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# A Review of the Africa Solar Market

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Webinar Panelists

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| **Manfred Hafner** | Enerdata |
| **Fabrice Poulin** | Infinergia Consulting |

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**Eric Lockhart** — Hello, everyone. I'm Eric Lockhart, with the National Renewable Energy Laboratory, and welcome to today's webinar, which is hosted by the Clean Energy Solutions Center, in partnership with Enerdata and Infinergia. Today's webinar is focused on the solar market in Africa. Before we begin, I'll quickly go over some of the webinar features. For audio, you have two options. You may either listen through your computer or over your telephone. If you choose to listen through your computer, please select the mic and speakers option in the audio pane. Doing so will eliminate the possibility of feedback and echo. If you choose to dial in by phone, please select the telephone option, and a box on the right side will display the telephone number and audio PIN you should use to dial in. If anyone is having technical difficulties with the webinar, you may contact the GoToWebinar help desk at (888) 259-3826 for assistance.

If you'd like to ask a question, we ask that you use the questions pane, where you may type in your question. If you're having difficulty viewing the materials through the webinar portal, you'll find PDF copies of the presentations at cleanenergysolutions.org/training. And you may follow along as our speakers present. Also, the audio recording and presentations will be posted to the Solutions Center training page within a few days of the broadcast, and be added to the Solutions Center YouTube channel, where you will find other informative webinars, as well as video interviews with thought leaders on clean energy policy topics.

Finally, one important note of mention before we begin our presentations is that the Clean Energy Solutions Center does not endorse or recommend specific products or services. Information provided in this webinar is features in the Solutions Center's resource library as one of many best practices

resources reviewed and selected by technical experts. Today's webinar agenda is centered around the presentations from our guest panelists—Manfred Hafner and Fabrice Poulin—who have joined to discuss the solar market in Africa, both at the grid scale and off-grid applications. Before we jump into the presentations, I'll provide a quick overview of the Clean Energy Solutions Center. Then, following the panelist presentations, we'll have a Q&A session where the panelists will address questions submitted by the audience through the question pane.

At the end of the webinar, you will be automatically prompted to fill out a brief survey as well, so thank you in advance for taking a moment to respond. So the Solutions Center was launched in 2011, under the Clean Energy Ministerial. The Clean Energy Ministerial is a high-level global forum to promote policies and programs that advance clean energy technology, share lessons learned and best practices, and encourage the transition to a global clean energy economy. 24 countries and the European Commission are members, covering 90 per cent of clean energy investment, and 75 per cent of global greenhouse gas emissions. The Solutions Center is one of the nine initiatives of the Clean Energy Ministerial. Other CEM initiatives include ISGAN, 21CPP, and Global LEAP. All the initiatives work towards three overarching goals—to improve energy efficiency worldwide, enhance clean energy supply, and expand clean energy access.

This webinar is provided by the Clean Energy Solutions Center, which focuses on helping government policymakers design and adopt policies and programs that support the deployment of clean energy technologies. This is accomplished through support in crafting and implementing policies relating to energy access, no cost expert policy assistance, and peer to peer learning and training tools, such as this webinar. Clean Energy Solutions Center is cosponsored by the governments of Australia, Sweden, and the United States, with in-kind support from the government of Mexico. The Solutions Center has five primary goals. It serves as a clearing house 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. The Solutions Center also fosters dialogue on emerging policy issues and innovation around the globe. And, lastly, the Solutions Center serves as a primary resource for project financing options, and information to expand markets for clean energy. This finance technical assistance service of the Solutions Center was announced last year at COP21.

Our primary audience is made up of energy policymakers and analysts from governments and technical organizations of all countries, but we also strive to engage with the private sector, NGOs, and civil society. 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 above, and include research organizations like IRENA and the IEA. Programs like SE4ALL, and regionally focused entities such as the ECOWAS Center for Renewable Energy and Energy Efficiency.

