# Off-Grid Energy Storage

—Transcript of a webinar offered by the Clean Energy Solutions Center on 18 July 2013—
For more information, see the clean energy policy trainings offered by the Solutions Center.

## Webinar Panelists—AM Session

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| **Richenda Van Leeuwen** | Energy Access Initiative |
| **Xavier Vallvé** | Alliance for Rural Electrification and Secartys |
| **Thomas Samuel** | Sunna Design |
| **José Gabriel Martín Fernández** | ACCIONA Microenergy Foundation |
| **Romina Arcamone** | Renewable Energy at the Trojan Battery Company |

## This Transcript

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Sean Esterly

Hello, everyone. This is Sean Esterly with the National Renewable Energy Laboratory and welcome to today's webinar hosted by the Clean Energy Solutions Center. Today, we are fortunate to have Richenda Van Leeuwen, Xavier Vallvé, Thomas Samuel, José Gabriel Martín Fernández, and Romina Arcamone with us to discuss off-grid energy storage. 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 practices resources reviewed and selected by technical experts.

Before we begin, of course we'll go over some of the webinar features. For audio, you have two options. You may either listen through your computer or over your telephone. Now if you choose to listen to your computer please select the "mic and speakers" option in the audio pane. By doing so, you'll eliminate the possibility of feedback and echo. Now if you select the telephone option, a box on the right side will display the telephone number and the audio PIN number you should use to dial in. Panelists, we ask that you please mute your audio device while you are not presenting and if you have any technical difficulties with the webinar, you may contact the GoToWebinars Help Desk at 888-259-3826.

Now, if you'd like to ask a question and we encourage everyone to ask questions throughout the webinar, we ask that you use the 'questions' pane on the right where you can type in your question. If you're having any difficulty viewing the material today through the webinar portal, you can find PDF copy of the PowerPoint at https://cleanenergysolutions.org/training and you may follow along as the speakers present. I'll also send out that link via the chat pane on the right, also an audio recording and the presentations will be posted to the Solutions Center training page within a few weeks.

Now, we have an exciting agenda prepared for you today that is focused on off-grid energy storage. We will hear an introduction from Richenda followed by Xavier who will be presenting the Alliance for Rural Electrification new position paper on off-grid storage. We'll then hear from Thomas, José, and Romina who will be presenting case studies on projects from their respective organization. Before speakers begin their presentations, I'd like to provide a short informative overview of the Clean Energy Solutions Center initiative. Following the presentations, we will have a question and answer session and then wrap up with some closing remarks and a very brief survey.

Now, the slide shows a bit of background in terms of how the Solutions Center came to be. The Solutions Center is an initiative of the Clean Energy Ministerial and is supported to a partnership with UN Energy. We've launched in April of 2011 and it's primarily led by Australia, the United States, and other CEM partners. Outcome to this partnership includes support of developing countries through enhancement of resources on policy relating to energy access, no-cost expert policy assistance, and peer to peer learning and training tools such as the webinar you are attending today. The Solutions Center has four primary goals. It serves as a clearinghouse of clean energy policy resources. It also serves to share policy best practices, data and analysis tools specific to clean energy policies and programs. The Solutions Center delivers dynamic services that enable expert assistance, learning, and peer to peer sharing of experiences. Lastly, the center fosters dialogue on emerging policy issues and innovation around the globe. Our primary audience is the energy policy makers and analysts from governments and technical organizations in all countries but we also try to engage with the private sector, NGOs, and civil society.

Now, our Ask an Expert is a marked feature that the Solutions Center provides. Ask an Expert is a valuable service offered through the Solutions Center. We have established the broad team of over thirty experts from around the globe who are available to provide remote policy advice and analysis to all countries and at no cost. So, providing the expertise in the area of energy access, we are very pleased to have Ellen Morris, associate professor of Professional Practice in International and Public Affairs at Columbia University. Ellen is also a founding partner of the Embark Energy and president of Sustainable Energy Solutions. Additionally, we have Ibrahim Rehman, director of the Social Transformation Division at the Energy and Resources Institute in India serving as an expert on rural electrification with renewable energy. So if you need policy assistance on energy access needs or any other clean energy sector, we encourage you to use this useful service. Again, this assistance is provided free of charge and to request assistance, you may submit your requests by registering through your Ask an Expert feature at http://cleanenergysolutions.org/expert. We also invite you to spread word about this service developing your network and organization. So we

encourage you to explore and take advantage of the Solutions Center resources and services including the expert policy assistance. Subscribe to our newsletter and participate in this webinar.

Now, I'd like to provide brief introductions of our distinguished panelists. Today, we will begin with an introduction from Richenda Van Leeuwen. Richenda is the executive director of the Energy Access Initiative overseeing the UN Foundation's work on energy access and its engagement with the UN's Sustainable Energy for All Initiative.

Next stop is Xavier Vallvé, Board Member International Consultant and partner with Trama Tecnoambiental as well as a member of the board for the Alliance for Rural Electrification and Secartys. Today, he will be presenting the Alliance for Rural Electrification's new position paper on off-grid storage.

Following Xavier, we'll hear from Thomas Samuel. Thomas is the founder of Sunna Design and will be speaking to us about their work in the Syrian refugee camp Zaatari. After Thomas, we will hear from José Gabriel Martín Fernández. José is the project manager of the ACCIONA Microenergy Foundation and will be presenting on their "Luz en Casa" or "Light at Home" project in Peru. Finally, we will hear from Romina Arcamone Garcia, International Business Development Manager for Renewable Energy at the Trojan Battery Company. Romina will be presenting the Trojan Battery Company's Spice Village Resort in India. With those introductions, I'd like to welcome Richenda to the webinar.

