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Trends in Micro-grids and Smart Grids to Scale Up Solar PV in the Pacific

—Transcript of a webinar offered by the Clean Energy Solutions Center on 16 July 2019—
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Webinar Panelists

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Matthew

Hello, everyone. I'm Matt Keighley and welcome to today's webinar, which is hosted by the Clean Energy Solutions Center in partnership with the Pacific Region Infrastructure Facility, or PRIF. Today's webinar is focused on the trends in microgrids and smart grids to scale up solar PV in the Pacific.

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. If you listen through your computer, please select the "mic and speakers" option in the audio pane. If you want to dial in by your phone, select the "telephone" option and a box on the right-hand side will display the telephone number and audio PIN.

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Finally, one important note of mention before we begin our presentation is that the Clean Energy Solutions Center does not endorse or recommend specific products or services. Information provided in this webinar is featured in the Solutions Center's resource library as one of many best practice resources reviewed and selected by technical experts.

Today's webinar is centered around the presentations form our guest panelist, Sam Booth, as well as commentary from Kamleshwar Khelawan and Gavin

Pereira, who have joined us today to discuss current trends in microgrids and smart grids in the Pacific region. Before we jump into the presentations I'll provide a quick overview of the Clean Energy Solutions Center. Then, following the panel's presentations we'll have an in-depth question and answer session moderated by Tim Reber, where the panel will address questions submitted by the audience. At the end of the webinar you'll be automatically prompted to fill out a brief survey. We thank you in advance for taking a moment to respond to this.

This webinar is provided by the Clean Energy Solutions Center, which is an initiative of the Clean Energy Ministerial. The Solutions Center focuses on helping government policymakers policies and programs to support the deployment of clean energy technologies. This is accomplished through access to no-cost expert policy assistance and capacity-building activities such as this webinar. The Clean Energy Solutions Center is cosponsored by the governments of Australia and the United States.

The Solutions Center is an international initiative that works with more than 35 international partners across its suite of different programs. Several of the partners are listed on this slide and include the Pacific Region Infrastructure Facility, or PRIF, our cohost for today's webinar.

A marquee feature the Solutions Center provides is expert policy assistance known as Ask an Expert. The Ask an Expert service matches policymakers with more than 60 global experts selected as authoritative leaders on specific clean energy finance, regulation, market, and policy topics. We offer this assistance to eligible governments free of charge and requests can be submitted through our simple online form at cleanenergysolutions.org/expert.

So, quickly, before we get started on today's webinar, I'd just like to provide an overview about you, the participants. So, so far we've got—we had 72 registrants from over 25 different countries around the world. This consisted strongly in Australia and New Zealand, as well as the Asia-Pacific region and abroad. Most of you come from the energy, chemical, and utilities industry, but also a significant portion from education, consulting, and government as well. So, we hope this diversity is reflected in our Q&A session at the end.

So, our first presenter today is Sam Booth, who is a Senior Project Leader at the National Renewable Energy Labs in the US. Sam has over ten years' experience in the clean energy industry and most recently has been working on the Power Africa Beyond the Grid Program. So, I'll just—while I get Sam's slides up—welcome Sam.

Sam

Thank you, Matt. And thank you, everybody, for joining. Let me get my slide deck going. So, it looks—it should be up.

So, I wanted to share some of the work that the lab has been doing on microgrids for energy access and energy resiliency for the Pacific and kind of talk about some of the key issues and lessons learned.

So, within that context I wanted to start out with saying that islands present a really unique opportunity for microgrids for energy access and energy resilience, but they face unique challenges related to resiliency and technical challenges related to system design and things like corrosion. And I'll talk about those more on the next slide. But this is a space that NREL has been supporting for about 25 years in terms of microgrids for energy access. And we've done a lot of work around the globe and a lot of work in the Pacific. I led a lot of project in Indonesia. So, as Tim—kind of our moderator, I'm going to share some kind of broad lessons from those projects for this presentation, but also share kind of some more specific work from our work in Power Africa and our work with Power Africa because that's the more recent work we've been doing in terms of kind of direct lessons.

So, in terms of kind of general planning considerations for islands, we see kind of a large opportunity for isolated microgrids on islands. Given the fact that they're islands, there are great opportunities for kind of small-scale power systems. Just an example: There's about 600 islands in Papua New Guinea. There's kind of thousands in Indonesia. So, really great opportunity for project, for microgrid projects and small-scale power systems. But the islands face kind of unique challenges given the geographic conditions of being remote, kind of disperse, hard to access. These all increase cost for things like shipping of equipment, installation of equipment, particularly if you need things like trains or other heavy machinery, and O&M. They do provide kind of unique business value, business proposition, if you do renewable microgrids, that you only have to install some of this renewable technology and renewable generation, let's say, once as opposed to kind of more traditional solutions that ship in diesel fuel or have more centralized grids that have kind of larger kind of O&M, for instance, and more ongoing maintenance.

So, these small- and medium-scale power systems do have considerations for high levels of renewables. So, in terms of kind of hybrid power systems, this might be things like solar PV, diesel microgrids. We see a lot of systems with kind of, let's say, 20 to 75 percent renewables and kind of good experience and good technical solutions for that. As we drive higher, towards 100 percent kind of instantaneous penetration, or even more renewables from a kind of instantaneous perspective and maybe higher from an average perspective, we still see a lot of these technical solutions require storage and other unique features. And the islands really need kind of projects designed to support their unique concerns. So, this might be like typhoon wind, which often requires things like special fasteners for PV, or wind turbines that can fold down in a storm. And also, the marine environment, we see a lot of increased issues for things like corrosion and the need for specialty materials, things like special alloys or stainless steel for PV racking because of the kind of saltwater marine environment.

But I'm really excited about island projects, and I really like an island project because they're just really great scale to me that allows for mall solutions on kind of the, let's say, tens of kilowatts, hundreds of kilowatts, maybe up to a few megawatts in terms of the microgrids and energy access projects and resiliency projects, but they really provide a good place to do demonstration projects and provide value in prove-out lessons that can have broader applicability to larger power systems.

So, I'll start out talking a little bit about our energy access work. And the broad picture here is globally there's about a billion people without access to energy. Most of these people reside in Africa or Asia, and most of them are in relatively rural areas. You can see in the chart on the right the electrification rates of a few Pacific islands. You'll see the rates of some islands are relatively high, like Samoa or Fiji, and others like Vanuatu are relatively low. So, I would say in the context of this webinar maybe some of the resiliency points on kind of grid-connected—microgrid points are maybe more relevant for some of the higher penetration of electrification rate islands.

