives.

Our third speaker today will be Doctor Peter Lilienthal. Peter is the president and CEO of HOMER Energy, and since 1993, has been the developer of the National Renewable Energy Laboratory's HOMER Hybrid Power Optimization software, which has been used by over 135,000 energy practitioners in 193 countries. He has been active in the field of renewable energy and energy efficiency since 1978. And our final presenter today is Pierre Telep, energy advisor at GIZ. Pierre has more than 10 years of global experience in the energy sector, including operational leadership of energy organizations.

He has worked across energy supply chain, including development in engineering for generation in distribution businesses. And so with those introductions, I'd now like to turn things over to Tripta. Tripta, are you able to connect and hear us?

Tripta Singh Hi. Can you hear me, Sean?

Sean Esterly Yes, we can.

Tripta Singh Great. Thank you very much. So, in my presentation, I will provide just a very brief overview of the sustainable energy for all initiative on the practitioner network, which is part of the broader umbrella of _____ for all initiative, and go over the objectives of the clean energy mini-grids high impact opportunity. Are we able to go on my slides, Sean? Could I go to the next slide, please?

Hello?

Sean Esterly Yes, Tripta, we're on the next slide, now.

Tripta Singh Okay. Thank you. So, as we all know, there are about 1.2 billion people all over the world who currently don't have access to electricity. And a billion

more have only irregular access. And about three billion people currently lack access to clean cooking solutions.

And it's an astounding number of people that currently are without these modern energy services, especially given the fact that we now have the technology to be able to provide these to those who don't currently have access. And in response to this problem, the UN Secretary General, Mister Ban Ki-moon, started the initiative on our Sustainable Energy for All, which has three main objectives. The first one is ensuring universal access to modern energy services, the second is doubling the global rate of improvement in energy efficiency, and the third is doubling the share of renewable energy in the global energy mix. In 2014— the decade from 2014 to 2024 was declared as the Decade of Sustainable Energy for All. And more recently, earlier this year in September, during the Sustainable Development Goal Summit, energy was adopted as sustainable development goal number seven.

Next slide, please. And the Sustainable Energy for All initiative provided a global framework— or the background— to declare or to adopt energy as a sustainable development goal, and called on the world to ensure access to affordable, reliable, sustainable, and modern energy for all. And along with it, this is increasing recognition now of the role that energy plays in enabling the other development indicators such as health, education, women's empowerment, improved livelihoods, et cetera. Next slide, please. And at the UN Foundation, we have what is called the "Energy Access Practitioner Network" that a number of you are probably already familiar with.

It currently has about 2,000 members and who have, to date, collectively provided energy solutions to more than 230 million people around the world. And our membership is spread across 170 countries. And the focus of the Energy Access Practitioner's Network is mostly on decentralized, renewable energy solutions. It focuses on market-based mini and off-grid solutions. In fact, the majority of our members are based in developing countries, and providing energy services to populations in remote locations who currently don't have access to them.

Next slide, please. And with that background, the International Energy Agency, I think, in 2011 projected that over 40 percent of the additional capacity that is required to provide universal energy access by 2030 would be most economically delivered through mini and micro-grids. And in recognition of the important role that mini and micro-grids are likely to play in the provision of university energy access, the Sustainable Energy for All initiative classified all designated mini-grids as an area of— as a high impact opportunity, which means that the category of action that's likely to produce transformational impact. And so in June last year, during the Sustainable Energy for All forum, the high impact opportunity on mini-grids— on clean energy mini-grids— was launched. Next slide, please.

And so this HIO currently has around 150 members, and it's constantly growing. And it has— and the HIO recently provides a framework and a coordination mechanism that can create or that can result in accelerated

investment and deployment and application of mini-grids to contribute towards the global goal of energy access for all by 2030. And the five objectives of this HIO are better integration of clean energy mini-grids in national and international energy plans and regulations; improving the coordination and interaction in the mini-grid sector— so, basically, building better partnerships, catalyzing greater involvement of stakeholders in promoting this sector forward; also, creating agreement and knowledge of key concepts. So, making sure that a number of terms or standards that are needed or used in the mini-grid sector, that there's a common understanding of what all those mean. It also focuses on increasing on facilitating greater deployment of business models.

And a way to do that is to develop and test business models and then increase the visibility of all the ones that are innovative and successful to promote greater application or scaling up. And also, the last one is improved visibility and recognition of clean energy mini-grids as a viable approach. So, that includes educating people or making them aware— including policy makers, investors, et cetera— of the possibilities that this sector offers, and also, improving their understanding of the way the sector functions so that they're— for example, their perception of this that they consider to be a part of the sector is consistent with what is actually the reality on the ground. So, for this— next slide, please— for this webinar, what we would like to do, is to present some tools and resources that can be useful for mini-grid practitioners. And it's a contribution to the clean energy mini-grid's HIO— and particularly, the different objectives of this HIO.

And I will end just by kind of pointing out two of the tools that we will be producing in the coming days— or coming months, I should say. We're going to publish an investment directory sometime in December of this year, which will showcase investment and financing needs in the sector— in the decentralized renewable energy sector overall, but focusing mainly on the financing needs of mini-grid's projects and companies. The second project that will be coming up soon is a quarterly mini-grid's newsletter that will carry the activities of the HIO, but will also showcase best practices, opportunities, and events in the mini-grid's sector more broadly. And we invite contributions from members or from all those who are on the webinar today, for instance, that you would like to see featured in that newsletter. I should also mention, that earlier this year, the HIO produced a tool on that [Break in Audio] provided all the finance opportunities and technical assistance sources that are available.

And it did a mapping of these resources that are in the sector and the alliance— rural electrification _____ co-hosts the secretariat for the key managing mini-grid's HIO with the lead on that. And so that tool is available on the mini-grid's website as well, and you can find the website address in one of the earlier slides in my presentation. And, of course, this presentation will be on the Clean Energy Solution Center website as well, so you can access it there. And— next slide, please, Sean. And if you have any comments or suggestions or if you would like more information, you're welcome to write to me directly at Tsingh@UNFoundation.org.