A marquee feature that the Solutions Center provides is the no-cost expert policy assistance, known as Ask an Expert. The Ask an Expert service matches policymakers with one of the more than 50 global experts selected as authoritative leaders on specific clean energy finance and policy topics. For example, in the area of energy access, we're pleased to have Catherine Deembala from Accessible Energy serving as one of our experts. If you have a need for policy assistance in energy access, or any other clean energy sector, we encourage you to use this valuable service. Again, the assistance is provided free of charge. If you have a question for our experts, please submit it through our simple online form at cleanenergysolutions.org/expert. We also invite you to spread the word about the service to those in your networks and organizations.

Now I'd like to provide a brief introduction for today's panelists. First up today is Manfred Hafner, who brings almost 30 years of experience in the field of energy to his work at Enerdata, where he's a partner and vice president. Following Manfred, we'll hear from Fabrice Poulin, who is an expert in market research on technology, and renewable energy markets, and serves as a managing director at Infinergia. And with those brief introductions, I'd like to welcome Manfred to the webinar.

**Manfred Hafner**

Thank you very much, Eric. So I'm going to start with an overview of on the outlook of the African energy and solar market, and in particular assessing a universal access to energy to the African continent. First of all, a word on Enerdata. Enerdata is an independent energy research and consulting company. It provides analysis and forecasts of global energy and climate issues. It has globally recognized databases and forecasting models. It operates globally. And our client bases are in Europe and Asia and the Americas and Africa and so on. Our main field of expertise is energy efficiency and demand. Different types of market studies. And the global energy forecasting.

Today I'm going to speak about Africa. African energy and outlook in the solar market. And I divide the African continent into three parts. North Africa, which is constituted by the five North African countries—Morocco, Algeria, Tunisia, Libya, and Egypt—the north. And then the Republic of South Africa on the south. And then everything which is in between is what we call the rest of Sub-Saharan Africa. So Sub-Saharan Africa excluding the Republic of South Africa, which is what I will put some emphasis on.

Let me start giving a little overview on population and GDP levels of these three broad subcontinents. The Sub-Saharan Africa represents about one billion people out of 1.2 billion people of the total continent. So it's about 80 per cent of the continent. The total population in Africa is 1.2 billion. This is comparable to India. And the GDP of all of Africa is comparable to the combined GDP of Germany and France. So I already say that 80 per cent of the population is located in Sub-Saharan Africa, excluding Republic of South Africa. The GDP per capita of this part is about $4,400.00 per our purchasing parity per capita, if we were to use market conversion rates, it would be one

third of this figure, about $1,600.00. This compares to a European GDP per capita of the order of $22,000.00 per person.

Now these overall figures—by the way it is quite interesting to see that *[inaudible]* over decades Sub-Saharan Africa has lagged behind in its economic development. Over the last 10 to 15 years, there has been a very strong growth in Sub-Saharan Africa on the order of five to six per cent a year, on average. And it is expected Sub-Saharan Africa is expected to be the continent of the present century. The problem is that these figures, which I just showed, which you can see here, they hide the fact that in Sub-Saharan Africa about half the population live with less than $1.50 per person, per day.

Now, on this graph, we just show the level of energy consumption per capita. We can see it's an average about one ton per person in North Africa, 0.5 ton per person in Sub-Saharan Africa, excluding South Africa, and 2.5 for the Republic of South Africa. To get the comparison, in Europe this figure would be about 3 tons per capita, and in the US it would be about 7 tons per capita. Now on the right hand side of this graph, you can see the very different energy mix in these three areas. The three sub-regions. If you start with North Africa, we can see that a very important part of the energy demand, primary energy demand, is based on the gas and oil. As a matter of fact, the North African countries do have a lot of oil and gas resources. If you go to South Africa, we can see that two thirds of all the primary energy consumed is based on coal. Indeed, South Africa is one of the major exporters of coal, and they do produce a lot, and they do use a lot domestically for themselves. And then when we look at this Sub-Saharan Africa region in the middle, we realize that not only do they consume very little energy per capita, but most of the energy they use is traditional biomass. It's mainly food root, fuel root, and charcoal, for cooking.