Sean Esterly Alright, Richenda might be having some technical difficulties so we're going to skip the UN introduction for now and we'll go ahead to Xavier who is presenting now on off-grid energy storage. Xavier, welcome.

Richenda Van Leeuwen We had some problems with my mic, so we can go back to my presentation.

Sean Esterly Okay Richenda, we'll come back to you at the end after the presentation.

Female Speaker Sean, we can have Richenda right now. If Richenda would prefer to start first, we can go ahead with her.

Richenda Van Leeuwen Okay, thanks. As I was saying, sorry we had some technical difficulties at this end. We've been very pleased to have the Clean Energy Solutions Center such a strong partner with us in the work on energy access and for Sustainable Energy for All overall and certainly for any government who maybe on the call with us this morning. We cannot overstate the value of the technical expertise that is available on a pro bono basis to help with that aspects supposedly development that was just mentioned in the introduction. From our standpoints, many of you are familiar already with the Energy Access Practitioner Network that we

were on out of the UN Foundation that does a contribution to the growth of Sustainable Energy for All Initiative and as a network of networks in many ways to help bring together global experience and expertise around what is happening in the Energy Access sector, what is happening more broadly on particularly low-carbon energy solutions and where we can be bringing those innovations into field settings much more quickly through helping to disseminate knowledge and knowledge sharing throughout the sector. We work in many other areas as well but one of the pieces that we have seen that is absolutely critical is the energy storage aspects because we recognize that there have been a lot of innovations but we still have a long way to go in this sector and so we're very excited this morning to be able to listen from some experts both in terms of Trojan's perspective on developing battery innovations and also from the fields perspective of how things are working in the fields.

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If you're not familiar with the overall Sustainable Energy for All Initiative, just very quickly, this is an initiative of the United Nation Secretary-General and now the World Bank President, Jim Kim, as well which was launched in 2011. It has three global objectives for us to achieve by 2030. The first of which is ensuring universal access to modern energy services. That's where we in the Practitioner Network already focusing particularly on the electrification aspects of access to modern energy services. Additionally, the second objective is doubling the global rate of improvement in energy efficiency, and the third one is doubling the share of renewable energy in the global energy mix. Both of those very much play into the energy access sector as well. The UN General Assembly following on a very successful UN into national year of Sustainable Energy for All has declared 2014 to 2024 as the Decade of Sustainable Energy for All. For those of us who are working on the ground, this is very important because it really says the context to ensure that UN agencies, the United Nation Secretary-General, Member States says the United Nations will be maintaining the focus on different aspects of energy and that really is the sustainable development for the coming ten years. Within the Sustainable Energy for All Initiative, we already have seventy-two countries engaged already in the initiative and they have all committed to action plans around energy access within their particular country context as well. Again, we are really looking to ensure that all of the relevant applications within a systemic approach but also within individual pieces of that are brought to the table as we engage with government, as we look up policy, as we look up practice as well.

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Again, just to say that we launched the Energy Access Practitioner Network in 2011 as a contribution towards the development of the Sustainable Energy for All Initiative and really to bring the voice of companies and organizations and investors focusing on the contribution of

mini-grid and off-grid solutions towards the achievement of universal energy access. It's not that we're opposed to grid extension but that we really see that there is a very strong contribution through mini and micro-grids and also through off-grid solutions, and they all require certain components of energy storage. Today, we have fourteen hundred members in the network. It's going very quickly. We have a number of battery companies who are a part of that network and all of us pretty much use batteries in one shape or form for storage for the solutions that are utilized. We recognize that about sixty percent of the people globally do require micro-grids and decentralized energy solutions and we're learning how to implement this in many different developing country context, but particularly on the micro-grid side is also a very strong engagement and interest in other markets like the US where in fact we're looking at more decentralized approaches to help with energy security going forward. About a quarter of all members currently are working primarily on energy storage, although as I said more broadly, everybody really needs different types of energy storage for the work.

I'll be moving on now to the Alliance for Rural Electrification, I think is our next panelist and we work very closely with ARE more broadly in the network and we're delighted to be able to help showcase it's new off-grid storage position paper. So, thanks very much and I'll hand it back on to the next speaker.

Xavier Vallvé

Thank you very much. This is Xavier Vallvé from Barcelona. Good morning or afternoon to everyone. My presentation is to introduce a position paper that has been edited by ARE and it's available to anyone that wishes to have it. I will first make some preliminary comments.

May I have the next slide, please?

The reason why we are looking at engaging in off-grid Renewable Energy Technologies of course is the access to the large number of people un-electrified but also to people that have access to electricity but technically they are what we consider to be under-electrified because the quality of the service is poor in general. Out of this, a large part of the potential market development is going to be with off-grid solutions and this if done with renewable energy offers great opportunities to also electrify and do it in a sustainable way.

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In this case, I'd like to say that this is not a talent for policy makers and for institutions but it's also a direct talent for the business sector. We have this association called ARE that is a platform essentially focused on the industry we are at present, seventy members mainly from industry but also some institutions representing academia and the public sector. Our activities follow three service lines: Business and intelligence support, public affairs support, and supporting administrations. Next, please.

Here, you have some of the logos of the wide variety of institutions and the companies that are members of ARE, which are worldwide, Europe, the America, Asia, essentially from Oceania, all parts of the world. Next.