And with that, thank you very much and I would hand it over to the other panelists.

Sean Esterly Great. Thank you, Tripta. And we'll move right along now to the next presenter, Bozhil. And Bozhil, you still are on mute, but we can see your slides.

Bozhil Kondev Perfect.

Sean Esterly Great.

Bozhil Kondev I hope you can hear me now.

Sean Esterly Yes, we can.

Bozhil Kondev Great. Hi, everyone. As mentioned, Bozhil Kondev is my name. I work for GIZ. Before jumping to the catalog, I just wanted to mention a few words on GIZ, just in case some of you have not come across the name.

We're part of the German development corporation, and assist the German government in implementing its development policy. We are a publicly funded, non-profit enterprise, headquartered in Germany, with activities in a number of countries. We also work on behalf of a number of other governments supporting mainly public sector, but also private sector and civil society. Our activities on mini-grids currently span 20 countries, and we focus on the entire value chain of mini-grid from the promotion to policy and strategies, through the development of national programs and incentives for the promotion of mini-grids. We assist private sector in taking on an active role in developing and implementing and operating mini-grids.

We work with strengthening institutions— public sector or private sector— through second men of experts. We organize exchanges within the sector on different topics. We manage knowledge and, as part of our work at global level, we also work with international actors. And in that framework, we are part of the mini-grid HIO that Tripta just mentioned. Jumping to the catalog of tools, in many of the meetings that we've been part of over the last few years, there was always an interest to map out where are and what kind of tools are available for mini-grid's development and implementation.

So, we decided to venture on that, and we've been collecting input from individual organizations and we have drafted something that we would like to share with you and also get your input as to other tools that you are using, find use for, so that we can just map everything and have a comprehensive list. We do that to avoid duplication while developing new tools. In our teams, we usually exchange quite often, and sometimes, we get questions from— some of the countries say, "Do we have an Excel sheet for certain calculations?" And, in the headquarters, we do have access to some of the tools and we share those that have been used. We don't endorse the ones that we've listed just because there's so many.

We haven't really tried all of them, but those are two that we've heard some practitioners have used and some that we have used ourselves. By doing that

exercise, we also try to map where there are existing gaps, where there are no tools at the moment. And I think it will be always good to have to continue the discussion on those tools and see how some organizations jointly can develop tools that are currently missing. So, until now, we've managed to group the tools that we've identified in six categories— you'll see them in a second. Some 40 plus tools have been identified.

Those include software packages, checklists, templates, cloud-based solutions that are tied to certain products. And we're currently in the latest phase of collecting input for the catalog and we hope to release it in the first quarter of next year as part of the outputs of the clean energy mini-grid HIO that Tripta presented and we are part of. So, what are the tools? I won't go through all of them. Some, probably you've seen. Some are things that you probably use on a daily basis.

But we've grouped some of the categories that are— we grouped them in. They're tools for planning and mapping that we've identified. I won't read all of them. Just look at the logos. They're— all these are hyperlinks, so you can just click them after you download the presentation from the website.

We found some tools for resource assessments that are available through different providers, and there are a myriad of tools on technical system design and analysis. Some will be presented in a few seconds by Peter and Pierre. There are tools, also, that we found and have used on financial planning, business model development. We've also done some small contributions ourselves in filling in some of the gaps that exist. Some other tools are in development.

We're in touch with _____ now, and their project navigates to the adding element on off-grid. So, those are quite useful ones. There are also tools that we know and have partially co-developed in some cases on operations and management. The productive fuse tool is one thing that some of our teams have been working on over the years, and you see some of the other providers. [Break in Audio] payment platforms, cloud-based solutions for customer management or management of suppliers on this slide.

And there are also a number of tools that we're in various topics that are indirectly directed to mini-grids. We decided to map these out as well so that people have access to those, and just in case they want to present their work to a slightly different target group, they can also do that or expand their activities into areas that are not directly linked to mini-grids.

So, that's just the brief overview. As I said, we are still collecting input and there are two ways that you can easily contribute to the development of this tool. There is a survey that we just putting online that you can fill out. It will take you probably less than five minutes. You can review the catalog.

It's available as a .doc file on the link that's on this slide, and you can just send us your feedback via email. With that, I'll close the presentation, and thank you for your attention.

Sean Esterly Hi. Thank you, Bozhil. So, now, we'll move right along to Peter Lilienthal for his presentation. Great. And Peter, we can see your slides, but you're still muted.

Great. So, we can see your slides—

Peter Lilienthal Sorry. You're right. I was still muted. Are you seeing it in slide show mode or in Power Point?

Sean Esterly We're seeing it in Power Point. We had slide show mode for a second there. And the lower right, if you click the "Slide Show" it should go to it. So, Peter, if you go to the lower right there of your screen, next to where you can adjust the size, there's the slide show option. Peter, are you still there?

I think Peter might be having some technical difficulties. Let's give him just a second here, see if he can come back on. If not, we might move right along to Pierre's presentation. But let's see if he comes back on. We'll just give him a moment.

Peter Lilienthal Hello?

Sean Esterly Hi. Peter?

Peter Lilienthal Yeah. So, I lost the audio connection. But you can still see my screen?

Sean Esterly I believe we're still seeing your screen. It's still in Power Point mode. Do you need us to run your slides for you?

Peter Lilienthal Yeah. Well, I don't know. Well, you might as well, I guess.

Sean Esterly All right.

Peter Lilienthal So, let's go to the next slide.

Sean Esterly Yep. Give us one second, Peter. We gotta get your slides up.

Peter Lilienthal I apologize for the glitch here. Just as I was about to start, I lost the audio connection, according to this.