The problem with this is that it generates a major health effect due to indoor smoke, mainly. And this is mainly also an issue, a gender issue. In other words, we have about 15 per cent of the world population who live in Africa, and they consume about three per cent of primary energy of the world. Sub-Saharan Africa represents about 80 per cent of the African population, and they consume about half of the energy consumed in Africa, if we include the traditional biomass. But they would represent about 25 per cent of the commercial energy in Africa, since all this green part which we see her is non-commercial biomass.

Now as far as the power mix of the electricity consumption is concerned, there is a very strong particularity, which is the electrification rate. The electrification rate Sub-Saharan Africa, excluding South Africa, is extremely low, only about one quarter of the population has access to electricity. In North Africa, this rate is now already 99 per cent. Half a century ago, in Morocco, it was very low as well, but now all of North Africa has caught up tremendously, and in South Africa, the Republic of South Africa, a very high electrification rate is available as well. So not only is the electrification rate very low in Sub-Saharan Africa, excluding South Africa, but obviously and as a consequence, power consumption per capita, the average power

consumption per capita is very low indeed as well. You can see the power consumption per capital of the three regions here, just to get a feeling of what it means. For instance, in Europe, this figure today would be about 6,300 kilowatt hours per capita.

Now on the right hand side we can see how this electricity is being produced, and has been produced up to now. You can see that in North Africa, power generation is mainly based on natural gas. In South Africa, it is mainly based on coal. And in Sub-Saharan Africa, even though it makes very little production and consumption of electricity, but the part which is produced is mainly based on hydro and indeed there is huge hydro potential in Sub-Saharan Africa.

Now what are the issues? Let me briefly give you some issues related to the energy access in Sub-Saharan Africa. As I say, only about one quarter of the population in Sub-Saharan Africa, excluding South Africa, is presently electrified. This represents—this means about 600 million people do not have access to electricity today, and of the total, about 64 per cent of the urban and peri-urban population is electrified. So most of the urban and per-urban population is electrified, while only 14 per cent of the rural population is electrified. Now, what we call urban and peri-urban population—urban is cities, and peri-urban is what is around the cities, very often it is constituted by slums, which are indeed not electrified. There is a severe shortage of essential electricity infrastructure, is obviously undermining efforts to achieve a more rapid economic development.

Now this minority of people, there is one quarter of the population, these 600 million people located in Sub-Saharan Africa—no, 300 million people who are located in Sub-Saharan Africa who have access to electricity, who mainly live in cities, and they do have access to electricity, but the supply is often unreliable. It necessitates widespread and costly private use of backup generators running most of the time on diesel and gasoline. Moreover, there is a very important amount of electricity losses due to the poorly maintained transmission and distribution networks, and these are about two times as high as the world average. Now, in the urban areas, we can experience today a quite strong improvement on the coverage and reliability of the centralized electricity supply. On the other side, in the rural areas, there are about 70 per cent of those gaining access to electricity today. They do so thanks to mini-grid and off-grid systems, and Fabrice will talk to you about this in a short while.

Africa also has one of the—a very, very high solar irradiation. This is in particular true for the deserted areas. A little bit less true for the equatorial areas, due to the high humidity in the air. We also have, as you know, we have had, over the last few years, a tremendous decline in the cost of PV cells, PV modules. They have declined over the last five to six years by more than 80 per cent. And this also holds true for Africa, which you can see here on the right hand side, on the left bar of the right hand side of the graph, we can see that the PV technology in Africa, PV installations in Africa, they're slightly more expensive than in other regions, with exception of the Middle

East, because very often installations in Africa are more expensive than other regions, because it's more complicated to bring the installation infrastructure to the place, and because there is less competition in Africa. But the difference is not tremendous. And it has come down there as well very strongly.