Just a brief summary of some of the features that ARE through technical secretariat offers to its members and to the public in general is that we organize different activities focusing on different technological aspects. For example, during 2013 regarding countries, we have been focusing in Africa and Latin America and during the first semester of 2013, the focus was on small wind. The second semester was on energy storage and this document, this guideline that I will be presenting was developed as part of these activities. In 2014, the focus regarding technology will be on small hydropower and hybridization and power components. For 2015, we would like to be working on biomass and on mini-grids. This campaign that we have focused on energy storage has set us an objective to improve the business framework based on recommendations of the alliance, to create also awareness of the potential of this specific technology. It was active through a task force from July and it will be going on until December of 2013 and the strategy is to give access to the network of practitioners and decision makers and trying to enable private and public dialogue and to channel research articles and the journalistic activity.

Let us go on to the position paper, which is the objective of my presentation. This is a paper like I said that it's available to anyone. I will go through some of its key feature in a short summary. Please let us have the next one. It was done through a task force that can help as co-authors, representative from different companies throughout the world. Some of these companies as you can see are battery manufacturers but others are practitioners, so this paper tries to get the expert opinion of anybody, not only manufacturers of the technology but is using it in the field.

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This task force has objectives to improve the business framework and to raise awareness, and the paper itself is a summary that describes available energy storage technologies very focused on rural electrification and tries to highlight the competitiveness of each technology and the trends of the sector, and this is illustrated with five case studies and it has some recommendations. Those would be high-level recommendations for decision makers and policy makers. It's not an engineering handbook. I wanted just to highlight this aspect as well.

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So, just to introduce the term when we talk about energy storage, it's a very wide term, very wide concept that means anything that enable storing energy from a primary source and that you can store it to use at the later time, but here the big difference between technologies is what is the

primary source and what it is the time that it will span between when you store it and when you use it.

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These are the big families of technologies used in storage. The first one is electrochemical storage, which is the one we are most familiar with and typically those are batteries. The more common battery technology is the lead-acid battery that we know say from our cars, but also all the emerging technologies is lithium. Other well-known technologies are the nickel and sodium-based batteries and also new emerging technology is a flow batteries. The technology itself has been well known for years, but some are more recent from the point of view of their commercial applications. As chemical energy storage will mean for example storing hydrogen or synthetic natural gas, these means that you use a primary source of energy, you convert it into gas and then you store this gas that you can use at a later date and you can see for example in these cases those technologies allow you to use that energy a very long time after it has been stored. Electrical energy storage is what we call typically capacitors or superior conducting magnetic energy so these are the technologies that are used for short periods. Mechanical energy storage is flywheels, this also very old and well-known technology, but now it has been seeing important technological evolution to make it more efficient or other examples is to pump hydro to reversible dense for example or compressed air. The last group is thermal energy storage, which means heat. It's heating. Hot water will be a simple example, but also there are most sophisticated technologies that allow you to store more energy in less volume, which is phase-change materials, molten salts, which for example is used in concentrated power solar thermal applications. This is a market segmentation that has been defined by the European Association for the Storage of Energy. Now the position paper that we are presenting has been focused out of those technologies on electrochemical energy storage which is in particular batteries that we recognize it as the main technology that is practically applied for off-grid to the these commercial conditions. This is off-grid and backup applications. Next.

Now, let us look at batteries. We could classify them in different families. The lead-acid batteries are the most mature technology. Often you will hear that batteries are the weak link in off-grid electrification, but in general our field experience shows that they are not as weak as they say, that many times the batteries will not perform correctly because they are not properly treated, but if well managed you can expect very long service life and cycling out of the lead batteries. It's the most commercial technology also regarding their recycling. This is well established in many parts of the world because of course it's a technology that we share with the market of automotive batteries, which are slightly different but the materials are the same. The second group is the lithium-ion batteries. It's widespread for very small portable applications like for example cellphones, but it's starting to become cost-effective for bigger

applications like mini-grids especially in the short-term energy management. So, they are identities that they are lighter, they occupy less volume, and they are more expensive so they have to be selected for applications where they are cost-effective. What we call nickel batteries, which are the third group that has different technology options here. There is one which is called the Nickel-Cadmium System which is also well-suited for rural electrification especially under extreme environmental conditions for example regarding temperature and Nickle-Metal Hydride are well suited for small off-grid applications like buoys, street lighting where you need also again a high energy density level. The fourth group is sodium batteries. Those are used for large applications, large what it's called grid stabilizations so they are more linked to the market of the grid distribution and they are used for power quality and peak shaving. They are maintenance-free, immune to high temperatures, and quiet robust.

In the position paper we have selected five case studies, which will provide you with the showcase of what these applications are. One is a village resort that is a case study by the battery company Trojan and this is an application in India. The other is a rural electrification in a service building, head office of the company Rahimafroomz Renewable Energy Limited from Bangladesh. There is a particular example, which is Street Light to a refugee camp in the Middle East by Sunna Design, France. A fourth case study is a rural electrification with small systems for individual homes in South America in Peru and the fifth is in Mozambique by the company Phaesun from Germany. You can see that we have selected case studies in different parts of the world but also with different size of application, what if a large hybrid plants or various small individual systems like the PV in a streetlight for example. Next.

So out of the position paper some of the main conclusions is to create awareness that storage will place and will play a key role in achieving universal access to clean and affordable off-grid electricity services. This market is expanding very rapidly in developing countries and emerging markets. That if we want to have a good penetration, high penetration of renewables that are universal, but intermittent like for example solar or small wind, we will need these storage to provide a good quality service twenty-four hours a day. In this context there are two roles that can be played. One is short-term and the other is long-term energy management. Short term you may probably find it more related where you have weak grids, that they have blackouts and you can combine short-term storage and maybe some also self generation with renewables and long-term energy management like typically it's the range of several days of autonomy for off-grid electrification. The wide range of different battery families allows you to select the most adequate for each application and if properly designed the performance is quite good and leading to always looking at the lifetime cycle cost that make it very cost effective. We also want to create awareness that there is different qualities available in the market and that we recommend to use equipment that has been certified

according to international standards by independent laboratories and that this will always be a criteria that will help to make sure that we have long time service of this type of components.