Sean Esterly So, Tim will be running your slides, so just him know "Next slide" when you're ready to advance.

Peter Lilienthal Okay. Well, yeah, next slide, please. And I can't see the slides myself, so this should say "The Future of Power" and it's a very short slide just describing setting up the transition we're doing from highly polluting centralized power that use fossil fuels to distributive renewable power. And our HOMER software's the key to that transition. So, next slide shows the guy scratching his head.

There's a couple of challenges facing this transition. Mini-grids are small, but ironically, they're also more complex than simply connecting to the utility grid. Because solar and wind don't stand on their own, they must be part of a

hybrid system. And out of all these new technologies— both new and old— which combination makes the most sense. So, next slide, please.

The answer, unfortunately, is that it depends. There is no one size fits all cookie cutter solution like a Model-T. To answer that question, we need to know what are the resources available on sight? What is the load profile? What are the reliability requirements?

What are the load management opportunities? What will the cost of fuel be in five years? What do we want to assume about the cost and performance of batteries and other technologies that keep getting better? That's a good thing, but confusing. And a confused mind says, "No."

So, next slide, please. So, the HOMER software fits all those pieces together. It's the only that is a decision tool for distributive generation and micro-grids that models combinations of renewables with conventional generation storage and load management. It's fully chronological simulation layer dispatches generation and manages storage to meet the load in every hour. It does that for an entire year to calculate fuel consumption, run times, maintenance requirements, and operating costs. It then optimizes the design by simulating hundreds or thousands of different design configurations and ranking them by net present cost, total cost of ownership, or other criteria.

Finally, this is all packaged within a decision analytic framework to identify sensitivities and robust solutions. The utility planning tools that do this are 100 times more expensive, difficult to use, and inappropriate for smaller distributive power projects. Next slide, please. Actually, this is where I was gonna show as screenshot of our new HOMER Pro. Unfortunately, I can't do that.

But for those of you familiar with the older HOMER, the functionality has been expanded. It's still somewhat similar, but the user interface is completely different, so I suggest trying our 30-day free trial to get familiar with the new version. This slide is animated, so I'm not sure how well this is gonna work if I can't control that. But one of the uses that are our users tell us is the highest value— or a high value— for HOMER is as a communication tool.

So, yeah, Sean, if you can just— I would just click through the whole— I can't see what you're doing, but show the whole slide. That would be the best thing to do here. We work with renewable advocates who want to go to 100 percent renewable right away and with diesel mechanics who want to keep doing what they've always done. And these two groups don't communicate well with each other.

We also deal with power engineers who have their own specialized software for power flow and transient stability, but don't consider economics. And we deal with the financial community that have sophisticated spreadsheets, but don't consider any of the technical details. Power products don't get developed unless you can bridge the gap between these worlds, and that's what the HOMER software does. Okay. Next slide, please.

So, just a little bit of history. It grew out of the one of the outcomes of the 1992 Earth Summit in Rio. US National Renewable Energy Lab— NREL— created the Village Power Program, and as part of that program, I recognized the need for an optimization tool to design renewable power solutions where the only previous options were diesel generators and grid extensions. This problem is too complex for spreadsheets, so HOMER originally required specialized Unix spaced optimization software. But in 1998, we converted it to Windows and put it on the web for others to download and use.

Then, in 2001, we upgraded it to model grid connected systems and larger islanded systems of 100-megawatts or more with multiple generators. It became popular around the world with users seeing support and training beyond what is appropriate for National Lab. So, in 2009, we licensed _____ to lab, and in 2014, created an entirely new version— HOMER Pro— and we've been releasing substantial upgrades every quarter, and are now up to 135,000 users in 193 countries. So, next slide, please. HOMER's become a global standard.

Just three weeks ago, we held our third annual HOMER Micro-Grid Conference, this time in Australia. Previous ones were in Cancun and Barcelona. We had seekers and attendees flying in from around the world to attend. We had— 65,000 people get our monthly newsletter. RFPs issued by funding agencies like the World Bank and utilities like Horizon Power in Western Australia require that proposals to them include HOMER analyses. This quote is from a utility company in Alaska that created the first hybrid power system that can operate for weeks at a time entirely on wind power using load management for stability instead of fossil generation or storage.

So, let me talk about the market that we serve. It's a highly segmented market. One of our most important functions is to identify the promising segments. I know this is really about the off-grid segment, but just a short word about the grid-connected segment because it's new and potentially huge, and the interest has really increased since super storm Sandy in the Northeast U.S. highlighted the need for more resilient electric systems. And micro-grids are the best solution for providing critical services during outages due to extreme weather, terrorism, or simple failures of our aging infrastructure.

And in developing countries with inadequate infrastructure to begin with— so, micro-grids are an opportunity for them to sort of jump— leap frog to a 21st century power system. Micro-grids are also the best way to manage the variability of integrating high penetrations of solar and wind onto an electric grid. And we see that with micro-grids around the world that currently— off-grid micro-grids— that are currently at very high renewable penetration levels— much higher than what we see in the grid-connected world. And without this capability that micro-grids have of managing that variability, we're already seeing utility companies— such as NYE and Arizona here in the U.S.— pushing back against further renewable development. But on the off-grid and island micro-grid is really the focus today, and as Tripta pointed out, there's 1.3 billion people with no access to modern power.

There are even more who have only part-time power either because they're using a diesel generator that's only scheduled to run for a few hours in the evening, or because the utility service is just very unreliable. So, HOMER's been instrumental in showing how to cost effectively serve these fused markets, reducing fuel costs by 50 percent or more. These off-grid and island micro-grids where we have been working for the last 20 years, are already demonstrating how to have stable, high-quality power, relying primarily on renewables. This experience and expertise, developed by this community, is now becoming valuable to the much larger grid-connected world. So, I hope you've kept up with me on the slides. This slide is a map showing where HOMER's been used.