Over the last few years in Africa, we can—we have experienced a tremendous increase in photovoltaic electricity generating capacity, especially over the last few years. With over the last 15 years, an increase on average of about 70 per cent per year, mainly due to South Africa, the Republic of South Africa, also due to North Africa in particular Algeria and Morocco, but also Egypt, and Sub-Saharan Africa. The same can be said for concentrated solar panel power. The install capacity has increased tremendously over the last six years, about 75 per cent per year as well. And here, the development has been mainly driven by South Africa, followed by North Africa, and by North Africa it was in particular Morocco, followed by Algeria and Egypt.

And the projects are expected to continue. We have, at Enerdata, we have a very developed power plant tracker, which tracks all power plants in the world. And here we can see for the next few years, up to 2020, that in Africa, there are plans to add about 6,500 megawatts of additional capacity to the ones which are already in place—both PV and CSP, mainly PV, but also CSP, as you can see on this graph.

Now let's look into the future, and let's look at the baseline scenario into the future. So again, we have our three regions in Africa. I would like to concentrate on Sub-Saharan Africa. In Sub-Saharan Africa, which today has almost one billion people, will, in 15 years' time, add 40 per cent of additional people, which means 400 additional—400 million additional people. There's a strong population growth. There's a strong GDP growth rate. So GDP will almost double. And GDP per capita will increase as well. But still be at a very low level. Energy demand per capita is even expected to very, very slightly decrease.

Here we can see the evolution, expected evolution, this baseline scenario, on energy in Africa, North Africa, Sub-Saharan Africa, and South Africa. We can see that these trends which we have seen in the past will more or less continue, are expected to continue with a more diversified energy mix. More renewables, which are entering the energy mix, as we progress in time. But fundamentally, in Sub-Saharan Africa, we will still be 60 per cent of energy demand will be based on traditional biomass, and this as we will see is not so good as I have explained earlier on. There are huge health issues related to particularly ladies when they cook in their houses, and they have to breathe the pollution of the cooking stoves, which has been shown is a bigger issue than malaria or AIDS in these countries.

The power mix issue—electricity mix into the future. Again, the baseline scenario. Now, here, as well, we can see our diversification of the electricity mix, in this baseline scenario. But at the end of the day, when we look at the Sub-Saharan Africa, we will increase the electrification rate in 2015 of 27 per cent, by 2030 to some 45 per cent. Which is better than it is today. In

particular taking into consideration this is a huge effort, because we will have a 400 million additional people, and the electrification rate is almost doubling. Having said that, this does not conform with the sustainable development goals set up for 2030 by the United Nations. We all know these 17 sustainable development goals, all of which apply and are very important for Africa, and for Sub-Saharan Africa in particular, in particular number one, alleviation of poverty, alleviation of hunger, health issues, education, gender equality, clean water—but I would like to stress the SDG, sustainable development goal number seven, which is related to affordable and clean energy, and the idea here for Sub-Saharan Africa to have a universal access to electricity and to energy for everybody. And so by 2030.

So in this scenario which I just showed, which is very ambitious, which is a baseline scenario, where we make efforts to electrify, arriving at the 45 per cent electrification rate by 2030, is *[inaudible]* in line with the sustainable development goals set out in the agenda for 2030.

Now what we have done is to see what would need to be done in order to get to a universal electrification of—and access to electricity by everybody in Sub-Saharan Africa as well. So if you—if we look at this table on the bottom, we can see the present situation in 2015, presently we have 64 per cent of the population in the urban population which is electrified, only 14 per cent of the rural population which is electrified. And this gives a total of about one quarter of the population of Sub-Saharan Africa which is electrified. Now the baseline scenario for 2030 is shown here. The 45 per cent which I just mentioned before. And of which 73 per cent would be electrified in urban environments, and only 20 per cent in the rural environments. Now, the International Energy Agency in its report of 2014 on Africa, they have written a very interesting book on Africa *[inaudible]* Africa, they have developed this African Century Case. Which is a very strong development for Africa. And the scenario implies that by 2040, Sub-Saharan Africa would have an electrification rate of 83 per cent, which also is not in line with the SDGs, with the sustainable development goals. So what we have tried to develop here is what we call the SDG scenario, sustainable development goal scenario, which is 100 per cent electrification, both urban and rural, by 2030.