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These are our recommendations addressed to public authorities and regulating bodies, but also to creat awareness in general to implementing agencies that could rural electrification agencies or even multilateral agencies. So we need to make sure that only technology is adequate but that we need a well-fitted regulatory framework. Sometimes the regulatory framework for example has not recognized that there is the existence or that there is the need to have storage as part of the electrical service, that there is need to create awareness in general. Also technical assistance like that we recognize that often the product can perform but is not properly maintained or installed and this can create a problem and also that most of these technologies can be recycled quite adequately, but that many of the implementing agencies are not aware to introduce the recycling management scheme in their projects. Another recommendation is that policy targets for batteries should also be established and like most of the technologies based on initial investment like for example renewables that are high initial investment but low operating cost is that we also have to create awareness among the financing sector.

So, this is essentially the message that we are providing from ARE and we encourage you to download this publication going to the website at ARE which is here on the slide, www.ruralelec.org and you can download it from our publications where you will find all the publications that have been done in previous campaigns. I will thank you very much for the opportunity to provide this explanation and we will be providing questions with answers. Thank you.

Thomas Samuel Hello everyone. Thank you Xavier for your presentation. I'm very happy to introduce this case study which is Bringing off-grids PV LED street lighting to Syrian refugee camp Zaatari. Zaatari is a camp located in the north of Jordan.

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First let me introduce briefly Sunna design. Sunna designs is a start up selling LED solar street lighting solutions specifically adapted to tough climatic condition, developing countries in general. I personally created the company in India in 2010 after an experience with **OHO** [Phonetic][ 0:40:50] which is Rural Electrification Foundation located in South India. This experience allowed me to develop a first concept of solar streetlights, supposedly efficient protecting the challenges of bringing light to rural area. India is an interesting market as nearly four hundred thousand people are living without electricity. For strengthening of R&D and access to capital, we created the company in France in 2009 and as a start up we are

now a busy backed and that allowed us to establish collaboration with industry majors like Saft or R&D lab like CEA which are helping us for developing our own technology. We have executed projects mainly in southwest Asia, India, Sri Lanka, Bangladesh, and in Africa.

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Solar street lighting is one of the best ways to bring public lighting to area where a grid will never extend and people will live off grid for the long time. Unfortunately those projects are often government project tender based and CAPEX driven. Price matters very much and there is quiet often no lighting requirement and no sizing of the system that causes integrators to assembly poor quality parts. As far as we understood this market, the main technology bottleneck is on storage lifespan to achieve low cost, most integrators, ninety-nine percent in developing country are using low quality lead-acid battery with poor electronic without intelligence and this go sees a six months to two year lifespan of the battery and a lot of maintenance. This maintenance is oddly never funded by donors and so products are failing and they stay in field without working after a year. There are hundreds of thousands of products that are coming at the moment and we are hoping to bring a new solution that I am presenting on the next slide.

We have developed this concept iSSL standing for Integrated Solar Street Lights, which is a performance based, OPEX driven solution. We have chosen, and assembled, and designed the best quality parts. We are using the highest efficacy LED Luminare with advance optics system that allows to reduce the sizing of the system, using a smaller PV module and a smaller battery. In term of battery we are using an interesting technology that I am describing on the next slide.

Actually for entering a good market acceptance of this solare street lighting we knew that we have to provide systems that are not maintained for a long time. We have selected chemistry from the French battery manufacturing named SAFT which is made of nickel and which originally used for security lighting. It has a very high resistant to temperature and then its suitable for developing countries, in tropical or dessert countries and can provide an eight to twelve year maintenance free operation with low environment footprint which is very important where you are dong and eco-project. For managing this battery we have developed an electronic, which is a battery and light management system, which has a PCB on the top of the battery. The energy management system allows us to track the state of energy of the battery, which is very important. It’s like the fuel gauge on a car and this allows us to guarantee the lighting without blackout. It’s a patent pending algorithm, which is reducing the light consumption if there is a low energy. This is extremely important as solar street lighting is meant to provide lights and then security. Blackout should not be possible or accepted. As far as we know this technology offers the lowest total cost of energy for solar street lighting project.

I'm presenting on the next slide the case study we've talking about. We've been asked to develop a system by -- we've been asked by electrician who is out border, a French NGO supported by the French Ministry of Foreign Affairs. The project is about lighting up the registration area of refugee camp. As you know the Syrian treaties is getting worst and worst and hundreds of thousand of people have arrived in this camp through this range and area twenty four hours a day so people are arriving by night, exhausted, woman's alone and the camp needed to be lit. Unfortunately the Jordan grid was too weak and as a camp we are expanding so fast. There were lots of blackouts, so they decided to turn for solare street lighting with a light requirement, which was technically five-lux minimum with good uniformity. Solar street lighting is about lighting and that's our product. So, we've been doing a lighting study, which defines the type of product of the output of the lumens to pull out -- excuse me -- the number and the distance between pole and this is how you define the economics of a project as you need to light an area and you have to choose products, which are going to produce this lighting. It's important because most of the time as those street lighting products sold as products, but not as lights.