And we've been told that most of the micro-grids under development globally have used HOMER. And just the last few months, we started the collecting the locations of where people are using HOMER. We have over 8,000 distributed generation projects in our database, and adding about 1,000 per month. Our proprietary database has detailed data on the size of the projects, their reliability requirements, their cost expectations, and the reliability of the local utility service. We can tell how far along they are developing the project, are they ready for financing, who the developer is, what other services do they need, and what equipment do they expect to use.

This database of ours is the fat end of the sales funnel for every supplier in the industry. This is one of my favorite graphs. It's actually from the previous version of HOMER, but it shows how HOMER does a sensitivity analysis. And each of those little diamonds is where we performed and optimization. This is for a relatively small system.

And along the bottom, you can see we looked at five different wind speeds— from low to high— and likewise, fuel prices from $0.20 a liter to $1.00 a liter. And in the lower left where fuel prices are low and wind speeds are poor, diesel, actually, is the lowest cost option. But it clearly shows that what diesel price PV becomes a cost effective, at what wind speed wind becomes cost effective— which depends upon the fuel price— and where, in green, a combination of PV and wind is preferable to either one alone. Now, this is for a small system in the Philippines. The resources and the loads, et cetera, and prices— everything— all the factors could change what this could look like, but I like to show this to show how HOMER does sensitivity analysis.

So, next slide is another analysis that we did just looking at what happens as you add more wind. Molokai is about a five-megawatt power system, and without going into it here, we differentiate between low, medium, and high penetration systems. And it can show how the wind, in this case, was a very good resource— excellent wind resource— can bring down the cost of power substantially, but how there's always a turning point or a knee. And the trick is to find that minimum. And things like the cost of storage— the opportunities for load management will really affect the shape of that curve.

Another graph that we produced from HOMER results— this is for a smaller solar system— where we looked at the cost of reducing CO2 emissions. So, on that far right is the least cost system, which already actually has the

substantial amount of solar. But by going beyond the least cost system, you can reduce the carbon emissions even more, at relatively modest cost, again, until you start to reach a kind of knee where costs start increasing dramatically. What this graph shows to me is that the end points are the right solution. People act like you either do it 100 percent renewable or don't do anything at all.

What HOMER's showing is that you can accomplish quite a lot at a very modest cost. So, the next slide is— this is two days in July for just one analysis that we did, and the black line shows when the diesel generator had to come on for back-up power. You can see the— hopefully— the yellow lines are a little faint, but the first day is pretty cloudy, the second day is pretty sunny, and it affects how the battery is getting charged, et cetera. So, you can actually see operational details on how a system operates. And because every day is different, it really matters to model a whole year, chronologically.

Finally, just to give you a hint of where we're headed over the next year— in 2016, we're gonna continue our quarterly release schedule. We've got several Fortune 100 companies that are paying us to modify HOMER for use by their engineering and sales teams. We're about to release a Spanish version that's been funded by the Inter-American Development Bank, and have been contracted with the World Bank for a French version. The office-enabled research has funded another version for the Marine Corps, and we're beta testing a much simpler software as a service version we call "Quick Start". We're off to do a lot of HOMER training, and we're just expanded our training staff and are creating a certification program.

So, stay tuned for that, 'cause we would like to do a lot more trainings in country, around the world. And so we've expanded that just recently. Finally, my last slide— I'm just leaving up some of our industry partners. We've created this industry partner program. This is just the first few that have signed up.

But we'd love to talk with all of you more, but I'm gonna pass the presentation back at this point. Thank you.

Sean Esterly Great. Thank you, Peter. Great presentation. And, just a reminder to all our attendees, that we will be posting these slides at the Clean Energy Solutions training page. So, you can go out there to access that afterwards.

So, at this point, we're going to our last presenter today, Pierre. Great. And Pierre, we see your slides. Perfect.

Pierre Telep Okay. Thank you very much. Can you hear me as well?

Sean Esterly Yes, we can. Yep.

Pierre Telep Can you hear me as well?

Sean Esterly Yeah, Pierre, we can hear you perfectly.

Pierre Telep Okay. Thank you very much. Thank you to Bozhil for having presented GIZ already. So, I'm going to skip that part in my presentation. What I'm going to present today is another tool for mini-grids, and the tool is called "The Mini-grid Filter", which is a free tool and on the public domain right now.

We are not a GIZ software development company. Just a side note. This tool was a modest contribution just to enable mini-grids development. So, in this presentation, I'm basically going to answer two-three questions— why a mini-grid builder? What does it do? And how does it work?— just to present the tool.

Slide one of the presented— I said before— it has been recognized that mini-grids are a high impact opportunity for achieving the Sustainable for All initiatives' objectives. So, being on the ground developing mini-grids, we noticed that their development of projects have some challenges. One of the main challenge for mini-grids is that the projects are very much site specific. So, the demand is site specific. Also, the possible outputs are site specific.

Some areas may have lots of sun. Some other maybe suite-able with mini-hydro project, and other places might just be more blessed with more wind. So, one of the challenge is the site specificity of mini-grids. The other challenge is that the mini-grids are usually developed in areas where the main grid is not actually reaching. So, this has to deal with a project upfront cost.

So, we recognize that developing mini-grids sometimes require higher months of feasibility studies, and such feasibility study can be quite costly for project developers who need to travel in remote places. Another challenge is with the demand assessment. So, how can we properly assess the demand of a mini-grid project when we develop it? So, the reality is that there is a big difference between the demand and the effective demand. So, the demand is basically what the mini-grid can supply in the realistic world, where the effective demand is the demand which can be converted into money whenever the project starts supplying this demand.

So, from commercial _____, it's very important to design system which meet the effective demand. Another challenge— or the fourth reason why we need a mini-grid builder— is that at some point, the developer needs to set a tariff— a tariff at which it's going to sell electricity. And we recognize that there are many tools out there for calculating the tariff, but some of them are very complicated and require a high level of education to even understand the model. So, there is a need to have something which is just simplified. Then there is also a need to actually have a framework for data collection.