But as an example, that 85 percent that Fiji has, that's about the same electrification rate we see in Ghana, and we're working with Ghana to help them develop a universal energy access solution. So, even in some of these high rates there's still a significant portion of the population that needs to be connected. Globally, really what this looks like is about $52 billion in annual investments that's needed to meet these universal energy access targets, and with a target of about kind of 50 percent of that or so being in microgrids as the least cost solution to meet these energy access challenges. What we see in the market is about less than half of this investment is going in now and the solution we think is needed is to bring private sector capital in to close this gap. So, a lot of the investment that is going in now is government funding, kind of donor funding, concessionary capital. But there's really just not enough of this funding around to meet the full investment needs.

So, NREL developed a quality insurance framework for microgrids with the broader goal of basically drive private capital investment into this sector by increasing the kind of speed, scale, and standardization of projects. And this was really driven by our work in this space over the last kind of decades and seeing that projects really look kind of like one-off projects. They look a little bit different. People talk about them differently. They're reported on differently. They have different kind of standards. So, what that results in is kind of a lack of ability of the industry to standardize and scale, and that's kind of what our quality assurance framework was designed to target.

So, there's a Solutions Center page, basically, that goes into the quality assurance framework and a bunch of public documents. I'm only going to mention it briefly here, but what it's trying to do is take lessons from the utilities sector and successful utility business models in that utilities really know and understand their customers well. They know how much energy they're going to consume. They're highly regulated, so they come in as relatively not very risky investments.

When you reverse that and look at the microgrid sector or the energy access sector, that traditional utility model breaks down as a result of things like the high cost of providing power to customers, a higher perception of risk for customers in terms of how much energy they're going to consume, their credit profile, and really a lack of proven business models for the private sector. So, the quality assurance framework is really designed to help lay the foundation for those successful business models to help the industry grow and scale.

So, in terms of key challenges, the cost of power is one of the ones I already kind of mentioned above. Another one is really the supportive regulatory environment. So, a lot of the things we've been working on in Africa, and you can see a kind of related publication on the right, is around tariffs. And the reason we're working on this is there's a lot of countries and governments basically that have sort of a uniform national tariff policy, as in they charge a standard rate for electricity regardless of where and how that electricity is provided. And the problem with that, at least for private sector microgrids, often that rate is lower than the cost of supplying that energy to those customers, even if that's the least cost solution to supply energy to those customers, and even if it's cheaper for the customers than kind of their alternatives, which might be things like kerosene lamps or household diesel generators.

We've worked with utility companies on this same problem. As an example, I worked with a utility in Brazil that was supplying power to an island off the coast of Brazil. They had to supply it at the national uniform rate but they were generating—their cost of generation was much higher. They were trying to lower their cost, trying to take an all-diesel system and add solar PV and wind and other things to lower their cost for the hybridized system. And also, we see kind of risks around grid arrival at times with these microgrids. And I'll talk a little bit more about that on the next slide, but on a larger scale I have at least—I've seen a lot of systems where there's kind of a central main commercial port, maybe a port or some part of the island that has a grid, and kind of smaller outposts on islands that don't and maybe have more isolated power systems with significant investment going into those power systems. And there's a risk of what happens if the grid arrives around those.

And that brings us to kind of the technical standards piece of how do you incorporate those systems into the grid? And how do you make sure in that context customers are getting what they wanted, kind of utilities—or, microgrid providers providing power at a reasonable rate.

We also see challenges related to access to finance, kind of the high cost of financing, financing within the context of local currencies versus international currencies, which can be a problem if you're collecting revenues in one currency and paying out debt in another currency. And all of this kind of leads to uncertainty in business models, and not very much information out there right now in the performance of the existing systems, so a high risk perception. So, one thing we're trying to do is provide more information on the performance of the existing systems, so we would certainly be interested in partnering with folks that have kind of microgrids operating now who are interested in kind of assessing the performance of those systems.

A little bit more detail on the grid arrival piece. So, we're working in Uganda currently to draft broad off-grid regulations for the government of Uganda, and these cover a broad range of things like tariffs, technical standards, but I'm going to focus here on the grid arrival piece. And there's three mechanisms that are in those models. So, one is basically buyout of the existing microgrid asset system and build a microgrid when the broader utility grid arrives. But there's challenges for this in terms of who pays, how likely they are to pay, and how do these assets get valued.

The second kind of model we often see is maybe that microgrid generation is converted to a small power producer. That small power producer sells power to the utility. Likely, this isn't enough revenue to recoup the investment costs per microgrid.

And the third option is that the microgrid operator becomes a mini-grid utility that supplies power to the existing customers they have, partially self-generated and partially maybe from the broader utility. But again, this tariff issue comes up here of can they charge more than the national tariff to recoup some of their investment costs?

Another area we work on that's kind of key importance to this sector is around productive uses of energy. This is because a lot of these energy access or energy electrification projects really have a broader goal of trying to increase incomes and increase local economic development in rural areas. So, productive use means basically appliances and/or businesses that use energy to help increase income or provide services. So, agricultural commodity processing, irrigation, small shops and retail, sometimes health clinics and schools. Microgrids provide enough power for these systems that maybe smaller standalone kind of home systems or solar lanterns cannot. The hope is that—at least most people, when they do energy access projects—is that basically these productive uses, they come and they start growing. And what we've seen is unfortunately sometimes that happens and sometimes that doesn't. And really, the productive use needs broader support and stimulation to ensure it happens. This can come in the form of entrepreneurial training, financing for appliances, incentives, and other things. And basically, it requires careful consideration to add loads to systems in terms of looking at the load, the risk of the customer, the seasonality.

So, one example from our existing work is if you look at the chart on the bottom right of this slide. This is a microgrid—basically, it's a microgrid in Tanzania. It's the orange bar, and we look at adding a ten-kilowatt maize processing mill to this microgrid that would operate kind of Monday through Friday during normal business hours. The yellow bar and the gray bar are showing how if you add this mill and it's operated kind of year round, either at 33 percent loading or 50 percent loading, it actually lowers the cost of power for everybody, helps improve the overall business model for the microgrid. The green bar shows that if this is a seasonal, basically, processing operation, it actually increases the cost of power to everyone to add it to the microgrid, in addition to adding about $10,000.00 to the overall cost of the microgrid. So, if you don't think that customer's going to be there, let's say, for the duration of the system, that comes at increased risk.

The picture at the top is from our work in Indonesia. It's basically a small-scale outfit in rural Indonesia that bought some machine tools and started making—those are hydro turbines—locally and then selling microgrid space on those hydro turbines. What I really liked about that example was there was local jobs, but there was also local O&M. So, if somebody bought one of those turbines, they installed it locally, they knew where to bring it to fix it and kind of solve that problem should something happen.