Then, the next slide, I'm just showing two very nice pictures of the results. One hundred streetlights have been installed on the first phase by electrician resolved boarders. Very quickly, only two volunteers from NGO installed android lamps in less than a week. Thanks to the plug and play architecture, you just have to place the all-in-one remaining on top of the pole and since last November, this is procuring a security around sunny terrace and transit area out of the camp. We are hoping to deploy a southern system in the new camps that are being dated for month by UNHCR. With this new battery technology and new battery management system that we updated, we would hopefully produce a very pleasant comfort and lighting for the refugees that are arriving at the moment in Jordan. Thank you for your attention. I'll pass the mic to Jose.

José Gabriel Martín Fernández Thank you Thomas. Hello everyone and many thanks to the Energy Access Practitioner Network, to the Clean Energy Solutions Center, and also of course to the Alliance for Rural Electrification for this opportunity. I'm representing ACCIONA Microenergy Foundation, the corporate foundation of the Spanish group ACCIONA and I'm going to present to you our activity in rural electrification in Peru.

Just kindly pass to the next slide, please. Thank you.

During the next ten minutes, I will present you the mission, the scope, and the activities of FUNDAME. Then, I will focus my presentation on the activities of our first social micro-enterprise created in Peru for rural electrification through our first project there in Jicamarca in the north side of Peru. We just called it "Luz en casa" and it's developed within Jicamarca, which is the lower region of Peru in terms of electrification rate. Then, I would finish describing our experience with this particular issue of energy storage in our electrification projects.

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First of all, where were at the FUNDAME, the ACCIONA Microenergy Foundation.

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FUNDAME was created to focus the company's efforts of ACCIONA in social development. That's the reason why we're focusing in the strategic business of our company of ACCIONA with our infrastructure mainly whenever with energies and now showing water infrastructure. We are promoting social development in remote rural areas in developing countries through increased access to basic services mainly in electricity, but also in the future, we will also supply services in water and other types of infrastructure.

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Which is our scope at ACCIONA Microenergy Foundation. We are always thinking on a long-term project sustainability and for us, the most that we are looking for the economical, social, and the environmental sustainability of our implementation. We are always thinking on providing long-term services and not just focusing on the project execution. How we reach this goal, we create social microservice companies and usually base it in a free-for-for service income model, which warranties the sustainability of the project. For example, for rural electrification, we try to give at least twenty years of service. Now, we have created two social micro-enterprises. First one was in Peru, which is ACCIONA Microenergy Peru and since 2012, creating our second microsocial company in Mexico, which is ACCIONA Microenergy Mexico. We are also -- we are always focusing it on isolated rural areas and we work with an open mind collaborating. I was trying to collaborate with other organizations creating partnership with them and for example, with administration with the government, with NGOs, other foundations, companies, etc.

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Now, I would start to describe our activity in detail in Peru.

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ACCIONA Microenergy Peru is a nonprofit Peruvian company created in 2009 and it aimed to be a sustainable energy service social micro-enterprise. Our main project, Luz en casa, will benefit at the end of this year at least three thousand households, which means three thousand families with electricity supply. We used to install solar home system. Solar home system is composed by one solar panel of around eighty watts. One battery -- lead acid battery with around hundred amperes per hour of

capacity. We installed also the CFL lamps in each household and another one plus to connect an efficient radio, mobile phone charger, or varied efficiency TV. Obviously, we control all these systems through a charge controller with protective battery of the charge. ACCIONA Microenergia Peru is -- they are responsible of the execution of the installation of the project and the design, but mainly we are proficient on the maintenance of the system during the lifetime of the project, which is establishing it in twenty years. The reason of the three thousand people or three thousand users or beneficiaries is because this is their breakthrough point of our management model, which warranties the economical sustainability of the project. Obviously, we would like to arrive to a higher number of people, but the first goal is to achieve three thousand families with energy or electricity supply. In Peru, we take advantage in this project of new tariff framework developed it by the Ministry of Energy of Peru in 2010 and it means that we are under the regulated market of energy supply in Peru. We receive money from the government through the tariff and part of this tariff is paid by the beneficiaries. The goal of the project -- the program Luz en Casa is to show the affordability for very low-income people and locating in isolated rural areas and also, to demonstrate the sustainability of the program during at least twenty years of lifetime. Our main results during these forty years of experience -- now, we are providing electricity services to one thousand three hundred families for solar home system. It's to be the first Peruvian rural electrification company exclusively with solar power at all types of solar power. This year, we'll have another objective. It's an important goal, which is to reach the number of three thousand people, three thousand from beneficiaries -- three thousand families through the acquisition and installation of one thousand and seven hundred more solar home systems. The acquisition of this equipment and the installation and the development of the program is co-finance it by the inter-American development bank and through a loan of our own one million dollars, which will be rendered through the income or through the cash flow generated by their own projects.

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Now, how we manage this program. Who mandates this program?

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We have designed it on implementing the multi-actors management model. On the top of the management model is ACCIONA Microenergia Peru, which is the -- at least, we are the -- at the end, we are the owner of the PV kits in the solar home system. We are in touch of the operation maintenance of the equipment and obviously, we are also being responsible of the sustainability of the model. On the other side, on the bottom of the slide, we have the beneficiaries of the service who are entitled of the payment of a monthly payment of three US dollars. This amount is less than the amount of money that they spent before our implementation and they are also in charge of clean and obviously,

caretaker of the solar home system. We're doing our activity in our organization in Peru on the beneficiaries. We create PV electrification committees in each village who are in charge of the collection of the payments every month. They gave us also basic technical maintenance of the agreement. Since that's a yes, we have taught a part of our user a sample of them in order to become our technical operators for maintenance activities of our equipment. They have found another way of income for their families through this way. Obviously, we can see that in this manner to remodel the local council and the local administration through a collaborative partnership with us and permanent communication and they give us any type of support and also to our PV electrification committee and also to our users. Obviously, as I mentioned, we are under regulated market. So, we are permanently in contact with the regulating authority in Peru in terms of energy of electricity and there are these charts of the fiscalization of our activities in our work and our monitoring model.