So, there's nothing like one model that can work every lesson. Every project is site specific. It's needed to collect data before starting developing a project. So, this tool, The Mini-Grid Builder— what does it do? It provides the framework for data collection for feasibility study.

So, instead of somebody going on the ground with questionnaires that they have to fill on paper and then coming back, converting them into any kind of digital input, they just have this framework all ready. The Mini-Grid Builder also aim at reducing project up-front cost. So, at the end, the output is the

feasibility study that the project developer has. It's like a 12-page document which can already inform into a decision making process for developing the project. Another output of the mini-grid is workover assessment of the effective demand.

So, when collecting data, the tool gives a framework for seeing what is the ability to pay, what is the willingness to pay. And all of this data calculate it to assess the effective demand. Then, the tool also provides a realistic and applicable electricity tariff, which is based on the arrived cost of electricity, which we just saw on one side on the HOMER presentation. And something which is also very important— sometimes, there is— the time difference between the moment a feasibility study's been carried and the moment the actual project is implemented. When there are such variations, it is very important to always have the ability to update the whole feasibility study without starting it from scratch.

So, with the tool, someone has all the data stored in one place, and then, if there's an increase of demand, just updating this data can also automatically update the feasibility study. What we've seen in Kenya— if we consider the cost of the feasibility studies— where we are actually right now for multi mini-grids is that we can save up to 15 percent on total project cost. Of course, this will reflect at the later stage on the tariff at which electricity can be sold in the rural areas. Just a few notes how it works— the tool is available for free. So, it is at this link: http://www.minigridbuilder.com/.

How do you use it? Basically, you just create an account. Like, it's usually done on the internet, and one can use now the tool maybe going on the site where projects are being implemented to collect social, economic, and demand data. So, this data are both qualitative and quantitative. At the end, the tool is going to provide for the feasibility study report, and this data can be updated at the latest stage.

So, what the tool does not do— it's not the mapping tool to actually see where is the potential, but it provides the project developer with load assessment. Just one slide to have an overview of the tool. So, we have here both qualitative and quantitative data. At the beginning, the user is going to key in load profile data. He's going to validate also some financial assumptions.

For instance— the cost of solar panels are not the same in all the countries, so those assumptions have to be validated. Then, at the end, there is the report that the tool provides. Right now, it's just covering East Africa— five countries in East Africa. We are trying to see if there's going to be more demand. We are going to extend the tool.

It is best just for solar hybrid mini-grids for now. So, hydro— mini-hydro technologies are not yet included. Just another slide to have an overview of some of the output. Once data has been collected, it's possible to see a lot of fives. This is an example of a lot of _____ on a site in Kenya. So, with this, thank you very much.

Sean Esterly Great. Thank you very much, Pierre, for the presentation. So, now, at this point, I'd like to go ahead and open up the question and answer session for the

webinar. So, just a reminder to all our attendees out there— if you have any questions for our panelists today, please feel free to type those into the question pane and we can present those to the speakers right now. So, with that, I'd like to get started with the first question that we did receive, and this one was for Peter on the HOMER tool.

They were wondering, Peter, what the cost of using the tool is.

Peter Lilienthal Yes. So, we have several different licensing, and it depends on— we have discounts for students and for academic researchers. We have monthly, annual, and permanent licenses. We have the base product, and then add-on modules— like, for example, the advanced grid is an add-on module. So, probably the most common thing is for people to buy— an annual license of the base product is $500.00.

And the monthly licenses for that would be— oh, you know, I don't know the exact number, but it's around $100.00. The first 30 days or the first month is free, and students get something like a 75 percent discount.

Sean Esterly And Peter, just a quick follow-up— is that available on— the tool's available on Macs as well, I would assume.

Peter Lilienthal I'm sorry— available on— what was the last word?

Sean Esterly On both PCs and Macs— Apple Macs?

Peter Lilienthal It runs very well under a Windows emulator. It doesn't run native on Mac OS, but parallels or VMware— it runs well under those.

Sean Esterly Great. Thank you, Peter. We have a question for Pierre that came in. Pierre, they ask, "What sort of financial factors does the model account for?"

Pierre Telep What sort of financial factors? So, the tool does not look into the operation of the mini-grid. It basically just updates the page. So, it's going to see what is the cost, for instance, of solar panel or the cost of different technology within the county. The user can also, for instance, update his internal rate of return.

He can put the target profits that he's looking in terms of rates or the payback, which is foreseen. And this is on the third slide. And all these financial assumptions can be freely validated before just clicking and asking the tool to do the calculations. So, it's possible to do different simulation, and have different scenarios based on one set of collected data.

Sean Esterly And Pierre, another question directed towards you. It was asking, "You noted that The Mini-Grid Builder is good for— it works best in five countries in East Africa. Could you just explain a little bit why you focused on that and why it's not— is it effective elsewhere as well?"

Pierre Telep Yes. But the reason is that behind the tool, there is the database with solar insulation and there is a database with exhaustive places. So, we are using, actually, accurate data in this database. It was just lots of work for the consultant, OneShore Energy, who was hired to do this work to actually put

this database. Therefore, that's why we have targeted one area— East Africa, for the moment.

But we foresee that if there is a higher demand, we can populate the database with much more data.

Sean Esterly Thank you, Pierre. Now, we have a question for Bozhil on the catalog of mini-grid tools. Bozhil, they were wondering if you have any good practice projects integrated into the catalog— any best lessons learned or best case studies, anything like that?

Bozhil Kondev We haven't included such until now. There has been discussion within the HIO to come up with some standard model for describing business cases for mini-grids, and once we have that standardized model, I think we could expand. But we haven't cleared that so far.