So, another thing that I mentioned and that we're working on is basically the costs for microgrid are still relatively high. So, this is an example of a 100-household village providing power right now at about $0.90 a kilowatt-hour, and our work is looking at what are the ways we could reduce the cost of providing that power. There isn't really a silver bullet but there's a lot of opportunities through incremental solutions in a bunch of categories to reduce costs, kind of up to about 50 percent. That comes kind of across the board from lowering capital costs, lowering cost of capital, adding more productive use, and better system design. So, I'm happy to kind of discuss that further. I won't go into all the details there. And most of these slides, including this one, have a link to kind of related publications.

Another thing we worked on that I think is particularly applicable here is new work on battery selection and battery economics. So, most microgrids now have lead acid batteries, and those lead acid batteries are sensitive to temperature, although a lot of microgrids don't have any sort of temperature management cooling option for their battery enclosures. So, we took some thermal modeling tools, and that's the chart on the top right, showing that if you add basically either fans or air conditioning to a battery container, this is how much you can improve the temperature management in that container. The reason that matters is batteries are generally rated at about 25°C; for every 10° above that that you operate on average, that about halves the life. So, it's pretty common in our experience to see people that thought batteries were going to last five years, let's say, that they last one to two years, one to three years. A lot of that has to do with the thermal management of batteries. And we also did some modeling of battery lifetimes based on our experience with lead acid batteries and some NREL laboratory testing of lithium-ion batteries to show expected lifetimes for batteries, and looked at basically the levelized cost of energy for building microgrids with full lead acid and lithium-ion batteries. One of the key takeaways from this is at least in all of our modeling the lithium-ion batteries were the lower cost option. And again, there's a publication that you can look at and we're happy to discuss more details around this.

One of the reasons we look at batteries is really risk reduction. So, batteries are the most expensive component in a system, and driving the risk out of that system helps ______ the finance and also lower cost. Another big risk in the system is related—so, the next slide—is basically correctly predicting the demand of systems. We see a lot of systems that are about four times oversized based on inaccurate demand estimates. So, we did a lot of work with a microgrid developer in Africa and Carnegie Mellon University to look at actual consumption relative to survey questions. And this chart shows basically what survey questions when you're asking about future demand are good predictors or relatively high demand. Those are the ones on—so, the right of zero are positive, and the ones to the left, or negative, are not as good predictors, or predictors of lesser demand. So, these are about picking which customers are going to be good customers and which ones are going to consume a lot of energy to improve your business model. There's also some more of looking at kind of the accuracy of predictors in that report.

A little bit on smart metering. It's basically we've done some work with kind of leading manufacturers of smart meters in this space. Meters can provide great things like monitoring, management, and insight into loads, including remote diagnostic, system/portfolio, forecasting, design improvement. The charts on the right show some examples of the kind of data—or, sorry, the charts on the bottom—you can get out of smart meters. Through conceived profiles when operating microgrids you can see some frequency spikes. You might want to do some remote diagnostics around what's causing those spikes. The chart in the middle is a portfolio analysis of operating microgrids in Africa, and where at least in this analysis the customers of microgrids fall relative to QAF service levels. And also, just a consumption profile. This has broad use and broad applicability for a lot of stakeholders in the industry.

Now, a little bit more about resiliency. So, this is really about grid-connected microgrids that provide basically a redundant power supply for grid outages, natural disasters. And then, when the grid is there they provide economic savings to either the customers or the broader grid for things like demand response and peak shaving and efficiency opportunities. We see a lot more of these for resiliency purposes, and they provide local distributed generation that increases customer resiliency and a lot more outages from weather. And also, the business case and business model end up improving from reductions in renewable energy and storage costs. And also, if you have existing RE development, that really lowers the cost to kind of add the additional equipment that allows you to provide for isolated power and redundancy. And advances with inverters from things like ride-through and controllability really improve the ability to manage variable generation in hybrid systems.

Kind of the last slide here is talking really about resiliency and kind of resiliency planning. And the general process we use for resiliency is looking at what are the hazards and threats. So, what kind of—this might be storms. This might be cybersecurity. What are the vulnerabilities that your particular island or system has to these threats? What are the impacts if there is one of these hazards that does happen? What kind of technical solutions can you provide to reduce these risks? So, microgrids are one technical solution but there are others. And the process is really doing that holistic planning process, understanding vulnerabilities, hazards, solutions, and kind of ranking the solution, finding what works for a particular context and executing those projects. So, you get the benefits or reduced impacts, kind of faster recovery, continuity of operations. And we have some planning tools about this.

The picture on the right just shows a PV project, and we did some work in the USVI basically pre- and post-hurricane, and it shows how this particular project didn't survive that hurricane that well. It's interesting to see if you look at some of the projects on the island, some were relatively unscathed and some were more like this, with total damage. So, there's a lot of work that can go into upfront demand and planning to make sure that this kind of thing doesn't happen.

So, here's a resource list of basically NREL resources. I'll just leave this kind of in the slide deck. Feel free to do check out these publications, and feel free to kind of reach out to me for collaboration opportunities, Ask an Expert support. I look forward to kind of the continued discussion with you all. And there's my contact information.

Matthew Thanks, Sam, for a great presentation. I'm sure there's going to be plenty of questions coming from that, and I'm glad to see there's already a few questions coming through. But as a reminder, please submit any questions throughout the webinar today, whether it's about Sam's presentation or any of the other following presentations to come. You just use the questions pane on the side.

So, moving on, let's get the slides sorted… great. So, we're going to start the next section *[inaudible due to distortion]*.

Kamleshwar Thanks, Matt. Can everyone hear me?

Matthew Yes, yep. Good.

Kamleshwar Okay. Thank you for the introduction. Welcome, everyone, and I hope you find this webinar useful. I look forward to the Q&A session at the end and ongoing dialogue with the participants here as we embark on our mini grid developments in the Pacific. Slide one, please.

The countries in the Pacific have different energy imperatives, as Sam mentioned earlier. The Melanesian countries, the challenge is increasing the access rights. For the Polynesian countries it's more a transition from diesel to renewable energy. And for Micronesia it's a mix of both.

The Pacific has some unique characteristics compared to other countries like Asia and Africa. There are hundreds of islands spread over a vast ocean area. There is an increasing demand for product use applications. Some home systems are no longer sufficient. And mini and microgrids are possibly the only solutions for a lot of these islands because this will—these islands will never have any significant grid on them. So, I guess one of the benefits of this is that the developers of mini and microgrids do not have the worry that at some point they'll be threatened by a grid extension. And as indicated, most of these countries are prone to natural disasters, and in particular serious cyclones. Slide two, please.

