Hybrid Renewable Mini-Grids

—Transcript of a webinar offered by the Clean Energy Solutions Center on 6 March 2013—
For more information, see the clean energy policy trainings offered by the Solutions Center.

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Vickie: Hello everyone, I'm Vicky Healey with the National Renewable Energy Laboratory and I'd like to welcome you to today's webinar hosted by The Clean Energy Solutions Center. Our discussions today are focused on hybrid renewable energy grids. These mini grids have great potential for improving sustainable and affordable energy access yet support for these new technologies requires a different set of policies from traditional electrification programs and this webinar will explain these differences and describe the requirements of sustainable mini grid electrification programs. Next adverts please?

Before we get started, there's one important note I mentioned that I need to state and that is a disclaimer, basically the Clean Energy Solutions Center does not endorse or recommend specific products or services and the information provided in the solution center's resource library as one of many informative and best practice resources that are researched and provided by our technical experts.

Next slide please.

I just like to deliver a few quick housekeeping items. So, before we begin I'll just go over some of the webinar features. For audio, you have two options. You may either listen through your computer or over your telephone and if you choose to listen through your computer, please select the mic and speakers option in audio pane. By doing so, this will eliminate the possibility of feedback and echo and other types of background noises. If you select the telephone option, a box on the right side will display the telephone number and the audio pin you should use to dial in.

We also ask that you please mute your audio device before the presentations begin and one last very important note, if you're having any technical difficulties with the webinar, you may contact the go-to webinar's help desk and that phone number is 888-259-3826. They're very helpful and they'll be happy to provide you assistance if you're having any difficulties.

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One more item to go over, we do encourage attendees to participate in the webinar by asking questions and also providing relevant comments and if you would like to ask a question or add a comment, we ask you to use the questions pane where you may find in the — again in the right hand box on the right hand side of the screen, and there you can type in your question. Also, if you're having difficulty viewing the materials through the webinar portal, you can find PDF copies of the presentations at cleanenergysolutions.org/training and you can access the PDFs there and follow along as our speakers present.

Also, I just want to let you know that an audio recording and copies of the presentations will be posted to the solution center training page with a few weeks so you can go back and listen and review the presentation at another time. Next slide is agenda.

First of all, we really do have a terrific agenda prepared for you today and this agenda will focus on hybrid renewable energy grids, their importance in providing energy access and the types of policies and programs that support this technology. For our speakers, Peter Lilienthal and Richenda Van Leeuwen begin their presentations. I'm going to provide a short informative overview of the Clean Energy Solutions Center initiative.

And then following the presentations, we'll have a question and answer session and then we'll follow up with just wrap-up and discussion and a few closing remarks.

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Okay, this slide provides just a bit of background in terms of how the solution center came to be. The solutions center is an initiative of the Clean Energy Ministerial and it is supported through a partnership with UN Energy. The initiative was launched in April of 2011 and is primarily read by Australia, the United States and other CEM countries. Our outcomes of this unique partnership include support of developing countries through enhancement of resources on policies relating to energy access. We offer no-cost expert policy assistance and peer-to-peer learning and training tools such as the webinar you are attending today. Next slide please.

The solution center has four primary goals. First, it serves as a clearinghouse of clean energy policy resources such as reports, tools, analysis and various things of that nature related to clean energy policy. It also serves to share policy best practices, the data analysis tools that I just mentioned, the solution center delivers dynamic services that enables expert assistance, learning and peer-to-peer sharing of experiences and lastly, the center fosters dialog on emerging policy issues such as our

renewable hybrid mini-grids is one of our emerging policy issues that we're addressing, and innovation occurring around the globe.

As far as our audience, our primary audience is energy policy makers and analysts from governments and technical organizations in all countries but we also strive to engage with the private sector NGOs and civil society. Next slide please.

One important — this is really our marquee feature that the solution center provides, is expert policy assistance. We call this ask an expert and it's a very valuable service offered through the solutions center. We have established a broad team of over 30 experts in clean energy policy areas from around the globe who are available to provide remote policy advice and analysis to all countries and the services provided to requesters at no cost. So, if you have a need for policy assistance on micro grids, smart grids, regulations, renewables, energy efficiency, clean transportation or any other clean energy sector, we welcome and we encourage you to use this very valuable service.

Again, just to reiterate this, assistance is provided free of charge and to request the assistance, it's very simple, you may submit your request by registering through our ask an expert feature at cleanenergysolutions.org/expert and there's a little icon there that states, "ask a question." That's all you need to do is click on that and submit your question and I will receive that question and respond to you quickly. And we also invite you to spread the word about the services to those in your networks and organizations. Next slide.

So, a few ways about how you can become involved with the solution center. First, we ask you to explore and take advantage of the solutions center resources and services including the expert policy assistance. You can subscribe to our newsletter, participate in webinars as you are doing today and we welcome you to recommend relevant resources and we invite you to test and provide feedback on some of our tools that we have developed, for example, our global renewable energy opportunity tool which you'll find a link to that tool in this slide and it's currently available on our website. So, we welcome your usability testing and feedback on this particular tool. Next slide please.

We also have what we call our policy forum discussions and we encourage you to read and comment on the blogs and articles that are located on our policy forum page. On this page, you will find many interesting and informative articles discussing progress of clean energy policy development and implementation occurring in countries all around the world and we also follow similar articles posted by our partners at the renewable energy and energy efficiency partnership, also known as WEEP. We follow articles on Leonardo Energy and we followed podcasts

that are developed by Bloomberg new energy finance. Our next slide, please.

So, without further ado, I'd like to introduce our speakers for today. And I'm very pleased to introduce Dr. Peter Lilienthal who is president and CEO of HOMER Energy and also we are joined by Richenda Van Leeuwen who is the Executive Director of the Energy Access Initiative, overseeing the UN foundations work on energy access and its engagement with UN sustainable energy for all initiative. Richenda is our first presenter today and I would like to turn over the presentation to her at this time. Richenda, welcome.

Richenda: Thank you very much Vickie and thank you for that introduction and I just want to sort of reiterate the value of the clean energy solutions center experts in terms of helping provide guidance around policy for micro grids and other aspects of energy for all as well.

I'm going to talk a little bit from the context of the sustainable energy for all initiative about our view on micro and mini grid, hybrid renewables energy access. Next slide please.