Sean Esterly Thank you, Bozhil. And now, I have a couple of general questions on the existence of other tools. So, we'll start with the first one that I have. So, this is for all panelists. "Do you know of any monitoring systems that link to design tools such as HOMER or others so that a feedback on the system performance is given and continued assessment of the system is ensured?" So, really a monitoring and assessment tool on that with link to design tool.

Is anyone aware of any mini-grid tools like that?

Peter Lilienthal This is Peter. We're investigating that. That question comes up— well, it's coming up with more and more frequency. If we go back a couple of years, it didn't come up very often. There weren't that many operating systems out yet.

So, we're looking at that, but right at the moment, I wouldn't say that we have that capability yet.

Pierre Telep Yeah. It depends, also— this is Pierre. _____, we have put in place some kind of extra fits that can be used for monitoring, but this is just like tracking to keep performance indicators on the given project. If it's about remote monitoring, right now, we've heard of the Strathmore University— they are developing a tool which is going to be best on GTSM technology for remote monitoring. Right now, what we know is it's just monitoring, basically, the load, which is a good start already.

But I'm not sure if it's out yet. I think last time I heard, it was still under development.

Sean Esterly Great. Thanks.

Peter Lilienthal You know, along those lines, I might mention a project that's sort of underway at— with NREL and the Department of Energy— on the quality assurance framework that includes an accountability framework. So, they're defining the parameters that you'd want to measure or monitor in a mini-grid. So, that's still in very much a draft form, but we just got a call in on it yesterday. It's under active development. And that would feed into what you're talking about.

One of my frustrations, up until recently in the past, was how infrequently the systems who actually had monitoring— you couldn't even collect data from. So, private practice would get done with no monitoring, which sort of defeats the purpose of a pilot project. That seems to be changing rapidly, though, and there should be a lot more data now. So, I think that was a really apropos— a good question to raise.

Bozhil Kondev I can also add here— we've carried out a number of technical inspections of mini-grids in Indonesia, and we have quite a lot of data. The guideline— the checklist that we've used are available online. I'd be happy to share the links. On top of that, we're currently in discussions with a number of organizations and are trying to collect more data on load profiles and load development curves. So, those— we haven't— I mean _____ developing a methodology and a way to plug in the data and get some results pretty quickly. So, that's something that we'll do here in the next few months.

Sean Esterly Great. Thank you, guys, for the input. We did have a couple attendees also comment as well. One attendee noted that— Peter Stevenson noted that a lot of monitoring software often comes with component suppliers, so depending on who you buy your components from, sometimes they will supply those. Other examples include on attendee, Silvario, is using eGauge— the eGauge tool to monitor a project that was actually modeled in HOMER.

And so there are some out there. Whether or not those can be fed directly into a tool like HOMER, I'm not sure. But there are, at least, some tools out there for monitoring and assessing the performance of the mini-grid. So, we'll move on to the next topic. Peter, this one's for you— just a quick question, again, kind of on cost for HOMER. Is the tool available for free for NGOs?

Peter Lilienthal No. But we do— we do try to be very flexible for the small NGOs in developing countries. So, you know, send us a note. I want to comment that NREL is an NGO. The concept of an NGO covers a huge amount of terrain, including— some very, very large, well-funded organizations are still NGOs.

But we are very interested in maintaining our user base in the developing world with organizations that may be very resource limited. So, we don't want to be too blanket on that. But we do have a support staff to support and et cetera.

Sean Esterly Great. Thank you, Peter. Next question asks was HOMER or GIZ or are you aware of any other organization that would help— or a system— the developing of alternative tools. So, to help develop tools in maybe a specific area where a tool doesn't exist. You aware of any resources that could assist with that process?

Peter Lilienthal We'd love to have those resources ourselves. So, no. Sorry.

Sean Esterly Yep. That's what everyone's looking for, right?

Peter Lilienthal Yeah.

Pierre Telep Maybe the person who has asked the question may touch base with us and we might be willing to explore much more, as GIZ, what is the scope of this kind of tool. And if it fits some of our objectives— for instance, like reducing _____, reducing costs— if this is something that can be useful for the mini-grid community, we would like to explore. So, if I can just encourage the person who asked the question to just get in touch with us.

Bozhil Kondev Yeah. Not only that, I think just because we have these discussions on a regular basis in the framework of the HIO, it would be good to be aware of what kind of tools are needed so that we can also use the network of the HIO to map and find— match potential resources. Just because in the network, the membership— there are organizations that are looking at supporting certain knowledge pieces, including the development of tools. So, that's something that I think it would be great to share in the HIO network. If the person that asks the question could get in touch with Tripta or myself, then we'll channel it to the rest of the route.

Sean Esterly Great. Thanks, guys. This one's for all the speakers. "Is anyone aware of a toolkit for conducting a market assessment of mini-grids on a national level?" Sorry— marketing assessment for mini-grids on a national level?

Pierre Telep Yeah. Maybe I can just say a few words since mini-grids are very much site specific. I think that they can be, also, very much country specific. So, a tool that can just see the whole market as a whole might be something that needs to be frequently updated, but we know, for instance, of the OBIN Indicator from the solar system in Germany, which has mapped the potential market for Africa. It is a release which is done every year, and it's looking into, for instance, the existing of solar home system. It is a general indicator, but can give like a first idea in terms of what is the real potential market.

It's an indicator. It's called OBIN—O-B-I-N.

Peter Lilienthal There have been a number of studies done, and I don't sort of have that bibliography in front of me. We're in the middle of a study for the Inter-American Development Bank in Haiti, and we also have been working with Irene— and not so much, on a sort of somewhat related project, but as Pierre's said, it's a real moving target. It absolutely would be a worthwhile endeavor. And our new database— we haven't figured out exactly how to use that, but it could really feed into a market study like that. It's so new for us, we haven't actually started to mine that data yet. But I think that's a really good question.