And you can see here on the graph, on the top, what this would mean. It would mean a very strong increase in power generation, power demand, and therefore generation, and it would also mean a very much higher demand level per capita, because obviously many, many more people will consume electricity. So it will almost be multiplied by four, from 300 to almost 1,200 kilowatt hours per capita.

Now, what does this mean? If we look at the left hand side of this graph, we have divided in red the urban population, and then blue, the rural population. Now the urban population represents about 350 million people today, 38 per cent of the total, and of these, as we said before, 53 per cent are electrified, 222 million people, and 37 per cent are not electrified. So the challenge here is to electrify this part, let me see if I can show you, this part here, which is presently not yet electrified. So by 2030, to electrify it, and this will be

electrified with on-grid systems, obviously. Now, when we look on the other side, on the rural population, where only a tiny little part, only a small part, about 18 per cent, 19 per cent are electrified, so far, and 81 per cent are not electrified, here the challenge is to electrify these 480 million people today which over the next 15 years will become much more people, because the population is growing very fast. But the idea is that by 2030 everybody will be electrified.

How will this be done? Let's look at the right hand side of the graph. Most of this electrification is going to happen with on-grid systems that we can see here, the lower part, in pink, which is the urban population which will get access with on-grid system. And most of the rural population will get access with on-grid system as well. But there is about 21-22 per cent of this part which will rely on off-grid systems, which are much more cost effective for them than to bring in grids.

So here we can see what this means. The three scenarios, baseline scenario. The IEA-ACC scenario, and the SDG scenario, and here we can see that this would mean, as far as the SDG scenario, would mean as far as photovoltaics, as far as solar is concerned, would mean a very strong increase in about 80 gigawatts of solar power by 2030, by the time span of 15 years. So it's a much, much higher level than the baseline or IEA-ACC scenario. We can see here again these are the cost—what would this scenario cost? While the total cost of power generation development for the 15 years to come in the baseline is about $9 billion per year, on average—the sustainable development goals scenario, which means electrification for everybody by 2030, would imply a cost—an average yearly cost of about $33 billion. In addition to that, if you want to also reduce and to bring to zero, or to reduce very strongly the traditional biomass for cooking, and to convert it into clean cooking facilities through biogas systems to advance biomass cook stoves and LPG stoves, this would add another $4 billion per year of additional investments.

Now this would make a total investment need on average of something below $40 billion per year. But you may say this is a lot, this is a huge amount. Yes, it is. But if you compare it with the total investment cost for the energy sector worldwide, which is about $1 trillion, one thousand billion, per year, it's a tiny little amount. It's less than four per cent compared to the overall investments to the energy sector. Now, obviously there's a big problem. The one threat *[inaudible]* easy to find the money for the $1 trillion per year, because this is to satisfy solvable demand, while here we are in front of people who are not solvable, and which have a problem of bankability. Which brings me to my conclusion. The role of development banks and agencies, which is tremendously important.

First of all, let's remind—energy access is a precondition to socioeconomic development. Energy access will increase standards of living and create a condition for markets. This means it will create the conditions for consumption, but also for local production in addition to imports. The role of development banks and development agencies, and therefore public private partnerships, is of utmost importance. Because we need here the private

sector alone cannot deliver. So the G20, the German President of the G20, has launched the idea of a Marshall Fund for Africa. The benefits, we think, should be huge. Both for the African continent, and for the world as a whole. Let's just remember, when the US launched, after the Second World War, the Marshall Fund for Europe. This could be—could have been considered as costly but at the end of the day it allowed to reconstruct and develop very strongly Europe, but also the US, since at the end of the day, it created also demand for American products.