So, within the context of the UN Sustainable Energy for All Initiative, we're really focusing on how to address the fact that 1.3 billion people around the world today still has no access to electricity and globally, we've had a lot of support through the U.N. in the last couple of years particularly around making energy access a target for a combination of development expertise, of governments, of public and private partnership as well. The U.N. has recently declared 2014 to 2024 as a decade of sustainable energy for all and has put a large global goal around ensuring universal energy access is achieved by 2030 and as well as doubling the global rate to improve energy efficiency and also doubling the use of renewable energy and the global energy mix by 2030. Next slide please.

So, just some more context for the overall Sustainable Energy for All Initiative, one of the key focal areas within the initiative is specifically looking at distributed electricity solutions. Next slide please.

Within this, as we've been modeling and looking at how do we achieve universal energy access, the role of mini grids or micro grids, and again there's no set universal definition, I will come to that in a moment around what constitutes a mini grid or a micro grid, but the International Energy Agency in its 2010 world energy outlook really stressed the role as they see for mini grids in terms of the contribution to additional generation power in order for the world to achieve universal energy access by 2030.

A lot of the investment that will be required also concurrently is on the right side of the slide, also is going to be statistically on mini grids. And

we are seeing increasing global interest in the configuration of mini grids, the business case and the financing for these kinds of solutions. Next slide please.

In terms of our work specifically at the UN foundation, we launched an energy access practitioner network in 2011 in support of the sustainable energy for all initiative and we've had very rapid growth with the network to now more than a thousand individual members. And we're focusing particularly on market based sustainable energy applications and specifically looking at renewable and hybrid mini and off grid solutions and catalyzing energy service delivery at country level again towards achieving universal energy access.

We promote new technologies, we provide advocacy on supported policies, financing and new business models and also help very actively to broker new partnerships and then disseminate best practices. And I want to specifically mention the work of the network because we have a working group focused on mini/micro grid, which has a hundred members currently with strong technical and knowledge sharing capacity. And for the purposes of this webinar, neither of the presenters this morning, neither Peter nor I are going to go into a lot of technical detail around micro grid design and implementation but our working group has very, very strong technical capability.

So, for those of you who may have very specific questions, then we really do encourage you to join the network and also ask our other network members how they may have solved specific design installation capacity issues and we have a very strong knowledge sharing capability among our membership. Next slide please.

Last year, through the network, through the membership, we also, at the Rio+20 Summit in 2012 came up with specific recommendations from the membership, identifying five areas as they saw it for particular importance that's going up to energy access and one of those was very much advancing mini and micro grids around the world, particularly for those areas that have no access to electricity, that Peter will also talk about the application where we have an incumbent energy source such as diesel and looking to bring on renewable components for that. Next slide please.

So what is a micro grid? As I've already mentioned, there is no universal definition with a size gratification. There's a definition thought that we are using that has come from the U.S. Energy Storage Technology Advancement Act here in the U.S. Within the context of the network, the practitioner network, we are generally looking at smaller scale micro grids, particularly configured for energy access and I will give a couple of case studies before the end of the presentation. So, we are generally looking at I would say sub 1 megawatt installations.

I think Peter who's also again going to talk about some larger installations and as we see they can go down to even as small as a 1 kilowatt wind turbine that is connected to a community setting for providing electricity to a certain number of households and perhaps a school or doctor's clinic.

So, we can go down I would say as low as 1 kilowatt and all the way up to a megawatt in terms of where the network is predominantly focusing. Clearly, there are other configurations as well that can go larger. Next slide please.

So, a modern micro grid, although micro grids aren't new, they may include renewable and some fossil fuel based generation particularly where diesel may already be there or there is a requirement, the energy stability and the generation capacity has to be absolutely maintained, for example for a cell phone base tower or for example in a district hospital where you need to be able to have absolutely sustained power generation in order to provide emergency medical care and other types of medical care.

Looking at energy source facilities and control aspects, one of the key areas that we are all looking at is the capacity for being scalable, scalable in the context of the community so that you can add on additional generation to meet potentially growing loads without compromising the operation of the existing grid and also scalable in terms of replicable. We're very much looking at — although there's a customization in mini grids, we're also looking at the extent to which there can be perhaps more plug and play aspects where we can roll these out in different context and geographies with perhaps a more standardization of components.

Typical off-grid energy resources, wind and solar combined with diesel, some purely social mini grids now, CHP systems and also biomass gasification as well as micro hydro, which is very well known already in terms of how micro grids using micro hydro are operated. So, some key issues to consider, ownership and governance, whether it's owned by government, whether it's owned by a cooperative, whether it's essential utility or whether it's a private individual or company, the governance, the ownership will change very much many of the dynamics of how the micro grid should and can operate, particularly in terms of the customer relationships.

So, again depending on the type of ownership as the slide shows, that there is either an obligation to serve all residents or it's more on a capacity to pay. It can be dependent on also perhaps a certain amount of government obligation through a social protection system to provide some sort of threshold of generation free of charge beyond which somebody can pay to gain additional electricity or it can be completely privately operated in which it's the regulators who define the customer relationship.

Again, in terms of the regulation, it varies very much country to country and some independent power producers are actually not able to operate. In some countries they are able to operate but the policy and the regulation have not yet caught up with the practice on the ground. In other countries in fact, there's a smaller system, they fall within a very different regulatory framework than perhaps those larger micro grids that may eventually has interoperability with the national grid. Next slide please.

So, key issues to consider again, regulation of the micro grid, who owns, it, who has the responsibility for maintaining it. Is it the center utility? What is the relationship between a center utility and the independent power producer whereas ultimately whereas the regulatory responsibility. This also very much determines the sources of capital with our use to establish the micro grid, whether it's through tax revenues, whether it's government bonds or debt, whether it's foreign assistance, whether it's private sector investment.

Again, this has been one of the key challenges I think that we have seen through the practitioner network is the investment — the capital investment that's required to be able to install a micro grid even though overtime, in fact the operating cost for a renewable energy hybrid micro grid are going to be significantly less than a fossil fuel based diesel grid and again, I think Peter is going to provide some more context on how the price points are changing very rapidly. Next slide please.