Sean Esterly Thanks, guys. And a couple of quicker questions for Pierre on The Mini-Grid Builder. Pierre, can that tool be downloaded? And also, once downloaded, can it be used offline or is it purely web-based?

Pierre Telep Right now, the version that we have is web-based, and it can be accessed from any normal web browser. But it's a good question. We are thinking that it may be an alternative to have it also downloadable and have probably maybe a map or something that can be worked also to tell you offline. Because one of the challenges is the places where data are being collected— sometimes they are offline. So, it's a valid concern. But what we have right now, it's purely web-based.

Sean Esterly Thank you, Pierre. Here's kind of a more general question. What can be done for private companies in West Africa— or other developing countries— to help them master the project development phase in mini-grids using tools? So, I think more generally— what can be done to help those private companies access and use these tools to develop mini-grids? Any insights on that?

Pierre Telep Maybe I can jump in. It's like initiative like this one. Just, first of all, making sure that people are aware of the tools that are existing out there. It's works like what _____ is doing— compiling, already, all of those tools. And with this kind of webinars, just sharing. I think that will be a good starting point.

Sean Esterly Great. Thanks, Pierre. So, outreach and just making them aware of the tools will definitely help a lot. Pierre, we had another question for you regarding your tool. Is it possible to include project financing metrics— like, loan terms, equity percentage or grant percentage— of total project cost?

Pierre Telep Yes. The tool already has that. It has a percentage of the financing which comes from loan, the financing which comes from equity. So, in the validation of financial— the financial assumption, the developer or the user of the tool actually can just adapt to his basic need. And he can even put his own complex specifics internal— to get interest rate, for instance, for the loan.

Sean Esterly And Pierre, what the cost to use that tool?

Pierre Telep The tool is free for now. So, all you need to do is just to go to MiniGridBuilder.com and just create an account. So, it's free. It has been financed by public money. The difference, for instance, with HOMER, is that the initiative of GIZ looking into supporting mini-grid.

Of course, we also looking to the sustainability of such tools. But for right now, it is purely on a free base, and it's not like a money generating tool.

Sean Esterly A quick question for you, Pierre— I think you already touched on this, but can The Mini-Grid Builder Tool be used in Nigeria?

Pierre Telep I would say, "Yes." The only thing is that solar insulation data which are into the database are not the specific ones of Nigeria. But with some approximation, if somebody will select a country at the equator which has like, a similar insulation characteristics, it can be used.

Sean Esterly Perfect. Thank you. And this one— now, moving on to Peter— another question about HOMER— a couple of questions about HOMER. What is the best geographical scale to apply to HOMER?

Peter Lilienthal Scale. We use it for quite a wide range of scales, really. And I usually think of scale in terms of the size of the load, actually, not the geographic extent of the mini-grid. So, I'm not probably answering the exact question that was asked, but we've used it for systems as small as a single kilowatt. It's probably kind of overkill when you get down below that.

And we've also modeled 100-megawatt systems or even 250-megawatt systems. I would say a sweet spot is kind of in the middle of that range— sort of 50-kilowatts to 5-megawatts is, I would say, the sweet spot. That's in terms of load. In terms of scale, it doesn't actually model the poles and wires and transformers. It just meets— it models what's the supply and demand balance to meet the load, but it's an entirely different modeling problem of modeling voltage drops and reaction power flows, and the distribution planning aspect of it.

That's where the geography would come into play. So, it's really not a geographic or a distribution planning tool. It's really more about the power supply and the balance between supply and demand. I hope my answer's— I hope that answers the question.

Sean Esterly Yeah, I think so. I think that makes sense. Definitely. Just another question on HOMER— a couple of questions on HOMER. Are the trainings that you offer for HOMER remote online so that people can take them from wherever they're located? And what is— it obviously depends on each individual, but approximately, what would be your guess on how long it would take to learn the basics of the HOMER tool?

Peter Lilienthal Right. So, the training comes in a variety of ways. We do a lot of in person trainings, but we also have some regular online trainings as well. And, as I mentioned, we're expanding our training program, so that's all gonna expand quite a bit over the next couple of months. So, yes, we have online trainings typically twice a month, and we try to vary the time of day that they're offered so that times that are good for Africa aren't really that good for Southeast Asia, et cetera.

So, that's all on our website to use. Sign the training page on our website— it'll give the times and days of the next online training. And in terms of how long it takes to get proficient really does depend on the individual. The intro training is typically two to three hours, and that gets you started. It gets you familiar with the interface.

We also have a tour built into it, and quite a bit of the help. You can do that on your own as well. And I would say that in three hours, you can get started. You can get so that you're doing stuff. There's a lot of capabilities that's not necessarily really visible.

So, when we think about the new training programs we're creating, they're gonna be in multiple levels, and we'll have a basic level and a variety of advanced levels. So, it doesn't take a lot to get started, but to get really good at it, it would take some dedicated effort depending upon what's your background with renewable power, computer modeling, et cetera. So, I'm not— it's difficult for me to answer the question, "What would it take to get really good at it?" But to get started— it's a couple of hours.

Sean Esterly Great. Thanks, Peter. Another question came in for Bozhil. Bozhil, one of our attendees just wants to thank you for the list of tools in the presentation and wonders— are any of the tools evaluated ready for more complex grid

connected systems? So, do any of them go beyond the typical mini-grid and start to deal with grid-connected systems? You there, Bozhil?

Bozhil Kondev ...capabilities, so that will be something to start with, and if there are questions, we can usually answer.

Sean Esterly Sorry, Bozhil. I think you were muted at first. Can you just repeat your response, please?

Bozhil Kondev Yes. I sorry for that. I think it would be great to just review the list and where— in the descriptions of the tools, some of them provide already the relevance for grid or off-grid systems.