So this is my last slide. The conclusion is there is a moral need to electrify and to bring access to the people in Sub-Saharan Africa. It is costly, but it can be done. It's—and with this, I give the presentation, I give the floor to my colleague, Fabrice, from Infinergia, who will speak on—will speak about off-grid systems, which is a very important issue, because it is to electrify the rural populations.

Fabrice Poulin: Thank you, Manfred. So hello everybody. I'm Fabrice Poulin. I'm from Infinergia. I'm the managing director of the company. And here I would like to extend the presentation of Manfred from Enerdata to discuss about the off-grid solar market in particular. So first to introduce this work, this work and the data that we present here is based on the report that we published by the end of 2014 that was a full analysis on Africa off-grid photovoltaic market. Let me describe basically the main steps of the presentation I will make today. So first I will give some few introductions about off-grid electrification issue. Second, I will look into the PV installations and giving you numbers about the installed capacity in particular. Third, I will describe for you how we came to build a model for the assessing the development of the off-grid market in particular. And ranking the specific countries. I will give you the top five of those countries. And as the fourth and last part of my presentation, I will give you this description of how we see the market evolving until 2020 in terms of volume, and install capacity, in megawatts. And of course the challenge and opportunities that remain for this particular market.

First, definitions. What we mean by off-grid is basically a system that is not connected to the main or national grid. So it can be a system, as such, for example, a telecom tower, a pumping station, or whatever autonomous system we call standalone system. Or it could be also a site. So that means it could be a village. It could be a single house. Or it could be a larger community supplied by a mini-grid. And just to introduce mini-grid and making a small side comment on mini-grid, we did most of our study on off-grid, and excluding mini-grid, which is a topic as such, and it's a separate topic. But typically a mini-grid is connecting several houses, and several villages or communities into—and supplying them with a centralized system which is not connected to the rest of the country system. So it's basically a grid that is not connected to the grid, and it's limited in terms of regional spread. Usually it's on a smaller—let's say geographic like few towns, or small region.

So that's why I wanted to put aside this mini-grid aspect, and let me give you some context on why we did this study on off-grid photovoltaic in particular. So first as was presented by Manfred, we have a huge problem in terms of access to electricity. So I will come back to that. But we are basically 600 million, 590 million people living off the grid today. And they are using different type of solution to let's say comply with this problem of finding a solution to this problem, and most of them are based still on fossil energy. So we will look into off-grid and photovoltaic, or PV, as a source for electricity for this off-grid population. Certain aspect that we found and that led us to make such a report is that we have noticed that there was a lack of information on both the market situation, volumes, and description by country, but also industry, manufacturers, distributors, integrators, or OEMs, and basically we wanted to clarify that and bring some extra information for people to base their strategy, market strategy, and also development, market development decisions.

So this is how we got to build this report that I will give you some few insights today. It's basically studying three things. We are studying needs—so basically the electricity access issue. We are putting these needs into a macro-economical context, which I will also describe, and we're also putting numbers on it, with installations numbers, current and forecasted installations. And last but not least, the forecast, and the modeling, we will also indicate how—what are the factors that we believe at Infinergia are affecting the development of a market. So they both favor or help the market to develop. Or they slow the market. And I will also describe those factors via our off-grid model.

Moving onto how many countries. So here we have another description of the African market from the one that my colleague, Manfred, presented. We basically have split Africa on five different sub-regions. Basically, Northern Africa, Western Africa, Central, Eastern, and Southern Africa. So it's another let's say analysis. We've basically—those five regions. I will describe on why we did that, and also why we selected only 33 countries for this. Basically, it's countries that have an interesting number in terms of population, and, as such, have leverage, so off-grid solutions can have a leverage on the population. And also electricity access issue, of course. So our work has been done on 33 countries, and I will describe why those 33 countries are basically representative of Africa.