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Thank you. To finish, I would like to show you our most important issues identified and related to the energy storage, which had been collected from our fortieth rural electrification experience.

Next slide, please.

First thing [Indiscernible][1:02:47] for example as mentioned, we identified that not all actors involved in this sector of rural electrification are used to thinking in service. They are usually thinking in projects. It means to think in a certain view of like one, two, or three years at maximum of operation of the systems, but we will leave that. We must be thinking a lot of service provision at least twenty years of service to warranty good services for our beneficiaries. Specifically, in terms of battery, we think this is the most critical equipment of the system to warranty specifically the quality of the battery to warranty the sustainability of our model. Because of the expected lifetime of batteries and its cost of replacement, which is replacement impact in terms of the [Indiscernible][1:04:04] is tremendous for our social micro-enterprise and without a good quality of battery, we can endanger the sustainability of the project, but we have not told the conviction about the quality of the battery supplied and there are two reasons. At least, we have identified to two different reasons. First one was the lack of technical data from manufacturers and sometimes maybe the lack of transparency in that data.

Let me give you two examples, which are critical for us to warranty the -- to be sure about the sustainability of our model. First point is that it's not easy to get for example the current tariff in representing the number of cycle of the battery expected versus the depth of discharge rate. This is critical to warranty -- as I mentioned, to warranty the lifetime of the model and I'm critical for the economical sustainability. Another example about the lack of technical data, we usually use a task controller. We are basing

it on voltage to control or to prevent the lifetime of the battery and it is not easy to get the battery voltage versus depth of discharge curve. Usually, they are not available and these are indispensable for just our conventional charge controller. Another issue, sometimes, there is not coordination or we don't find coordination between the charge controller and the battery -- the charge controller supplier and the battery supplier, which means a not-well protection of the battery. This is something that we get from our experience and after forty years of rural electrification projects, but I'm thinking in the future related to the energy storage, we are worried about the lead-active battery recycling. Remember that we are talking about isolated rural areas and we are talking about a thousand meter of it and we expect around two or three battery replacements during the lifetime of the project during the twenty years of lifetime. So far, this will be an important issue in the future in the short term. On the other hand, in the future, we have also a lot of confidence in lithium batteries for solar -- rural electrification through solar technology.

Next slide, please.

I'm finishing. Many thanks for everyone for attending this webinar. The following presenter is Romina Arcamone from Trojan Battery Company. Romina, I give you the floor. Thank you.

Romina Arcamone Garcia Hello everyone and thank you for joining us today. My name is Romina Arcamone Garcia and today, I will be talking about an off-grid commercial micro-grid system that provides energy storage for a resort in India. I have a lot of interesting information to share with you. So, let's start.

Let's go to the next slide.

So, before jumping to the case study, let me introduce to you briefly the Trojan Battery Company. Trojan has more than eighty-five years manufacturing high quality recycled lead acid batteries. That is VRLA, AGM, and gel batteries. We have four state of the art manufacturing plants. Two of them are located in the east coast and two in the west coast. We developed all distribution networks in over more than hundred countries around the world.

Next slide.

Thank you. Trojan batteries are used in different residential markets such as off-grid residential, self-consumption, rural electrification, and micro-grid. Next one, our batteries are also used for unstable-grid backup and emergency backup. Next, Trojan also serves industrial obligations such as solar street lighting, telecommunication, and remote monitoring and control.

Okay. So, now that you have some background knowledge of Trojan, let's move to the case study. So, the Spice Village Resort is the first of the kind of grid solar eco resort. At sixty-five kilowatts, this system is used to power sixty-six cottages to [Indiscernible][1:09:36] and other service areas. The solar floor of this system was commissioned in 2012 by our local partners [Indiscernible][1:09:48] and the total cost of the system was near three thousand dollars.

Next slide.

So, the Spice Village Resort is located near the Periyar Tiger Reserve in the Kerala Province of Southern India. As you can see in the picture, it's located in a very remote area, though it's not that easy to access and to take components to this particular area.

Next one. So, what was the main motivation for the project? Before the solar system worked and so, the Spice Village operated in diesel generator for more than eight hours a day, seven days a week, to cover the power needs of the resort. Because of fuel, transportation, and maintenance, you can imagine what a huge bargain. So, the company decided to invest in a solar PV system that would allow them to take advantage of governmental incentive while at the same time making the resort more attractive for eco-friendly tours.

Next one. To ensure that the project was cost-effective, the original load was reduced from seven hundred kilowatts per hour to two hundred kilowatts per hour, incandescent lamps were replaced like LED lighting. Unnecessary items were removed from the room and the use of some appliance at night has to let be limited. Next. The micro-grid system is so -- as you can see in the image, it consists of sixty-five kilowatts p battery-based PV system. On the left hand of the screen, you can see the photo with solar panel, the building, the battery, and there are their chargers. It was not easy for the solar to find a space without shaping the entire village that's surrounding by trees. For this reason, the six hundred fifty solar panels were installed on top of the basketball court. We can see another image in the next slide too of the solar panel.

Okay, next slide.

So the topic of this Webinar is energy storage. Now we will focus on the battery bank. So for the five villages, we used a battery bank of seventy-two portables and one thousand three hundred sixty one Amp-H Trojan Industrial Line Batteries arranged at a forty eight-volt bank. The Trojan Industrial Line was selected for this project in part due to a seventeen-year service line.