So again, questions around covering the cost of operation of the micro grid, again, is the requirement around tax revenues, what are the connection fees, what are the connection charges. Also, what is the obligation around service and maintenance? Again, in a typical power purchase agreement, that's very well laid out. One of the challenges that we see for these micro grids in many developing countries, there is no PPA environment that's necessarily already very well-articulated and again by country to country, the structure of what the PPA or the PPA equivalent may look like there is and therefore there are many different types of obligation regarding the operation of the micro grid.

The next issue is customer demand meeting capacity to pay. Again, there are many micro grids that have been set up in the past, again, often using diesel where in fact — and sometimes renewables as well where there may be only the ability to provide six to eight hours per day of electricity and yet at the same time there's a demand for a lot more generation capacity on the one hand. On the other side, we've seen examples, particularly companies like electricity in Mali who have operated micro grids to provide energy access in rural environments in Mali and yet the challenge has been the capacity to pay for the community and really the ability to make the micro grid financially viable overtime.

Demand side management, this is a key area. Again, it's perhaps self-evident but we see time after time that the micro grid really needs to be streamlined with — it's actually demand side management as well, so a lot of the work that we are looking at now is in healthcare settings. So, ensuring that we are not just providing additional generation capacity but that we are able to bring in best of the class energy efficient appliances, whether that's a digital x-ray machine or other types of updated efficient appliances that have the ability to help to have more effective load management particularly in a very low constrained environment.

Regulatory operations at the micro grid, again, different obligations to provide power service whether in island mode or potentially if connected to a central grid for backup or standard power. Next slide please.

So, some of the barriers and challenges that members of our network have highlighted as impeding their work in terms of the insulation and operation of some micro grids, lack of enabling policy frameworks. Again, I've touched on this already. Some of the regulations around encouraging smaller grid systems or how, if there's a subsidy environment, what kinds of subsidies should be working for what kinds of size of micro grids and again, the question about planning around is the grid really expected to come over the next 10 to 15 years and if so, what happened to the micro grid? Is there a capacity for it to be integrated with the larger grid or what is the policy framework in which the micro grid operator has some sort of guarantee around being able to continue to receive revenue even if the grid should come and it bypasses their local grid. So, there are a lot of very difficult issues to work through there.

Next area is lack of information on viable financial and business models that can be replicated and bought to scale. That's one of the areas that at the network we are trying to essentially cover the universe of the types of models that are out there right now and share knowledge among practitioners so that they can each learn from each other around design, installation, operation of these micro grids.

So again, we really encourage those of you who are not already members of the network to join the network to be able to share certain aspects of your experience with other practitioners. Again, the need for long-term support for operations and management of micro grid systems, this is particularly relevant for some of the smaller operators who perhaps has come in more in a concessional basis and have installed a power generation source but they have not necessarily come and really worked out the long-term maintenance of the system. Again, I've seen examples of this in Central America where small wind systems have been installed but there's no regulatory environment, there's no power purchase agreement per se. It's really being installed for the community but the question is the

structuring around who pays the access to spare parts and the ongoing maintenance of the system then becomes paramount.

Lastly, the lack of mandatory international standard for mini grids and system components is an area that we are beginning to work on with some of the international standards bodies, looking at what should be the international standards for this type of the components and as well as the installation and maintenance of these mini grids. Next slide, please.

So, just to give a couple of case studies for members of our practitioner network who are working on installing micro grids in different context, the first one that I had the pleasure of visiting outside Dakar in Senegal last November is INENSUS, a German company who is partnering with GIZ and the rural electrification agency of Senegal, ASER to establish a pipeline of mini grids in 30 sites in Senegal using a public-private partnership model.

They have installed their first micro grid which is a 15 kilowatt wind, solar, diesel micro grid outside Dakar, serving a community that is about two hours outside of Dakar to meet their community basic electricity requirements. Within that business model, there had been certain aspects around the negotiation with the community to really bring them in a stakeholder setting of a village committee to oversee the way that the installation happens and also to negotiate around certain requirements such as even as far as the sighting of the system, who brings land, who provides land for the system, how is that financed. The installation in the village making sure of such things as the different boxes that the [inaudible] [00:29:24] children in the village, then on to looking at how we work with the types of technology for smart metering which INENSUS has been providing to be able to keep the grid stable and provide the amount of power that the community needs through the day and the night.

It's looking also at the key community load requirements to ensure in fact that they can provide the needed power. And then last which has been a challenge is looking at the tariff model to really provide reliability of planning to customers and also to INENSUS as a power provider. And one of the challenges has been that there was — it took time to negotiate the tariffs agreement with ASER although I believe that has been worked out now.

So, in this particular case study, even though INENSUS is coming in as a private sector company to install these mini grids or this first mini grid, I think the relationship with GIZ has been very necessary to provide some of the initial low-risk capital to enable them to do the installation and work out some of the issues around the tariff setting so that in fact they can then focus on a more commercial and then focus on a more commercial and

easier rollout for the project parts of some certainty of sites they've identified in Senegal.

So, that's one and please next slide. That is the micro grid generation station in Senegal. Next slide please. And that is just a diagram of the types of power provision. As you will see, it provides some power to the school, to their local medical center, for cell phone charging and then also for home use, particularly for lighting and also the smaller plants for television as well. Next slide please.

Our next practitioner study is OMC power operating in Uttar Pradesh in India, which has a very different type of configuration. It operates micro power plants and it really has a dual customer base. On the one hand, they have an 18-kilowatt solar plant and are working with provision of power for cell phone, telecoms based stations. At the same time, they are working with providing a sort of a business in the box type of opportunity for local entrepreneurs to run their own local franchise to provide power to households and community customers.

So, in their configuration, essentially the telecom base station become the anchor tenants and at the same time, the power is sold through local entrepreneurs who rent out lanterns and power boxes and other products to the local community. So, they're looking at essentially having a dual revenue stream in that part of India. Next slide please.

And just to show, this is the micro power business in a box that they have established for the local entrepreneurs then to be able to on sell the power and the energy services to local customers. Next slide please.

So, some lessons learned just in conclusion, the technologies are available. What we really need to do is to make the business case a renewable micro grid, again, particularly on the investment side, looking at how to lower risk in terms of initial capital cost, what kind of revenue streams, whether through an anchor tenant or whether through a combination of anchor tenants and community customers with variable capacity to pay is provided. Do you provide 24/7 power? Do you provide more constrained power? What is really the need of the community today and also mapping out what likely requirements will be needed 10 years on from now as well.