Sean Esterly Great. Thank you, Bozhil. And a couple of more questions for Pierre. And just a reminder— or just to let everyone know— we are starting to run a little low on time, but we have quite a few questions left, so we'll just keep the responses as brief as we can so we can hopefully address as many of these as possible. So, this one's for Pierre.

"Are lower efficiency of diesel generators and batteries with time reflected in the tool? And what lifetime is typically used for solar diesel hybrids?" So, a pretty specific set of questions there.

Pierre Telep So, I didn't understand the question, "What time is basically used?"

Sean Esterly Yeah. They're wondering what lifetime for the solar— so, lifetime of the systems— is taken into account.

Pierre Telep Oh, yes. Okay. Well, the lifetime for— for instance, it depends on the components. On the solar components, we have a different lifetime, for instance, for the solar panels. We have different lifetimes for inverters, different lifetime for batteries.

It depends, very much, on the design and on the manufacturer. For instance, if we go to tubular batteries, we can expect a lifetime of 12 years. If we go into inverters like SMA5, we can go something about 7 years, up to 10 years sometimes. If we are looking to the solar panels, most manufacturers are guaranteeing their output for 25 years. So, it depends very much on each one of the components.

So, the whole system, as a whole, cannot— it's very difficult to say, "This is the lifetime of the whole system." And therefore, the model— I see the why the question comes— the model behind the tool is taking like, standard lifetime for each one of the main components to actually come into a break-even conclusion.

Sean Esterly Thanks, Pierre. And are there plans to develop the tool further?

Pierre Telep Yes. We are looking into having a kind of partnership for the reason I have mentioned before— for sustainability reasons. The nature of GIZ work is that we support projects for a certain period of time, and when, for instance, our activities are done, the project's completed, then we may move into

something else. Well, a tool like this probably needs to be in the market for a longer time. So, right now, it's out there for free.

But, of course, behind, there is a cost for running the server, for hosting the tool. There might be some maintenance needed, plans for maybe making it a downloadable device. We are looking into actually also making an app also because everybody's now using apps and tablets, which might make things easier. So, we are exploring some of those options. Mainly, the main idea is sustainability.

So, at the end of our project, the tool has to still remain in the market and accessible to project developers.

Sean Esterly Great. Thanks, Pierre. We have time for one more quick question. This is one that I get quite a bit, so I'd like to ask this one. But please try to keep the responses brief as possible as we're running really close on time.

Is there any software available to determine— for rural electrification planning— to determine the least cost analysis between on and off-grid systems? So, whether they should pursue an off-grid mini-grid or extend the central grid.

Peter Lilienthal Well, in HOMER, we do have a simple calculator for what we call "Breakeven Grid Extension Distance" so we can compare the cost of the off-grid micro-grid hybrid system to the cost of grid extension and see, like, where the breakeven point is. It's a pretty simple analysis. We do that in HOMER. And I want to reinforce Pierre's point about replacement cost and of the cost of the system. You're not just going to replace the system.

You're going to replace individual components within the system, and a lot of the times, people don't keep track of that adequately. They don't set aside money for replacing— particularly the battery in the diesel generators. And it depends strongly on how they're used. So, that was a really important question, but I just wanted to throw that in.

Bozhil Kondev I can also add— Bozhil here— there are a number of tools that have been used. There's several commercial solutions for rural electrification planning that include both grid extensions and off-grid systems. I would be conscious to recommend any, because they all need some updating when it comes to the actual analysis because the cost of all the different technologies develop over time, and a tool that has been developed five years ago needs to be adapted to the current situation. So, we've listed a few of those tools in the draft catalog that you can find on the link, and there have been tools or models that have been developed in the past that are not available for download.

There are publications available based on the usage of these tools, and there's some that certain organizations have been using internally to provide such services as a consultancy. If there are specific questions, I'd be happy to pick them up and respond, if I can, or direct the person who's asked the question to the companies or organizations and individuals who have the _____ tools. We've reviewed a number of these tools and I've used several in different countries, so we have a pretty good overview.

Pierre Telep Yeah. Maybe— Bozhil, if I— this is Pierre— if I can just add something very quickly— is that The Mini-Grid Builder gives, at the end of the report, the cost of implementing a mini-grid after data has been collected. So, if the person is, for instance, what is the least cost, on one hand, they will have the cost of the mini-grid, and if one can just know what is, maybe the average cost in the country for grid extension, at the end, it's just comparing now to cost. So The Mini-Grid Builder already provides the cost, at least of mini-grids.

Sean Esterly Thank you, guys. We do have to move on and wrap up the webinar as we're just about out of time. Before we do that, I kindly ask that our attendees participate in a quick survey that we have. So, I will display the first question on the screen and you can respond right through that portal. The statement is "The webinar content provided me with useful information and insight."

And the second question— "The webinar's presenters were effective." And the third one— "Overall, the webinar met my expectations." Great. And just two more. "Do you anticipate using the information presented in this webinar directly in your work and/or organization?"

And then the final one— "Do you anticipate applying the information presented to develop or revise policies or programs in your country of focus?" Great. Thank you so much for your feedback through the survey. We appreciate your responses. And on behalf of the Clean Energy Solution Center, I would just like to thank our expert panelists once again, and also our attendees.

We appreciate everyone's time and are happy that you joined us today. I do invite the attendees to check the Solution Center webpage— that's specifically the training page. We'll be posting the PDF copies of the presentations, an audio recording of the webinar, and we're also going to be posting that catalog of tools that Bozhil displayed. So, that will be up there as well. Additionally, you'll find information on other upcoming webinars and other training events.

And, just a reminder, we're now posting webinar recordings to the Clean Energy Solution Center YouTube channel. We have a variety of other rural electrification, mini-grid, and energy access webinars up there as well. Also invite you to inform your colleagues and those in your networks about the Solution Center resources and services including the no-cast Ask an Expert policy support. So, with that, I hope everyone has a great rest of your day and we hope to see you again at future Clean Energy Solution Center events. And this concludes our webinar.