This has been mentioned before. The main challenges in the Pacific in meeting the energy needs are the small communities, which are spread over vast ocean areas, remote from main centers, low incomes, limited technical expertise, absence of supply chains, and limited access to finance. The Melanesian islands and most Pacific islands are also—have a community land ownership; individual titles are not available. So, dealing with, I guess, large land requirements can be a challenge.

Sustainable solutions in the Pacific require a demand-driven approach that engages the private sector in the community, addresses access to finance for buyers and suppliers, and provides an IT base platform for managing the operations as well as the transactions associated with the energy supply. The supply, operations, and maintenance of the infrastructure also needs to be embedded in the local day-to-day activities and business operations within each of the countries. Slide three.

The energy solutions for the Pacific Islands can be sort of segmented into three key areas: grids for the main islands where there are fairly high and dense populations, mini and microgrids for the small islands or for population centers that are remote and difficult to reach, and then solar home systems for the very remote in a collection—in villages with a collection of a few households. Slide four.

This is an example of how we've approached electrification in Vanuatu. So, we segmented the market into the grid-to-grid contiguous areas, outside grid areas where the population is much dense, which is more suitable for micro and mini grids, and then the very remote, where only the solar home systems will prove economic in the short to medium term. The bank is supporting operations in each of these segments since—for the last few years, and we are just about to embark on a significant mini and microgrid program. Slide five.

Slide five shows the opportunities for mini and microgrids in Papua New Guinea. Even though this country is a large land mass which could be easily covered by an extended grid, the cost of extending grids initially will be quite prohibitive, and the near- to medium-term solutions for these countries are mini and microgrids. Slide five—sorry, slide six.

So, in summary, do microgrids work in the Pacific? We need the engagement of the private sector, especially the local private sector, given the size of the installations. And there needs to be a regional approach to the development to achieve the scale necessary to make the businesses viable. In addition, given the economics of small systems, support will be required in terms of grants, concessional loans and equity to catalyze demand and also to support private sector development of these mini and microgrids. Systems need to be developed as scalable. We shouldn't look to develop a large grid in the hope that demand will come. That mistake has been made. What we need to do is start with what—based on what the demand is and then scale it up as the demand increases. So, the growth of the system will be the growth of the—the economic growth of the communities where the system is installed. And given the community land ownership, it is critical that there is a strong community engagement right from the start. The last slide.

Finally, in terms of the technology, I think the technology is available. It's the economics that is the challenge. And there needs to be a _____ of banking and telecommunications sector to support the energy, the delivery of the energy to these communities and to support the operations and maintenance associated with these remote systems.

That's it. Thank you.

Matthew Thank you very much, Kamlesh, for that. Our next speaker is Gavin Pereira from GIZ. Gavin is a Sustainable Energy Advisor for the EU-GIZ Adapting to Climate Change and Sustainable Energy Program. He also has experience as a consultant and business owner in the Pacific. We welcome Gavin. Over to you.

Gavin Thanks, Matthew, and welcome, everyone, to the webinar. It's been really interesting listening through Sam and Kamlesh's slides. And I hope you also gain something from hearing from our field experience in the GIZ Pacific office.

So, as Matthew had mentioned, I'm the Technical Advisor in Sustainable Energy for EU-GIZ's Adapting to Climate Change and Sustainable Energy Program, and that's an €18 million program that's across 14 Pacific island countries and Timor Leste. But of those countries under this program, seven of them have chosen sustainable energy projects. And so, I'm advising the governments of Fiji, Solomon Islands, and Kiribati on hybrid projects. I also have a soft support project in FSM, which I'll talk about soon. But yeah, so I thought I would focus a little bit on, I guess, the hands-on experience of working with the engineers and project management teams in each country. Our programs have a really big focus on capacity building and sort of providing the skills within the country so that they might be able to replicate these projects without external technical support in the future. And so, we've worked with the engineers within the ministries in each of those countries so that the understood the process from soil analysis all the way through doing TORs and capturing the considerations of which Sam had mentioned. And so, yeah, I thought I'd just reflect a bit on that.

So, across our hybrids we've got sort of two types of end recipient, if you will. One has been boarding schools. So, each of Solomons, Kiribats, and Fiji had submitted to the program funding request to support them with boarding schools. So, we've got a 150 kW PV system in Solomons down to a 0 kW in Kiribats. And so, the other type of project we've got is just unelectrified rural communities. So, we've got one that's under contract in Koro in Fiji, which is in the main island of Fiji, and that's a community of 55 households. They found local—they found kava, or yaqona, which is kind of a mildly intoxicating drink but it's got lots of medicinal uses. And they also found some ketelin (sp?), and there's also tobacco being found around there as well. So, that's in Koro. And in Kiawah we're planning a 90 kW system, which is not under contract as yet, which is to support a fishing community.

So, in each of those hybrids we undertook a site analysis to determine, I guess, where we would install the arrays and batteries and inverters and the types of resilience considerations. So, thinking of cyclones mostly in most of these countries, we rated the arrays through to the highest sort of wind speeds that were possible with the market supplies for racking and foundations. So, with the systems, yeah, we undertook this load analysis. And one of the issues that we'd found was in the boarding schools there was a real perverse culture with regard to energy usage, that when the generators came on the school users were instructed to just turn everything on. And so, absolutely everything that was—that could possibly be connected to the power was turned on. And so, we put a three-faced data logger on one of the sides and we monitored for a continuous seven-day period and we just had a singular flat line load, which was really quite frustrating, because we were expecting to see daytime peaks and nighttime troughs, as one would expect, but the energy usage culture of the school was such that it wasn't like that. And sadly, we repeated that load analysis project after doing an energy analysis fit-out with over 1000 LED lights, and we put in smart controls to switch water pumping over to daytime. And we then repeated the exercise to capture the load and we still received a flat line. So, there's risks around culture when it comes to supplying energy into environments where it's been previously provided for free. So, that was one of the issues we had.

Though, I guess, relating to smart metering and smart grids, we've implemented daytime timers to—for water pumping circuits so that the water pumps run during sunlight hours, so that sort of takes away some of the load off the batteries and provides, I guess, some measure of, yeah, smart monitoring and smart metering of the loads. And yeah, we just tried to optimize energy where we could.

Another of the design considerations that we looked at was the choice between gel lead acid and lithium, and sort of these projects have been in the pipeline since 2015, and so the data in the field feedback wasn't quite there yet for lithium, and also the process wasn't comparable sort of two or three years ago. And so, most of our—all of the led acid hybrids were designed with at least two days of autonomy. And the lithium—we did do one lithium system—so, the 50 kW system in Fiji is lithium, and it's actually got 1.5 days of autonomy, which is quite high. So, the ratio there is 50 kW of PV to 180 kW hours of _____ battery. So, it's quite high.