Price points are rapidly changing, so that changes the economics very much as well, again, as Peter will talk about. Next is really looking at the commercial entities such as the telecom base station or potentially a community facility such as a health clinic as an anchor tenant to ensure stability, but also looking at the capacity for backing out existing diesel generation.

At the UN foundation, we are leading a part of the sustainable initiative specifically looking at the nexus of energy and health, particularly women's health and the World Health Organization has recently identified that up to 40% of health clinics in 11 countries where they are operating in sub-Saharan Africa have no access to any electricity so far. So, the policy formulation, as we're looking at these micro grids also really needs to be inter-disciplinary. We tend to work in the energy sector obviously through ministries of energy but we really need to look at the different aspects, bringing in ministries of health whether federal or also at the local level, at the municipal level to look at how we best able to meet the requirements for the community and also for household as well as public goods if you will at the community level, whether it's a hospital, whether it's a health center or also on the educational side whether it's a school.

So, really looking lastly at monetizing the socio-economic benefit of electrification for communities without access to healthcare. So, one of the things that we've been looking at for example is just very simply how having lights in a health outpost may save the life of a woman who is being able to — who is in childbirth and experiences some challenges with her delivery, even very small amounts of electricity to run things like — see the heart rate monitors and other small appliances for doctors or nurses to be able to use, even being able to charge their cell phone to call in extra help if a woman is experiencing problems in labor.

These are some of the socio-economic benefits that we see come from having a reliable source of power in the community that are not necessarily generally monetized in terms of the purely investment case but from a broader development perspective of some of the key benefits that we see from being able to provide these solutions. Next slide please.

So please, if you haven't already, please do join us as part of the energy access network and we're available at http://www.energyaccess.org/. You can also follow us on Twitter as well. You can follow me on Twitter but the practitioner network as well has a Twitter account. So, thank you very much. Peter, over to you now to provide some background information on HOMER.

Peter: Okay, thank you very much Richenda. That was a great introduction and thank you also to Vicky and the whole team for setting this up. Give me a second to get my screen set up here and hopefully you all are seeing my first slide. Yeah, great.

So, let me go to my next slide and just jump right in and start talking a little bit about our experience with mini grids or micro grids. Mostly, it's built around the software HOMER, which was developed at the National Renewable Energy Lab starting in 1993 with the Village Power Program at that time. And about 10 years ago, we started making it available to the

public and it sort of took off and we, in 2009 spun HOMER energy office as a private company to support our global user base of over 86,000 users at this point in pretty much every country in the world.

And the relevant piece of this is that almost all of those -

Vickie: Peter? Did we lose Peter?

Richenda: Vickie, shall we take a few minutes for questions while we wait for Peter to get back on the line?

Vickie: Yeah, that will be great. So, I'm just going through and there is one question that came in Richenda, specifically for you and the question is do we have a tried and proven management and monitoring tool or tools for renewable energy, mini grids on islands?

Richenda: If I can speak to that, there's a lot of work on the way currently on looking on islands mini grids through different international organizations such as IRENA, the International Renewable Energy Agency which is developing road maps for specifically island mini grids looking at bringing in more renewable energy capability onto existing, mostly diesel generation capacity. So, there's a lot of work that they have underway currently.

There's also another organization called [inaudible] [00:40:49] that has been established over the last several years which is focusing again specifically on the ways to bring in investment and also policy, the right policy formulations to island renewable energy generation capacity. It's micro grids but also looking at other aspects beyond micro grids as well.

So, they're two organizations that are very specifically focusing on the situation in the islands at present. I would say that again, there's a lot of different — across different islands in terms of the way that policies are formulated. So, it's a little bit difficult to say there's a sort of a global management tool or global approach to this but those are two organizations that are very actively working on the specific island context that's present along with others that -

Peter: Excuse me, Heather, this is Peter. Am I back on line again?

Vickie: Oh you are, yes thank you. Welcome back and I'm going to be driving back to you.

Peter: You know what, you should do the slides for me though because I'm just coming in through the phone. I don't know what happened to our network here.

Vickie: Okay. Richenda, I think you were still answering the question.

Peter: Yeah, sorry to interrupt.

Vickie: That's all right.

Richenda: No, that's fine. I think the other thing I wanted to just mentions is that there is a very strong focus on taking islands to be either completely using as much renewable energy as possible and the carbon war room has been working specifically on some test cases using the island of Aruba to look at if making a carbon sort of a — just really sort of a carbon-free Aruba if you will but looking at Aruba as a test case for bringing on as much renewable energy as possible in an island context. So, I would definitely follow what is going on in Aruba over the next several years.

Vickie: Great, thank you so much. With that, we'll turn this back over to Peter.

Peter: Okay, I still don't have internet connection so you'll have to do the slides and you'll also have to tell me when I got cut off because for all I know, I kept going.

Richenda: You stopped at the end of the first slide. So, I can move to your second slide, mini grids are not new.

Peter: Sure. Thank you and I apologize. I have no idea what happened to our internet here locally. But as Richenda said, she gave a great definition of sort of what I would call then clean, smart, new micro grids but there are lots of dumb dirty diesel micro grids out there that there's millions of them and they are micro grids in the sense but they're just really simple diesel generators. The challenge with them is the fuel cost. Their operating costs are unsustainable.

So, if you look at these island grids, maybe in the megawatt scale, you've got a real utility company there that engineers and know how to keep a utility system up and repair distribution lines, et cetera. They've been collecting tariffs from their customers already, et cetera. They'll typically have multiple generation units.

That's one used case. I would still consider that a micro grid and they still — and they're burning oil and so the economics of renewables are excellent. So that's a very important kind of micro grid and there are thousands of them. But if you go down to the smaller systems, the more village power kind of systems that are more relevant on the energy access issues, there are millions of these isolated diesels.

Typically, it's a single diesel and a single diesel has a hard time providing 24-hour power. So, frequently, it's part time service only in the evening or something that's not adequate for productive uses and our prime candidates for retrofitting with renewables and storage to provide 24-hour power to a more sustainable way and as Richenda said, there are billions

of people with no service at all. So, the opportunities are enormous. Next slide, please.

So, these clean, smart, hybrid renewable mini grids or micro grids, that's the focus of our discussion here and the important point is solar and wind are very promising new technologies. They don't stand on their own. They always have to be connected to something else whether it's just a storage system like a battery or a big grid like we do in developed countries but in these applications, it's probably some combination of conventional generation like a diesel generator and storage and there's very promising opportunities for load management as well.