As mentioned, we found out that there is 590 million people off the grid as of 2012. And these numbers are from the IEA. And out of these 590, we have 535 million that are basically locating in only 33 countries out of the 54 countries that Africa is counting. So basically this is one of the first reasons why we focused on those 33 countries. And also an important aspect that was also exposed by Manfred before is the rural population. And on these 33 countries, we have 439 million people that are basically the rural population, and that is off the grid. So 82 per cent of this number is basically rural population. So here we basically have an important amount of people off the grid and living away from urban centers.

Moving on to electrification issue. So as I mentioned before, there is both an aspect of population, but also access to electricity. So taking those 33 countries that we described before, over those five regions, we basically have 17 out of 33, so that's about half of them have an electrification for rural geographies below 10 per cent. So this is the first huge impact that we have on many countries. Rural communities are basically mostly off the grid, so they don't have access to electricity. And so we have of course a variety of countries, but this is the first point to highlight. So then comes the question—how can we solve that?

And this is where the numbers come into the picture, and where we present the install capacity over those regions, so those five regions, basically let's put the numbers into perspective. We have in 2012 totally 168 megawatts cumulative installation of PV system off the grid. And let's put this in perspective. Those 168 megawatts can be compared in terms of for Africa we can compare those to grid connected. So we know that in grid connected in Africa we had 0.6 gigawatts out of 102 gigawatts in the world. So 0.6 gigawatts only for Africa. That's one per cent—below one per cent of the total capacity install in the world. If we talk for off-grid, we've got these 168 megawatts, but are basically below 10 per cent of the total off-grid market worldwide that we estimate around 2 gigawatts, which is still a very small percentage, two per cent, of the grid, let's say, photovoltaic market. So we put here in perspective both Africa versus the world, and off-grid versus grid. Out of this, we see that we describe here five regions, but we have also six countries that amount to more than 50 per cent of the total install capacity, and this is where we're doing install based where is off-grid today in Africa? Or, as of 2012. It's mainly in Africa. South Africa, sorry. It's then in Kenya, Morocco, Egypt, Uganda, and Nigeria. This was the situation as of 2012 for off-grid, okay? So those six countries were representing 52 per cent of 168 megawatts.

So now that we have assessed the situation now five years ago, the question we can ask is, where do we go from this 2012 to 2017 and to the future, 2020? This is how we basically imagine a model, and that we have let's say tried and let's say improved, also. So we tried to find basically what defines the off-grid market. Basically, it's rather simple for the basic of our model. We took three parameters, three main parameters. The first one is electrical issue, access to electricity. The second one is based on population and the population needs. So we have people connected to the grid, typically, if we combine those two parameters. And of course the solar potential, which means the performance of off-grid PV systems. But this is not enough. We have moderating parameters that are typically influencing that. So let me go into further detail.

So the first one of those three parameters is how we define the number. For example, a country that had more than 50 million people off the grid, were ranked as ten, with a note as ten. And the basically the population was the same where we combined population density, the country area, etcetera, and the solar potential is also of course according to the solar irradiation map that

was shown by my colleague, Manfred. So this is the main structuring parameter. Three parameters that make a note out of 30.

Second is the moderating parameter. So here we take into account GDP, and GDP growth in particular. So the higher the GDP, and the higher the growth, the better. So we get an increasing note, thanks to this parameter. Then we have, to the contrary, a parameter that is a lowering the note, is the corruption index. So we've got lots of different rankings, let's say. One of them is very well known is Transparency International Index. And this, the higher the corruption, the lower the mark, basically. Third is competition. Competition to photovoltaic energy is mainly fossil energy. So a low cost of diesel is basically preventing higher adoption of PV systems, because they are making such systems less competitive. So the countries that are bringing basically some advantage of fossil or energy or for fuel that are basically inciting customers to use diesel, by being let's say abnormally low. Those countries are being moderating negatively. And to the contrary, the countries that are putting tax on diesel in particular are being moderating positively.