So, yeah, that all then—so, those were the kinds of—that was one of the design choices. Another was the oversize of PV versus days of autonomy, and so it's—the cost of PV has come down plummeting, and with the added sort of cushion of a diesel generator through these hybrid systems we had to make design decisions on whether to oversize PV or whether to have the extra days of autonomy to give the system more resilience. And so, particularly now with the trend towards lithium the oversize of PV will really start to come to bear in the design of these hybrid systems, certainly from what I've encountered in talking to the ministries on other donor-funded projects and also just talking to people in the industry as well.

One of the other issues we've had in some of these countries is that coming in as a donor project to a supplier hybrid through the ministries, we've had sensitivities with the utilities, which whilst they operate under the guise of _____ enterprise, they're also very anti-competitive. And so, it's created issues where they've sort of been less enthusiastic to cooperate and help provide technical assistance with the management and commissioning of these _____. And they're highly skeptical of the ministry's ability to monitor, in spite of the fact that they're receiving training on par with the Clean Energy

Council of Australia would recommend that system operators would have. And so, it's sort of been one of the challenges of these hybrids.

Tariff setting's another. And so, Sam was talking about a case earlier where the utilities charge a rate that's lower than what would be cost-competitive for a microgrid operator. We've actually had the opposite effect in the Solomons. The utility there charges around $0.75 per kilowatt hour. It's one of the highest in the world. And the teachers and the users of the hybrid in the Solomon Islands couldn't make effective use of the electricity if it was billed at the same rate, and particularly seeing as they used to—they're currently expecting energy to be used for free. And so, we've had to set a tariff rate quite a bit below utility rate. Yeah, it's more like $0.50. And that was also quite challenging to have that accepted. And so, yeah, setting tariff rates has been challenging.

And also, there's been a kind of a reluctance on the part of utilities, certainly the countries I'm working with, to allow entries for IPPs just because they're revenue-sensitive. These are small networks and small grids. They don't have a huge market to sell their electricity into. And they're doing it in products that they could easily knock in some instances. So, they're pretty keen on sticking quite high legislative fences up with regard to the entry of IPP. So, that's a challenge for what, I guess, Sam was also talking about earlier with trying to unlock that private capital, is actually having the national kind of legislative conditions to allow independent producers to come in.

And then, finally with these hybrids just trying to coordinate platforms for monitoring where there's lacking 3G—in some instances there's lacking in 3G networks. Often it's 2G. And so, that's quite—that makes it quite challenging to then run portals and things to monitor system performance and usage. And so, we're sort of looking into VSAT for some of these sites to facilitate that. But yeah, it's a challenge that you'll see in the field that might be interesting for you guys to hear.

And finally, again, just because a lot of these countries the hybrid systems are still relatively new the local suppliers haven't had the chance to really enter this market yet, because a lot of the projects that come in and—including through donors like ourselves—set too high a bar for the compliance for the established businesses in these smaller countries. So, often they've had to have turnover rates that are just unachievable or they've had to have had experience installing similar systems, which is not possible in a green field market. And so, yeah, it's been a bit challenging for certainly the Solomons and—yeah, mainly for the Solomons that was a challenge. In Fiji there's—it's not the case. There's a vibrant marketplace. We've had more than five bids on past projects, all of which would have been viable. And in Kirabats there's also a high level of competency through the ministries, actually, and through the standard enterprise of the Kirabats solar energy companies. So—but yeah, it's an interesting consideration. Next slide, please.

The second project that I thought I'd dedicate a slide to is this soft support project that I'm running in the Federated States of Micronesia. So, that project—the aim, overarching aim of it was to introduce net metering into the utilities of the four states of Micronesia to provide a boost to private sector investment in small-scale renewable energies. And this project, actually it's one of the most interesting projects I've had the chance to work on because it—to integrate net metering into utility requires a sort of—a corporate map of the utility and all of its functions, and to oversee where net metering impacts—and so, from billing to planning and distribution and lines-people, inspectors, all of them have sort of an impact—will be impacted from net metering. And so, we—through our project team there we've had to obviously develop and work with the material that we had available to provide training to all of the different units within the utility to sort of work through how they could operationalize net metering. And so, for the lines-people and the inspectors and distributors we had to figure out all the meter standards. For the billings and accounts people we had to provide an accounting system for their billing software that worked with the software that they had and with the capabilities of what would be viable for the meter readers to provide in.

Also, the utilities in FSM prefer prepayment of electricity, and so most of the customers are under prepayment. And so, that affects the—I guess, the financial planning of the utility and also the policy of the utility with regards to putting new customers on because it often is possible to integrate prepayment into net metering. It's quite challenging and difficult, and we're doing our projects not of sufficient size to buy the volume of meters and to provide the level of support that would allow that fix, so we've had to sort of provide a bit of a workaround for it. But yeah, it's been a challenging project. Another aspect of why it's been challenging is because the utilities themselves are quite small. And they're—whilst they're standard enterprises and are given a not-for-profit kind of tag, their mandate is to be revenue-neutral and to cover their costs. And so, if solar was to come on in a big way, and it easily could be triggered to do that with $0.40 tariffs that exist in FSM, and some states have $0.50 as a tariff, it sort of is challenging to really get the utilities to come onboard.

But I guess one of the avenues that's been successful to us is that there's just an incredible amount of solar and battery to come onto the grid in the four states of FSM under the master plans of the FSM government. And so, the EU—our project is readiness to an EU project that's coming with the next funding round from the EU that would put 5 mV of PV—and what you can read off this slide here, 2.5 mM and 1 MW of lithium battery, that's to reduce the kind of running operational requirement of having spare capacity of diesel generators running to provide speeding reserve and grid formation. But in addition to that EU fund the government of FSM is planning around $300 million of investment across PV, mainly across PV and battery storage. And so, all of the discussions that our project's having with the utilities regarding net metering and renewable energy penetration and setting limits on distributors and feeders and things like that is going to be just a really good stepping stone for them ahead of the larger investments that are coming under the FSM plans.

Matthew Thanks, Gavin. I'll just bring you to a close. Hopefully, we'll have a bit more time to come back to that, but with an interest in time we might get going with the Q&A session. So, if you have any more questions on Gavin's slides, feel free to just ask a question through the question pane; we'll come back to it in the next half an hour or so...

So, I'd just like to introduce Tim Reber, who is Project Manager for NREL. He'll be facilitating this Q&A session today. And if you—please, if you have any more questions throughout this Q&A session, please just ask them through the question pane. So, I'd just like to bring on Tim Reber.