One of the beauties of these technologies is that they're modular and that provides the scalability that Richenda mentioned but it also gives you a lot of flexibility in the design of the systems and that's a sort of a two-edged sword, flexibility is a good thing — next slide please — but it can also be a confusing thing. Could you move to the next slide please?

Richenda: It takes a second to catch up.

Peter: That was my mistake, sorry. So, there are many possible hybrid configurations. That's the flexibility that I referred to, so that it allows you to craft solutions to local conditions better, but it also raises a lot of questions that need to be answered such as how much fuel is it going to use, how much run time are you going to require out of the generators? How big does the storage need to be? How much autonomy will we provide? And these things all trade off against each other. Next slide please.

So, we have a saying that a confused mind says no and so I think one of the big obstacles that we have to overcome is this confusion and that's what I meant by this two-edged sword, the design facility is a good thing in many ways but we give the people too many options, it's confusing and we need to be able to sort through that confusion to move forward and deploy systems. Next slide, please.

So, people want to know what's best and unfortunately, there's no cookie-cutter, one size fits all kind of answer to that question. It really does depend on the application, what are the resource endowments in the location, what the [inaudible] [00:48:31], that therefore affects your load management opportunities and prices that are falling so that if the equipment choices are changing, the equipment is getting better. That's all changing and it all affects the design and so our goal has been to address that issue of helping people figure out what makes sense. We bridge this gap between very technical models that look at power quality issues and transient stability that's on a very technical level.

At a finance side, there's this spreadsheet that gets deployed towards the end of the — they look at simply the finance of it. We bridge that gap by having enough technical detail to understand how the system's really going to work but also providing economic criteria or economic figures, merit and results that can fit into a financial model. So, next slide.

So, to accomplish that, you need to look at every hour of the year, actually we go down to the minute and soon we will go down second by second, chronological simulation of how does — when do the batteries get charged, when do they get discharged, when do the generators come on, et cetera. So, you really do know what your fuel consumption, et cetera will be. That tells you what one system will do. You do that for hundreds of systems, rank them by life cycle cost or net present cost to identify the least cost system. That's the optimization loop if you will.

That tells you what's best for a particular situation but frequently we don't really know for example what's the wind speed in a particular location or nobody can really predict what fuel prices will be in the future or what kind of load growth will happen or how prices will change for different components. So, it's very useful to have to do a sensitivity analysis and to see how does that answer of what's best, how does that vary as you vary other factors that you have no control over.

That's the sensitivity analysis and so we've sort of automated that all into a single package. So, that's with HOMER. Let me go to the next slide and talk more about the market, if you will, or the opportunity that exists for micro grids. What's really change in the last couple of years as this slide shows, hopefully we're on the cost parity for PV on diesel grid slides because I could possibly go on separately.

Richenda: Yes, you are.

Peter: Thank you. At the same time that PV prices have been plummeting in recent years, diesel prices have been increasing rapidly and we are now at full cross-parity for PV on diesel grids, which the folks trying to develop solar in North America. I would love to see cost parities for PV here but it already exists against these diesel systems. These are some very conservative assumptions that we made for this, which I won't go over. Next slide, please.

So, up until recently, the opportunity for these hybrid renewal micro grids was limited to places that had a really good wind resource and it's often difficult to determine whether you have a good wind resource, when it could be a very cost-effective technology if you have a good resource but it's very sensitive to the resource, whereas solar is not very sensitive to the resource, so that's sort of the purpose of this picture here to show that across the x-axis, you're going from a resource of 3 kilowatt hours per

square meter per day is actually a very poor resource, so that's sort of Northern Europe or the northwest corner of the U.S. or something.

Then on the right and six is a good resource. It's not the best in the world but you can see that cost or the power from PV doesn't vary nearly as much as I think most people would expect it to across a range that sort of goes from Arizona to Seattle or from Southern Spain to Northern Germany. So, what's really critical for PV is the capital cost and that's what's been coming down dramatically in recent years. Next slide, please.

So, back to the bigger picture of the different types of micro grids, and there are many, many different types. So, I found it useful to think about, well, what's the value driver or value proposition and there are three basic ones I believe. Access is the one we're focusing on mostly in this webinar but a very important one also is fuel savings, and finally there's an environmental or emission reduction value.

So, the smaller systems, the village power systems are more focused on the access value and the larger systems, the island systems, they've already got access but the fuel cost is the driver, so you've got a more of an economic driver for it. Eventually, we think there's a very big market for micro grids in developed countries as a way to integrate high penetrations of renewable power. That's more of an environmental driver and we actually see that developing more slowly than the economic driver, which is really an imperative for many of these island nations.

There's another piece that gets neglected but most of the world, the utility service is not at all reliable in many — most commercial facilities will have a backup generator and if the service from the utility company, it really isn't reliable, that backup generator is going to be used enough that the hybrid renewable micro grid becomes an economically viable alternative in addition to being quieter, et cetera.

So, there are many, many different types of micro grids. On the next slide, I break it out even more but I've just included that for people to go and look at later so it's in the slide deck but it's too much detailed to discuss now. So, let's go to the slide that says clean power evolution at the top. Hopefully I — and again, a very interesting point that I like to focus on which is, there's been an awful lot of discussion about the smart grid, I mean Boulder which is the world's first smart grid city, of course my internet just went down, but it hasn't worked out well.

People that are looking to large utility companies to deliver this very innovative concept of a smart grid are frustrated and it's really not fair. Large utilities have very substantial security and regulatory obstacles to innovation. It's like chaining a tire on a car while driving 70 miles an hour, they're trying to keep the lights on and then they really can't be doing too

much innovation at the same time while they manage this extremely complex continent scale grid.

On the other hand, smaller systems don't have those regulatory obstacles and furthermore, they have a real economic driver that the large utilities don't have because they're burning oil. So, they're moving to renewables much more quickly and as you get to higher penetrations of renewables, you have to start looking at more sophisticated controls. That's the smart grid technology. So, it's kind of ironic that I think it's absolutely true that the smart grid technologies and practices and concepts are being implemented first on these island grids.