If we go to the next slide, I will expand on some of the important factors to select the battery and why a high-quality long-lasting battery was selected. So among the many factors to consider when selecting a battery

for a micro-grid application are the types of the battery, the cycle life, and the service life. For a micro-grid application, you need a battery that is able to conduct large daily load-wide cycles on a regular basis. A battery with high capacity needs to be high quality to ensure a successful operation of a demanding application. As well, the cycle life of the battery is important so that the batteries don't have to be replaced in a short period of time. In this case, Trojan Industrial Line offers two thousand eight hundred cycles at fifty percent depth of discharge, which allows to offer a very low cost for cycle. Finally, the service life is of to determine the expected life of the battery. The IEC 61427 standard is a common way to determine the expected battery life in a PV application. This is the standard set recommended by the industry, so you should always try to get this information from the battery manufacturer.

Next slide.

I will now go in detail in this slide. I just want to show you how the different battery technologies are classified by cycle life. The Industrial Line, being the red line on top in the graph and all of the other curves that are below our AGM line or our premium line or signature line. So, you will figure out that our presenter before was talking about number of cycles and the depth of discharge.

Next one. Again, the IEC 61427 standard as mentioned before is a standard for battery using solar photovoltaic energy system. If you want to learn more about this standard, I highly recommend watching our recent webinar about the importance of the cycle of batteries there.

Next slide.

So from the site, if you would like to register for upcoming Webinars or past Webinars to visit, you can go to trojanbatteryre.com and there in the Resources tab, you will find all the webinars, How to Size Battery Banks for Off-Grid Applications, Maintaining Deep-Cycle Batteries in the Field, and Importance of Deep-Cycle Battery Test Data. The upcoming ones are talking about our Trojan's Premium line.

Next slide. Thank you.

So we already talked about the cycle life of the battery, the service life size, but there's another configuration when selecting a battery to define if it is more suitable to use a flooded or a maintenance-free battery. So in general terms, if maintenance is an issue, then maintenance-free battery will be the best choice, but if line maintenance is acceptable, a flooded battery has several advantages. One, lower cost per cycle. Two, a flooded battery is easier to recharge when discharged deeply. Three, a flooded battery can be overcharged to do an equalization. Four, a flooded battery performs better at higher temperatures than a VRLA battery.

Next slide.

Okay, so to avoid oversizing the PV system in this hybrid system, biodiesel gen set would be used in the Monsoon season when the irradiation is low. If it is necessary, the diesel generator can run during the morning or the evening to cover the load and charge the batteries.

Next. So coming now to the end of the presentation, I want to share some information about the economics of the project. So the projected helped to achieve savings of forty five thousand dollars in the first year alone. Assuming twenty-five years life span, the project total savings are estimated in one million seven hundred and ninety thousand dollars. The economics of the project shows the excellent opportunity that provides solar to replace diesel gen sets or micro-grids in commercial applications.

Here in the last slide, you can see in more details of the economic and financial variables considering the project. I will not go in detail about this, you can revise the presentation and ask me if you have more questions by email.

So thank you so much for your attention and I will hand it back to Sean.

Sean Esterly — Yes. Thank you to all the panelists for their outstanding presentations today. We do have some time left for the questions from the audience, which we do have quite a few that came in. Again, you ask questions through the question pane on the right. If we run out of time today, any remaining questions will be emailed to the panelists so that they an answer them. So I'll begin and try to get through as many as we can.

We had a couple of people ask questions about battery cost today. So what is the cost per kilowatt-hour for batteries if you could just go over that in general and then a followup for that, are costs coming down or should we find alternatives in order to make systems affordable for low-income systems? Because we have a few panelists on today, whoever wants to jump in to answer the questions, feel free. So again, kilowatt-hour cost of batteries and are those costs coming down?

Xavier Vallvé — I can start to provide part of the answer. The cost per kilowatt-hour is not easy to calculate because often when you make the investment, you have a certain uncertainly of what is going to be the throughput of energy through the battery especially in rural electrification because you have also a certain uncertainly on the load profile. So typically, in a household that has what we call Category A load profile which means a household that only has a load that is based on illumination at night, on those applications, typically, you will have almost eighty percent of the energy going through the battery. So there would be batteries that cycle a lot. The more the battery is cycled, the more you use its capacity. So in a certain way, you could say that the cost per kilowatt-hour of energy going through the battery is lower. If you have an electrification that has what we call

Category B load profile, then maybe part of the load is consumed at the same time that energy is being generated from renewable energy, so typically, you would have maybe fifty to sixty percent of the load going through the battery. So with this, I'm going through simulation. You can try to estimate what is typically the cost per kilowatt-hour of energy that has gone through the battery if you want to calculate a lifecycle cost. Depending on the technology, this could go between ten eurocents to fifty eurocents depending on the size. Now, this would be a typical life cycle cost analysis. The other way of looking at it is investment cost. The cost per kilowatt-hour of capacity of the battery, but again, here, you could look at the lead-acid technology that maybe Romina can after correct me, but that it could be in the order of a hundred to three hundred euro per kilowatt-hour depending on the type of lead-acid technology. Then, you can have other technologies which are four or five times more expensive regarding the investment, but that they have higher cycling capacity. So there you'd have a lifecycle cost which is competitive if you really use this high cycling capacity. This is the order of management. Now are cost going down? Well, we have seen dramatic cost reductions say on some of the renewal energy generating technologies like could be PV. This maybe has created the opinion that all the renewable or off-grid electrification technologies are coming down. In the case of batteries, some technologies the costs are coming down a little, but bit the reference technology which is lead-acid, the costs are not coming on, but much in fact they are subject to the fluctuation of the cost of lead in the market, but what is happening is that there are better and better quality batteries that for the same cost will provide you much higher cycling capacity. So that's where you gain the advantage. Maybe I would ask Romina to complement on this as a battery manufacturer. Thank you.