Tim Great. Thanks, Matt. And thanks again to Sam, Kamlesh, and Gavin, our panelists. We got some really interesting insight from three different perspectives all with experience in the mini grid space in the Pacific. So, pretty interesting. We had a couple of questions here come in on the question pane. And I know I have a handful of questions myself that I'm keen to get answered. But I'd just like to reiterate that if you do have any more questions coming up during this Q&A session, please do go over there to the questions pane on the right side of your screen and type them in and we'll try to get to them.

So, I think there's a—there was a really good question early on from James Ellsmore that came in, and I think it's a good place to sort of kick us off bringing things to the Pacific island context. And his question really was "What guidelines are there—or do guidelines exist, even, for projects specifically in the Pacific?" And I think this question was a little more focused on specific technologies, maybe brands that are appropriate or widely used, and where folks might be able to go to figure out what kind of guidelines are available for Pacific island projects. So, why don't we maybe go in reverse order. Maybe—Gavin, I don't know if you have any perspective on this? And then we'll see if Kamlesh has any perspective, and Sam, if you want to say anything.

Gavin Definitely. Thanks, Tim. So, the Sustainable Energy Industry Association of the Pacific Islands, which is abbreviated and you can find it at SEIAPI.com, have developed the draft guideline for the development of standards and guidelines for design of hybrid power systems, covering some of those sort of tradeoff design questions that I was talking about earlier with regard to PV over size versus days of autonomy storage. So, yeah, the SEIAPI guideline exists. Prior to the SEIAPI guideline people were using the off-grid guidelines from the Australian standard for standalone power systems and sort of modifying down the days of autonomy due to the reliability and capacity of the operator to use a diesel generator. But anyway, now that SEIAPI is there there's a guideline that exists.

Matthew Great. Thanks, Gavin. Kamlesh or Sam, I don't know if either of you have other thoughts to add to that.

Kamleshwar Yeah, no, I mean, adding to what Gavin said, in terms of the technical standards the Pacific SEIAPI guidelines are probably the most advanced. And they also provide training in terms of the APL standards. I think the bigger challenge for the Pacific is to get sort of some sort of a framework for the institutional models that will support mini and microgrids in particular. Mini and microgrids will be a challenge for a lot of these countries. The economies, the remoteness, the size of, the demand, et cetera, is going to be quite difficult. And I think we are at the earliest stages of trying to get our understanding of what the best model for operating these things will be. So, we are working towards trialing different arrangements—extended utility model, a private sector model—and see if we can actually get the private sector to get involved on the back of a viable mini/microgrid model.

Tim

Great. Thanks for that, Kamlesh. So, I also have quite a few questions myself, and again, feel free to keep typing some questions in there in the pane. We had a couple of questions from Katerina, some clarifying questions. So, one I think was for Gavin, I believe. You mentioned the uptake of new lithium batteries coming in, and the question was "Does it really have any implications for system sizing, particularly of the solar array?" I think it was more of just a clarification question.

Gavin

Yeah. So, where we were hoping to use lithium—hi, Katerina—where we were hoping to use lithium, we had bumped up the array oversize coefficient is—I think in this particular system it was to 35 percent over. But yeah, there's been a really cool study done by GSES that analyzes the effects of days of autonomy and oversize for different climactic regions around Australia and the Pacific Islands, and it showed the number of blackout days you have down to one day of autonomy. And so, it's probably one of those budget and consultation questions, where if you can talk with the community and sort of see what's agreeable and what's disagreeable to the budget, then you can make that tradeoff in design. But yeah, certainly the push that I was—I've been getting and the reviews that I'm getting from people such as the guys that work at IT Power was that there's, yeah, a big favorable push towards lithium.

Tim

Great. Thanks, Gavin. We have another clarification, this one for Sam. In the case—I think it was Tanzania, where you said the maize mill with different operating loads and different seasonality—can you just remind us, tell us a little bit more about that? What was the base case for that ten-kilowatt mini grid system? Was it 100 percent diesel? What was the size? That sort of thing?

Sam

Sure. So, the base case for that system was a hybrid PV battery diesel microgrid that supplied a hundred households and also had a few kind of existing commercial visits, like two small shops and a school, I think. And it was adding a ten-kilowatt motor from that maize mill to that system and then looking at the implications of adding that to the system. So, we're happy to say more about that.

And I just want to offer one other comment on the battery sizing piece. Lithium ion batteries have a lower depth of discharge—so, you can just charge them down to about 20 percent, whereas most lead acid batteries you really don't want to do more than kind of 40 or 50 percent. So, what that means is for the same energy storage you can actually get more—or same size, you can actually get more throughput out of a lithium-ion battery. But they come at a higher upfront cost, so there's sort of a tradeoff between upfront costs with a longer lifetime and more capable kind of throughput, and that's where the kind of techno-economic analysis come in.

Tim

Great. Thanks, Sam. And it's a nice segue also to mention that for all three of our panelists, if any of you guys have any questions for each other, please feel free to jump in, let me know, or just go ahead and ask each other, get some good conversation going here.

So, we just had another question come in here regarding training, specifically training either for owner-operator of the systems or for the local communities that are using the systems. To what extent is this a part of the programs that any of the three of you are operating right now? And maybe are you aware of resources that some folks could turn to if they're interested in sort of training on these issues? Again, maybe we'll start with Gavin and then Kamlesh and Sam.

Gavin

Yeah, cool. So, as part of—so, I just mentioned the hybrid projects, but I'm also managing training projects under this program as well. And so, three of our countries have training requirements in solar and we as a program approached a company many of you would be associated—or working with or know of: Global Sustainable Energy Solutions, GSES, a training consultancy out of Australia. And with—GIZ has managed to secure an agreement with GSES to purchase a license to their training materials for grid connect PV, standalone PV, and grid connect PV with batteries. And so, those courses, as—GIZ's funding the institutionalization of those courses in the Solomon Islands through the university there, and also in FSM. And we're drafting an agreement to do the same in Vanuatu. But the beauty of that agreement we've got with GSES is that any of the vocational colleges within the Pacific Islands can access those courses. And these are the same courses that grant an electrician or a university student or any sort of course taker accreditation under the Clean Energy Council of Australia to design those systems—or, if they're an electrician, they can also install them. And I also believe GSES is mapping their course to meet the NABCEP requirement—so, that's going to be good for the North Pacific countries. So, yeah, that's got fantastic potential after our—even after our program is completed. But just within those three countries we'll be training as well. So, yeah, those resources will be online.

Kamleshwar

Yeah, from our perspective, from World Bank perspective, we engaged in training in various ways. Where we have implemented projects which are then handed over to the utility we include an O&M and a training program following the installation of the equipment to train the local utility staff, students from the local technical schools. For example, in solar installation in Kirabats we train the public utilities board as well as students from KIT.