That's where you're going to see these smart, clean micro grids and eventually, that will roll back to the large grids but they don't really have the economic driver that the small grids have to make this happen in the short run. So, our next slide please. But let's talk again about the village power, the energy access issue for a minute because I think there's a gap there and I think it's an important problem to focus on.

So, if you look at the really small end of the spectrum, solar lanterns are very successful because they're a product. They can be mass produced and they can be distributed the way you distribute razor blades or something. So, we know how to do that, it's simple an it's easy and it's happening. At the other end of the spectrum, what's been very successful are large wind farms and solar parks. These are $50 million investments that can afford a team of professional engineers and project developers and financers and it's an expensive process to develop the standard project development process but if you have a big enough project, you can afford all the transaction costs associated with that.

These island systems are similar in many ways to the larger systems but they're physically smaller and they're actually a little more complicated because the renewables become a substantial portion of the whole system and have the capability of sort of jerking around the system a little bit.

So, we need a much more streamlined development process to make them happen. But village power sort of falls in the middle. It's too big to be packaged, although we're moving in that direction. That's clearly the direction that needs to happen, whether you call it plug and play or cookie cutter or whatever, the more packaged they can be, the better and solar home systems are somewhat packaged, not as much as a [inaudible] [00:59:18]. But because they're too big to be truly packaged and too small to afford the kind of project development process that works for large wind farms.

There needs to be a program so that you can aggregate them. There needs to be much more government support to make this projects developable.

Now again, the next slide, the taxonomy on the top, I've just put in there so it's in the slide deck and you can look at that in more detail.

So, let's move to the next slide that says early project development steps are the risky ones and I think that's a really key point. So, trying to get the private sector involved and have them fly around the world and try to develop a lot of small projects scattered around the world, that's not practical. Someone has to get those projects through a series of early development stages before you can bring in the western finance. And there's plenty of western finance available once you get to that point.

So, we're trying to help by providing the tools to do the conceptual design that people can use on their own and using that tool, it acts as a screening device, does the project make sense? Do the proponents of the project know what they're doing? This is all much easier to evaluate by looking at an analysis with the HOMER software and it also gives people a communication tool to engage the various stakeholders. This is what the projects will look like and people can share the concept around much more easily.

I've put the one stage there listed permissions and contracts in red because I think that is actually a really key step where governments can really help, where public policy can really make a difference. What's really daunting to developers is trying to understand how to get the permissions they need, who do they need to talk to and every place is going to be a little different.

So, that's where you really need some capacity building at the local level because people in the local communities who understand that and you can't expect western finance folks to try to figure that out for every different place they might want to work. So, the more the government can streamline that piece of it, that would be critically helpful, and there's a capacity building piece to it of training local people, both in that process but also in some of the technical issues and finally, they could always help with resources definitely because everybody is going to need that.

So, next slide, which is my concluding slide. The first point is that we believe there's an enormous potential for mini grids and we're just starting to see that come to fruition but we're truly just starting. And that these mini grids are going to demonstrate that renewables can be deployed at high penetration in a stable and reliable way and it's kind of an exciting idea to think that they're going to lead the way, which is an unusual situation.

But I think it's important to distinguish between the larger mini grids where you have an existing utility company and it looks more like a project development and it needs a much more streamlined process. With the smaller mini grids, well, you have to kind of start from scratch with

just creating the institutions that are going to support the mini grids and you really can't afford a project development process and things need to be as packaged as possible, as standardized as possible so that you can do multiple — you can aggregate them.

So, the government has an enormous role to help especially in that latter problem. The main things I would focus on are standardizing the processes, making the permitting process more transparent, standardize contracts. The private developers at least in the U.S. and in Europe are used to having power purchase agreements that are relatively simple, just selling kilowatt hours to the utility. But when you're doing high penetrations of renewables, the renewable project is actually impacting the conventional generation is a substantial way and so it's not quite as simple and so that makes this problem even more important to solve of standardizing the kind of relationships of how the parties are going to interact with each other. So, that's a critically important policy issue. The other one is capacity building. So, get — much of the effort here has to be done at the local level.

So, the trainings like we're doing here, but more technical trainings, we do software trainings around the world and we also expand those but we should also enhance those to include some of the development issues, the legal and financial issues within us is a really important piece so that all those early developments steps in the development process that I talked about can be done locally and then the local people doing those steps know what the finance people are going to need to bring in the finance to make the projects happen.

So, the capacity building is both a technical issue and it's a legal financial issue and the standardization I think are the places where public policy can really make the biggest difference. So, thank you. That one is my talk. I guess we'll go pass it back to Vickie to manage the question and answer discussion.

Vickie: Great. Richenda and Peter, thank you so very much. Those were both outstanding presentations and we have had so many great questions coming in from the audience. We'll use the time remaining to answer and discuss as many questions as we can. I will warn the audience that we've received many more questions that we are able to provide answers to. So, I'll just begin at the top. This is one question that's come in from several people, and you've explained it in some detail but if you could recap, people are asking what is the difference between mini grids and smart grids and mini grid versus micro grid and rural grids? So, if you just could quickly give kind of an explanation or definition for each of those, I think that would help a lot of the people who have been submitting the question.

Richenda: This is Richenda. I'm happy to take the first crack of this. As I've mentioned in my earlier presentation, there is no one universal definition and this is an area we — smart grids, I'll let Peter speak to. That tends to have certain aspects in terms of control systems. Particularly, that's the term that's used here in the U.S. But between mini grids and micro grids, again, some practitioners, some policy makers out there do have a sort of a size definition but there is no one size fits all difference between a mini grid and a micro grid and in fact, even some people are talking about pico grids now where you're providing small-scale generation services just to a few households.

So, that said, as I mentioned within our operations as we're looking at this through the practitioner network, then generally we are looking at sub 1 megawatt. But of course, Peter I'm sure will talk about on the island situation and we're looking at multi-megawatt types of micro grid applications or mini grid applications as well.

Peter: Right. So, the reason that's such a good question is because there's not a very good answer to this question. So, I'm going to tell you how I use the terms because there's not a standard definition. Mini grid and micro grid I think are kind of interchangeable, to be honest with you and as you can see, the slides they kind of jump back and forth.

My definition is simply a grid that can stand on its own that either is not connected to a larger grid or if it is, it's still capable of standing on its own. So, within the U.S., there is some interest in micro grids that have islanding capability, but that's not what we're talking about here. So, I just say any distribution grid that stands on its own and it's too small to use the large — to have a coal fired or combined cycle natural gas plant.