Romina Arcamone Yes. Thank you, Xavier. Your answer was really complete. I just wanted to add to that something that I mentioned very quickly in my presentation. So, it's hard to compare the cost per kilowatt-hour of battery. The way that I will look at this is from the cycle life perspective. So, when you know the cost of your battery, then you can also know how many cycles your battery will have and you can see that it [Indiscernible][ 1:25:59] battery that it will last six months, not many, many cycles. Because it would be much higher than using industrial batteries that will last two thousand eight hundred cycles. So, I think that we should also -- when people ask me questions in general, like they say, "We are interested to know how much the battery will last and eventually, like the long-term scope of the battery for the project." They should look also at the cycle life of the battery.

Sean Esterly Very good. We'll move on to the next question. So could you just talk a little bit about the steps that are usually required to begin an energy storage project? This question comes from someone working in Pakistan and they're looking to start a project at the institutional or commercial level. Can you just talk a little bit on how they might begin that process?

Xavier Vallvé Is this a question addressed to me? Well I can try to provide my answer and somebody can complement it.

Sean Esterly Yeah. That would be fine. It was just addressed to all the panelists.

Xavier Vallvé Okay, first thing, I would say quickly to establish the horizon of the project so if you're looking at a long-term solution, meaning that for example you are in rural electrification and you don't expect the grid to be there for a long time or you are looking at a long-term solution typically ten years say or even at fifteen, that's the first step. Of course, you could be looking also at relatively shorter-term solution because maybe you are with a bad-quality grid or you expect that the needs will disappear in five years. So once you have established the timeframe, this already gives you the option when you have to calculate over the cycle life of the battery, like Romina said, if you are aiming at getting as much cycle as possible or you have a finite horizon. The next thing is to come up with your capacity. Typically, this is what we call autonomy. So you have your typical reference load which is the load that you want to be storing in the battery, the demand, and you want to establish if you are looking at a short-term autonomy, typically a few hours, or a long-term autonomy, typically from three to six days. That gives you an order of magnitude of what is called the practical capacity of storage that you need. Then, this you have to increment because different batteries and technologies allow you what is called the depth of discharge which is different. Some batteries will allow you to be completely discharged, some will allow you to be discharged I'll just say eighty percent or fifty percent. So, if the battery that you're looking at is only going to be discharged fifty percent, your rated capacity is going to be double than the practical capacity that you need as an example. So, this, you choose the battery size approximately. You compare prices for different technologies or models and then you do a check of the cycles. So you calculate how many cycles are that battery going to do in a typical discharge and recharge cycle over say, for example, one year, and that will allow you to see how long is going to be life of the battery in cycles. Then you compare this to what is called the shelf or the service life of the battery because batteries in some technologies, even if you just keep them in floating, they will also end up eventually failing because of chemical reactions and you try to match that both our similar. That is when you are going to get the best value for your investment, but this is very general. There are textbooks just dedicated to sizing batteries. So I'm just giving you a quick insight of the methodology.

Richenda Van Leeuwen If I can just add to that, if the question is a broader question and is also looking at the broader design at the system, then I would definitely encourage the questioner to look if they haven't already been utilizing it at the home energy software for modeling, system sizing, it also incorporates various types of battery storage and they can find more information about the simulations that HOMER can help with modelling for the incorporation of the whole system at homerenergy.com.

Romina Arcamone Yeah. I would just add that thinking that you should consider when designing a system. Some of them, as mentioned by Xavier, like the load, you need to look at that then how your loads will grow in the future, these all features, then the autonomy that you want for the battery. There would be days that you will not have the sun. The temperature is also very, very important and a lot of people don't consider that when sizing the battery bank. Then, the voltage of the battery bank and later with the size of the [Indiscernible][ 1:32:39]. Then you have to go to the implementation site of the project and see where the system will be installed. So if you have enough space, take in consideration if you want to do maintenance or not and then decide which battery you want to use.

Sean Esterly Alright, thank you. We do have quite a few more questions, but unfortunately we are out of time. What we usually do in this scenario is I will email out the questions to all the panelists and allow them to respond accordingly. There are a few that are directed at specific presentations, so I will sort those out for you. Again, I just want to thank everyone for their time and their presentations today.

Just quickly, we would like to ask the attendees to take a quick survey. This just provides feedback on how the Webinar went and gives us the information to improve in the future. So the first question for this survey, the Webinar content provided me with useful information and insight.

Sean Esterly The second question, the Webinar's presenters were effective.

Sean Esterly The last question. Overall, the Webinar met my expectations.

Sean Esterly Alright. Thank you for answering the survey. Again, I will be emailing out the questions to all the panelists so that they can get back to you on those.

On behalf of the Clean Energy Solutions Center, I would like to extend a hearty thank you to our expert panelists, Richenda, Xavier, Thomas, Jose and Romina, and to our attendees for participating in today's webinar.

I invite our attendees to check the Solutions Center website over the next few weeks if you'd like to view the slides and listen to a recording of today's presentation as well as any previously held Webinars. Additionally, you will find information on upcoming Webinars and other training events.

We also invite you to inform your colleagues and those in your networks about Solutions Center resources and services including the no-cost policy support.

Please have a great rest of your day and we hope to see you again in future Clean Energy Solutions Center events. This concludes our webinar.