We also have a program through the Pacific Power Association for solar and solar installation training. It is being run by GSES in conjunction with another company. And this is being rolled out Pacific-wide for grid installations. And for the project we are doing in Vanuatu we ran a special training program targeted to the specific nature of the project only. So, the training programs are available. I think I would say that they are evolving. They haven't been fully mainstreamed into the training facilities of the local countries. But it's getting there.

Sam This is Sam. Maybe just to add on that, we have done kind of training in the context of our programs more focused on either microgrid developers or policy makers in a variety of kind of technical topics and enabling environment topics around kind of system design, demand assessment, kind of regulatory policy, and other things. I think this question asked about community-level training. We haven't done a lot of that. Our focus has been more at a higher level. I know there are some pretty good kind of more basic online resources available. And I would say maybe at least kind of policy or government regulator training might be something we could support through the Solutions Center kind of Ask an Expert feature if there was a more specific need that maybe warranted a training opportunity. So, happy to discuss that further.

Tim Great. Thanks, all. Glad to hear there's some work going on in this space and some resources out there, and it sounds like there's certainly demand to increase some of those resources. I think that question about training communities is also a good segue into our next question. Kamlesh, you in your presentation mentioned that community engagement was important, specifically for the project in Papua New Guinea. Have you involved the community in the planning and sizing of systems in any way, specifically maybe thinking about inner linkages of energy access with some of the other SDG goals these communities are simultaneously facing, such as food security, healthcare, et cetera?

Kamleshwar In terms of community engagement, when—our projects, mainly in Vanuatu and Solomons, particularly on mini grids, are at the early stages of implementation. So, during the preparation of the projects, there were surveys undertaken in the communities to establish what the needs of those communities will be. And this was in terms of scoping out the potential mini grids and designing those. But as part of the implementation there will be much more deeper engagement with the community, because there are a number of issues that we need to deal with in addition to understanding what the local usage patterns, what the business load, what the public institution loads are coming to be. The more critical issue is getting the engagement of the community on where to locate the equipment, because the land is community-owned and without any individual titles. So, that engagement process will work with the community to identify sites for locating the equipment once we have actually got a conceptual design for the installations.

And I think one of the benefits of mini and microgrids is that these things are generally useful to the community. And in a situation where land is owned by a community, we feel that it might be easier to get the community buy-in as sort of a bargain with the community, to say, "Right, tell us where to put these things and you'll get electricity." Where you have bigger grids which traverse various communities and supply loads elsewhere, getting that acceptance is much, much harder.

Tim Great. Thanks, Kamlesh. And Sam and Gavin, I know this question of community engagement is a big one, so I don't know if—I want to give either of you a chance to comment if you feel so inclined or have encountered it in your work in any degree.

Sam So, this is Sam. We came across this a lot in Indonesia and in our projects in Indonesia. So, we see this in Africa too, and it seems like maybe the starting point for a lot of the planning and feasibility studies tends to be maybe community meetings where the community is engaged and kind of talking about the system and loads to be connected to the system, and it's really an important factor in kind of creating buy-in and overall kind of long-term success. So, I certainly encourage it and I think it's critical to success.

As far as the projects we've worked on, we've tried to link them to kind of other goals, but not all of the goals maybe mentioned in the question, but focus on things like agricultural intensification. Largely around farming in Indonesia we looked at kind of coffee production and chocolate production. In Africa we looked at kind of more maize milling or water irrigation. And then, also kind of more maybe businesses that could be connected. These are things like kind of provision of clean water, egg incubation, icemaking, preservation of fish for kind of fishing communities. I think the clinics and the other loads are really good, and we've looked at them a little bit, but not nearly as much as kind of the options to increase kind of economic livelihood.

Tim Great. Thanks, Sam. So, I have a question here that came up, and again, feel free, everyone else, I encourage you if you do have questions to go ahead and type them into that chat box. But I noticed—you know, Sam, you mentioned quite a bit about the importance of productive use and how that can help make for viable business models. In the meantime, Gavin and Kamlesh, I heard you both mention sort of a lack of telecommunications infrastructure as being a big challenge. I'm wondering—it seems to me there's an opportunity there to sort of link the two and use telecommunications as an anchor load, as a source of productive use for these mini grids. I know this is something that we've seen in Africa. Is this something that's happening in the Pacific Islands already in your experience? And if not, is there something we can do to sort of link that and tie that up? Maybe—I feel like we haven't heard from Gavin in a little while, so maybe we'll start with Gavin.

Gavin It's a bit of a hard one, and particularly in the Solomons, that's our biggest project, as you can see—160 kW over there. It's hard for us to sort of work with telecom, though it is something—it's definitely a dialogue that's definitely worthwhile to have, to see if we could generate some revenue through powering a receiver station of theirs and what that might look like. But it's sort of something we could look at once we've operationalized the grid itself and had some data on it and seen how it performs. Just feeding back into the discussion on community needs, that was the site where we'd had difficulty in—of obtaining a sort of reasonable and fair load analysis with regard to the system. And so, the 160-kW is actually undersized to the load that we've measured because they were using a flat 30 kW a day, and so there's quite a lot of diesel runtime in—that would have to come into play if they were to use 30 kW continuously off that energy system.

And so, a big part of our challenge in the remaining months of that project is to work on behavior change and sort of having the school understand the culture of energy usage that fits, I guess, a good usage pattern for a hybrid system, certainly one that minimized diesel usage. And if that's successful to the extent that I think is possible, then there would be the ability to then open the discussion up to see if we can, yeah, generate a bit of revenue from support of a telecommunications receiver or something of that kind.

Kamleshwar Yeah, my mention of telecommunications was not necessarily in a load context, but I can see it can play a role as an anchor load. My intention when I mentioned telecommunications, it was more in the context or remote monitoring, managing the system remotely, and then also managing the payments, whether it be the payment of a bill for a micro/mini grid or a pay-as-you-go purchase of a small system. So, in terms of anchor loads I think telecommunications could be a useful contribution to a mini grid. The problem with the telecom towers is that they're generally remote—located quite remote from the village. So, it might be a—decent to a business operation to offer a community grid rather than a connected—an interconnected grid. So, that would be the challenge in terms of using it as an anchor load. It might create a revenue stream for an operator that's running a grid in a village near a telecom tower.

But I think more importantly we need to focus on how we can use telecommunication—that's becoming quite widely available in the Pacific—to remotely operate the systems as well as to manage the financial flows and the payment schemes.