So, that's a more expansive definition than most people would use. And then on the smart grid again, that is used to mean a lot of different things. Some people think it just means meters that can be read remotely, but the way I meant it was — another term for it is demand response where the load can be responsive and can provide some of the stability services and some of the integration services to make variable renewables more cost-effective.

So, for example, if you have a battery charging station and a cloud passes over the PD, you can cut back on the rate at which you're charging the batteries rather than turning on a diesel for example. So, it's a level of communication and control that wouldn't have been possible 10 years ago but nowadays, it's actually from a technical perspective quite straightforward but that controls — it's more sophisticated controls which allow you to do renewables at higher penetration. So, the term smart grid can mean a lot more than that but that's the important piece for this discussion.

Vickie: Okay, great. Thanks to both of you for a great answer. I think it clears up a lot of the issues around the differences. Our next question, I'd like to ask because I think it could apply to many and the question is for sub-continent sized country such as India, what kind of micro grids do you envision to be economical and sustainable as compared to mega renewable power producing plants?

Richenda: Well, I think I can address this one coming from the access standpoint. We are already seeing a lot of activity in India with different types of micro grid, different types of generation capacity. I already gave a very quick example of OMC power who's working specifically in UP in India but there are other operating out there like Husk Power for example which is providing community level generation capacity using rice husk, biomass gas electrification as a particular solution based on the fact that rice husk has no alternate value in those particular communities where they're operating.

They have already developed probably 65 micro grids predominantly in Bihar in India. There's a lot of other focus currently as well. The Rockefeller Foundation in the U.S. has an initiative called the Speed Initiative which is specifically looking at the application of cell phone based stations as the anchor tenant and then concurrently being able to provide community level access through oversizing the power requirement for the base station and also then providing those services into the communities. It's somewhat like OMC power is which I believe is part of the Speed initiative but then looking at being able to scale that up thousands of times to cover many different areas of India.

Again there is specific context where micro grids are already used in some of the island communities like parts of the Sundarbans in coastal India. So again, there's no one size fits all. It depends on the particular local requirements, using Peter's HOMER analysis to really model out in that particular context what makes the most sense. I do know that the government of India is very actively focusing on the quality aspects of how they can be most appropriately developing their policy in terms of how best to be supported to micro grids as it means particularly for helping to provide energy access to communities that still do not have any access.

Again, one of the challenges there has also been the question around who owns the micro grid, who controls it, is it community owned? To what extent there's a sort of a — is it a purely transactional relationship and what are the responsibilities of the micro grid provider in terms of 24/7 which is certainly needed for the base stations but also to the local community as well. So, that's a very great question because it's a very current discussion and policy issue right now.

Peter: Yeah, I might just add to that that India is a great test bed in a sense because it has such a diversity of potential applications. So, there's also so many existing backup generators there that could be more rationalized if you will or could be turned into a cleaner and more efficient micro grid. So, that's a whole another type of micro grid and opportunity.

Vickie: Okay great, thank you. Next question is more along design manufacturing and installation of mini and micro grids. The question is, are there specific plans to create worker's cooperatives for design manufacturer installation maintenance of mini/micro grids? And if so, have funds been committed to make this a reality? Do either of you know of any instances?

Peter: Well, the manufacture of many of the components are — well, it depends. My first thought was if you're talking about inverters and PD systems, the manufacturing is kind of a big deal and a global industry that needs to be very competitive. But if you're talking about assembly of like solar lanterns, I think that is perhaps amenable to cooperatives. But Richenda might have more to say, I don't know.

Richenda: If you could — Vickie, if you could just quickly repeat the question.

Vickie: Oh sure, hold on one second. Okay, are there specific plans to create worker's cooperatives for design, manufacture, installation and maintenance of mini and micro grids and if so, are you aware of any funds that have committed to make this a reality?

Richenda: In terms of plans, I know that there are — I mean many micro grids are already operated in some sort of cooperative ownership framework and particularly, I would reference micro-hydro and for example there's a member of our network called IBEKA in Indonesia that operates micro hydro mini grids on a cooperative basis. So, that is an ownership model that is well-known and again I think Peter referred to though in terms of the manufacturing side that that is very much a global market.

So again, I think it depends on what aspects are relevant to the particular local context and here I do want to say one of the residual challenges that I see particularly for some of the smallest micro grids is in fact the capacity of the community to really maintain their own solution and one of the ways that we need to address this I think is much more systemically in many developing countries in terms of them incorporating renewable energy training into their vocational education classes across their countries so that for examples electricians are trained on different types of renewable energy applications so that we can build the capacity across the country to be able to provide services for maintenance of these micro grids.

And that's something that we're still seeing very much in development that there are many areas where there has been a tendency to expect things that the community that really we should not be expecting them to be able to do in terms of maintenance beyond very simple non-technical aspects.

Vickie: Okay great, thank you. Richenda, this is actually maybe a little bit of a follow-up to the question you answered regarding energy access in India and this question comes from Ghana, so, what would you recommend that developing countries like Ghana focus on hybrid renewable mini grids in the rural areas in an attempt to close the gap between those with access to energy and those without access or make our grids more intelligent in terms of the technology input. So, that's kind of like a two-part question and if you need me to repeat that, I'm happy to do so.

Richenda: It's a great question. Again, I think that it really depends on the local context. I know that Ghana in particular is also in the midst of a C change in terms of its energy production given the oil and gas production that's underway there on the conventional fuel side, so, whether or not that will be able to — the extent to which they are using conventional fuel for increasing grid extension is something I'm not completely conversant with.

They are planning around that but certainly I think the answer is a bit of an all of the above. I mean, there are context even now where we see that certain countries are providing concessions to a company to provide a certain amount of power to all of its customers and then that company, that concessionaire then determines, well, is it going through a micro grid, is it going to a combination of a micro grid and perhaps solar home systems for outlying customers for whom the cost of stringing wires would be too much really for them to be able to make it work with this particular structure.

So, it's a very localized question I would say and perhaps we can have a future session specifically as it applies to Ghana.

Vickie: Okay great, thank you. Next question, I think this would be one that many might be asking is, what are the main stuffs to build up hybrid renewable mini grid models. Peter, that might be — if you want to take that one?