Tim Great. Thanks—thank you, both. So, we had another question here, getting back to the issue of batteries. Gordon pointed out that the battery is the highest-risk component in many of these systems and is wondering if the full life cycle cost of the batteries are often calculated into the systems, including transportation and recycling, given the short life span of some of these batteries. I think maybe this is a question for Sam. I know you've done quite a bit on battery modeling. And I'll also tack onto that a question I had regarding the environment in the Pacific Islands and how that might change some of the battery calculus. I know we've looked a lot at sort of the hot, dry climates of Africa for battery modeling, but how might they fare in sort of the different environments of some of the Pacific Islands? So, Sam, maybe I'll throw both of those questions at you.

Sam Sure. Thanks. On the first one, we definitely factor in, I would say, I guess, the life cycle cost of the battery. So, that's usually—what it amounts to is a 20-year project lifetime with batteries installed and then replaced kind of at least a couple times over the project lifespan of the battery. And the costs we use are installed costs. We don't add a cost typically for disposal, only because we don't often know exactly what that cost is. Our general experience has been that your lead acid batteries, you can recycle about 90 percent of those, and there's a market for a lot of that material, so that it does seem like there's a reasonable recycle rate in a lot of systems for the lead acid batteries. That's more of a kind of unknown and ongoing research project for us, is around lithium-ion batteries and lithium-ion battery recycling and protocols and things for that. There certainly are ways to recycle lithium-ion batteries. That's not really cost-effective, at least in our kind of initial analysis. There's an ongoing kind of environmental challenge there, and a really good question—so, hopefully that answers that, but I'm happy to say more.

Around the kind of marine environment, kind of Pacific Islands environment for batteries, I think there probably are some special design considerations. The temperature management pieces of that will be the same probably, or similar. So, there are some of the solutions that we looked at for temperature management, like an evaporative cooler, that don't work well in humid environments, so those would certainly be out. But some of the fans or air conditioning would certainly apply. And then, a lot of the considerations around kind of shipping of batteries, transport of batteries, how to get batteries into kind of remote areas, maybe remote areas with shallow ports, would be somewhat unique to islands. Although, we've looked at some of those for places like Lake Volta in Ghana that maybe have a similar context, and there are probably design considerations around the battery enclosure and humidity in there. We haven't looked at those as much, though, _____.

Tim Great, thanks. Thanks, Sam. And I have another question for all of you. Before I propose this, I'll just say again if any of you guys have questions for each other, please don't be shy. Feel free to jump in. But every—all three of you have mentioned access to finance and increasing private investments as really one of sort of the keys to unlocking the mini grid sector. We hear this time and time again in a lot of our work. And so, the question I'd like to pose is kind of general, and I'll maybe just go down the line and get each of your perspectives, but what do you think would be the single biggest achievement or biggest thing we could do to really improve access to finance and build up interest from the private sector in investing into mini grids. I know that's a big question, but I would be keen to get all of your perspectives. So, Gavin, maybe we'll start with you, and then Kamlesh and Sam.

Gavin From my perspective, in some of these _____ countries with high tariff rates there's also, yeah, opaque sort of guidelines to investors in IPP—prospective independent power producers, as to how they would obtain a license to—and have the legal right to build up a generation asset and then distribute it and harvest the revenue from it. And so, that's probably from our end the biggest hurdle, certainly for the private sector in some of these countries, is how—what the steps are for them to actually register and become and independent power producer. Once that's cleared up, yeah, particularly looking at a country like the Solomon Islands where electricity is $0.75, basically anything is cost-competitive in that environment. And so, if it was possible even to legally connect a PV generator and it was made sort of fair and reasonable, then it would happen rapidly. But yeah. So, just having a legislative environment and a policy environment in some of these countries that allows it, because that's the first step, in my opinion.

Kamleshwar Yeah, I think to get the private sector interested in developing, owning, and operating these things, we need to work towards making these commercially viable for them. And to do that there are a number of constraints. So, one is we are dealing with communities with low incomes. So, they have a maximum amount they can buy, so we have to start off with what is affordable, and then perhaps look at the solutions that are not 24/7 grids abut are designed to meet the needs of the community. So, much lower standards initially but make it scalable so that as demand increases you build bigger systems. So, _____ viability, I think, is the number one priority to get the private sector interest.

And then, to get the private sector access to finance, what we need is some sort of _____ to get—for the private sector through government equity or concessional loans, and risk facilities to enable them to raise finance commercially from local or international commercial banks.

Sam So, I agree with those answers and kind of the focus on the regulatory environment and the policy structure and the business model. Maybe the thing I'll add to that—and I think these are kind of what Kamlesh and Gavin are working on—is really the need for projects. So, to the extent that the development community and the kind of patient capital can go in and fund project number one, project number two in a particular geography and location and reduce their risk in that sector by showing basically successful projects, viable returns, customers paying for power, things like that, that really unlocks a lot of the market for private sector capital. So, I think to me the intention of those projects is often to do that, so I think it's nice to see those projects coming in. And hopefully, they can demonstrate success in that space and then help move the private sector into that market. And one of the ways to kind of move the private sector into that market is still to support those private sector entities with kind of the viability gap, financing, or risk reduction capital or other things. But I think those demonstration projects are a good first step along the lines of showing viability, particularly if they are awarded the kind of private sector companies to execute and gain experience with.

Kamleshwar Yeah, and to add to that, in the Pacific context I think what we need to do is create scale. So, if you are doing two or three projects in each country it's going to be difficult, but if we are doing hundreds or projects across numerous countries it will be much more attractive to the private sector.

Tim Great. Thanks, all.

Matthew Well—

Tim Sounds like there's—Oh, sorry, go ahead.

Matthew Sorry, yeah. Thank you all for participating today. I think that was a great Q&A session. I hope everybody got a lot out of that. I'd just like to thank Tim for leading an excellent Q&A session and for the rest of you to—for your great responses as well. I'd just like to provide the panelists with any additional—or closing remarks you'd like to make before we close the webinar?

No? Great.

So, we'll move on then. So, thank you again. On behalf of the Clean Energy Solutions Center I'd like to extend a thank you to all of our expert panelists and to our attendees for participating in today's webinar. We very much appreciate your time and hope in return that you were provided some valuable insights that you can take back to your ministries, departments, or organizations. We also invite you to inform your colleagues and those in your networks about Solutions Center resources and services, including our no-cost policy support through our Ask an Expert service. I invite you to check the Solutions Center website if you'd like to view the slides and listen to a recording today's presentation as well as other previously held webinars. Additionally, you will find information on upcoming webinars and other training events.

We are also now posting the webinar recordings to the Clean Energy Solutions Center YouTube channel. Please allow for at least one week for the audio recording to be posted.

Finally, I'd like to kindly ask that you take a moment to complete the short survey that will appear when we conclude this webinar. Please enjoy the rest of your day and we hope to see you again at future Clean Energy Solutions Center events. This concludes our webinar for today. Thank you very much.