Peter: Yes, sure. Although the word model can mean a lot of different things, so I often refer to the HOMER as a software model, I'm going to guess that the question is really asking about sort of deployments models, sort of demonstrational or pilot projects. And we do have some examples or models of micro grids, Richenda served one in Senegal, there are several in India and it's happening faster and faster. I think the most important thing that we can do is to act as a clearing out, so people in one part of the world can see models or examples of what people in really different parts

of the world have done and then there might be some modifications for local conditions but really, it's kind of a shame, if there are models out there and people don't know about them.

So, I think the best thing that we can do is to develop case studies and publicize and disseminate information about what has worked and what has not worked in various places because there are these models or demonstration projects that have been done and actually we're beyond them, the social projects in a lot of places. So, the first thing I would do is find out as much as you can about what's been done in other places. And actually, Richenda's network is the practitioner network, that's kind of its goal. So, that's a great question in a way.

Vickie: Okay, super, thank you. I think we have time for maybe one more question before we close up and again, I just want to let the audience know, I apologize for not able to answer your questions during this webinar, but we'll take a look at them subsequent to the webinar and perhaps send a few of your questions to Peter and Richenda to answer via email or something along that nature.

So, again I apologize if we did not get to your question, we've just had far more questions than we have time to answer. But we will take one more I think and this is a little bit of a comment plus a question. It states, we at GIZ are currently working with [inaudible] [01:25:17] and some more countries — different countries and the key problem for their and other micro utility models is investment capital for the moveable assets such as generation units. So the question is how can more inexpensive capital be acquired such as with IRR is less than 10%?

Richenda: I'm happy to answer that one, it's a great question and the answer is, this is exactly where we're sort of working on all sides of the equation. Of course, there is a lot of interest by global commercial banks in micro grids in principle but then we're also looking at it from an investment standpoint which is, how can you mitigate some of the initial out front capital risk and as I've mentioned earlier in my presentation, one of the challenges in Senegal was in fact that there was no preset carriers for the micro grids that's very difficult to come in and building a fully commercial financial model when you do not already have a set [inaudible] [01:26:32] in place.

So, I think there's a bit of a chicken and egg which is having a set policy, an established policy that is stable overtime, can also help send the right signal to investors to be able to have assurances quite apart from all of the other sort of regular emerging markets investment challenges that one faces particularly when coming in with foreign investment that there is that risk mitigation just through having a stable policy regime in place that it's known, that it's set and therefore you can make projections overtime.

The other aspect I'd like to say is well, which is looking at vehicles for risk mitigation like risk insurance. Tanzania now has sovereign risk insurance for investors coming in there and there is an activity already underway in terms of micro grid companies looking at investing into Tanzania at this time and partly because of that sovereign risk insurance is already in place.

So, it's also looking at how we can help to mitigate some of the risks to enable investors to have that assurance that in fact if they do invest, they will be able to — that they will be able to get the expected return on that capital. Lastly I would say — I think this is also one of the reasons why there has been a tremendous amount of interest in looking at the telecom base station case because each telecom tower does need stable, reliable power over a period of years and effectively that becomes the anchor customer where there is a stable contractual relationship with essentially a fairly predictable revenue stream. And it's that predictability that I think as we can look at these contexts where we can see that predictability across a whole pipeline of projects, that that will give more confidence to investors really to be able to come into this market.

The return aspect of course, again, it really depends on the anchor customers and the particular context in a given country or whether you are providing — as Peter has said, there are industrial operations that are also working on using micro grids now. So, it really depends on your customer base and what kind of revenue generation expectations that you have as well and from an energy access standpoint, clearly, one of the challenges is in fact this capacity to pay which is why we do see a lot of concessional financing really being used like GOs to come in and help offset some of the risk that companies are taking initially to come and work in this sector.

Peter: And if I could just into that — what I think is the biggest financial obstacle is getting the projects to a point where the investors can engage and the stable policy environment is probably the biggest single piece of that but there's a whole string of tasks that need to be done to get to that point and that all has to be done before you get the western finance involved. It's totally depressive returns way too much if you expect the financers to do any of those early steps. So, that all has to be done locally which is why capacity building is so important.

Richenda: If I may make a final comment actually on that question which is I think the diesel generation stage is — and offsetting diesel is a slightly different investment model and I think that there, it's actually much easier in many senses to project the return profile and in fact many small, developing states like Barbados are looking to bring in more renewable energy generation capacity onto their island mini grids and there is investor appetite already in some of those islands to be able to do that, particularly because they've seen the sort of the sweet spot between this diesel and PV

price points and looking at sort of grid parity now being reached in that particular context where they may be already paying 50 cents per kilowatt hour for generation using diesel.

Vickie: Okay, great. Thank you so much both to you, Richenda and Peter. You've given such great, outstanding, informative presentations today and we've had some super great questions from the audience. So, I really appreciate your time and putting together these presentations. I think you really provided a terrific information for our audience today.

So, before we close the webinar, I'd like to just take a few seconds to post three quick — for the polling questions to obtain feedback from the audience, and these evaluation questions are important to us because it allows you, our audience to inform us on what we're doing right and areas where we can improve. So, we'll allow you a few seconds to consider and answer each question thoughtfully and Heather, I do believe you have the first question displayed right now so attendees, please go ahead and provide your response to this first question which is the webinar content providing me with useful information and insights.

All right, we're going to close this question and give me just a couple seconds, Heather to capture that. Heather, can you display our next question please? And our next question to the audience is, the webinar's presenters were effective in providing their information.

Okay, and Heather if we can go to the next question please? Our final question is overall, the webinar met my expectations.

Great, thank you everyone. That was terrific. I appreciate you taking the time to respond to our polling questions. So, with that I just like to again thank everyone, particularly I want to provide a hearty thank you to Richenda and Peter for taking their time to provide these great presentations today and I also want to thank you, the audience for attending and participating.

And I've had several questions come in about where you call could obtain copies of the PowerPoint slides and also review an audio and video recording of this webinar and I've provided the link here which is cleanenergysolutions.org/training/hybridrenewable-mini-grids. But if you just want to go to the training page, you'll find the link there to this particular webinar and can download PDF copies of the presentations. With that, I would just like to again say thank you and we look forward to seeing you again in future Clean Energy Solutions Central webinars. With that, this webinar is concluded.