Fourth parameter, industrial ecosystem. It's basically based on local industry. We have some companies that have started local *[inaudible]* manufacturing, solar panel manufacturing companies into particular countries, and also, and most importantly, the distributor and installation or engineering network. So the more this downstream part of the industry is structured, the more company we have, the more experienced they are, the better for the development of the off-grid market, because off-grid is a specialist market. And the last one is natural aspects, where we can have an influence from the geography of the country as such if we are basically desert or forest or particular difficulty mountains area, which are basically making it more difficult for grid to cross, and which is making of course it more favorable for off-grid. These are the five parameters that we have into our models.

And the winner is, or the winners are basically the countries that we are *[inaudible]* describing. So this is based on the 2014, again, I want to highlight. We had Tanzania, Ethiopia, were the two highest ranking on our model, followed by Kenya. So three countries from Eastern Africa. And we had South Africa that was coming also right behind as number four. And Nigeria as number five. This is where we stand today for these rankings. And these are the five, top five countries out of 33 African countries. What happened since 2014? What I can confirm is that Ethiopia is still a leader in the market. We are seeing a lot of, for example, tenders and announcements of installation for Ethiopia in 2016. And the country was ranking high on PV, off-grid PV installations. And likewise for Kenya, which is also very dynamic into this field, and of course Nigeria is very dynamic. So let's say those countries are standing out in 2016. South Africa has decreased, meanwhile, but we have a lot of parameters that favor South Africa. As I mentioned, some *[inaudible]* industry *[inaudible]* parameters *[inaudible]*, there is a lot of knowledge, basically, out of South Africa. And they also have an electricity issue for the poorest part of the population.

So then we have the installation as defined as of 2012, we have our modeling. So we combined both those cumulative *[inaudible]* plus our model to make a forecast, basically, for the coming years. And this is where we've *[inaudible]* 168 megawatt in 2012, to basically now 335 for 2017, for this year, and that shall reach 478 in 2020. So basically we can see from the time we have finalized the report, since 2014, we have a market that has grown by two, that has doubled in size. And this is also accelerating. We see that off-grid photovoltaic installation are accelerating, and several aspects are confirming this. So I was mentioning Nigeria, Tanzania, Kenya, Ethiopia, which are still important countries in that respect. So this is basically where we're heading. And compared to the data that was provided before by my colleague from Enerdata, Manfred, we can see that there is a trend. Off-grid is going to have its share into this aspect, because we just won't be able to connect everybody in rural areas with the grid. So and we can see that there is a huge growth of the rural population. So those people will need to have access to electricity, so we have economic development, and better situation.

As a conclusion, what I can give in a few slides, is basically that there is important growth. It is supported by many companies for off-grid. We've got over 500 companies in the world that provide off-grid components, or systems. 100 of them are providing systems. Plus, we have also increasing efforts from institutions. So Manfred was mentioning the development banks, and we have World Bank, African Development Bank. We've got also the American initiative, Power Africa, which was investing significant amounts. Plus, we've also private investments. So all of this combined means that we have both the industry and institutional actors tackling this electricity issue problem, and dedicating attention. This domain, Africa, is being strategic for these companies today.

However, the market development as we could see is still unequal. We have some countries that are leading in terms of deployments, but some others that are lagging behind. So it's not because we have the highest or the lowest electrification rate but the country is going to come first. And unfortunately in these developments on Africa, is still country dependent, and is not let's say equal on more countries. So the situation is varying, basically, based on the countries.

And moving onto opportunities, and developments. So four points that are basically interest aspects to highlight. First point, there are new offers on the market. The off-grid market is innovative. We are seeing new types of solar home systems, larger ones. Now it's no more about having a 10 watt solar panel plus one small light. We are talking about 100 watts and several devices, including solar charger, phone charger, TV, and other appliances. We also see—this is for rural electrification—but we also see on the industrial part, diesel power generator that are being hybridized with batteries, which means they can last longer, and use less fuel, which is, to an extent, a lower problem than if they were always running on fuel 100 per cent of the time. And finally, the system that are generally optimized for efficiency, and they are also properly remotely monitored. So we have first technology in terms of offer. Second, we've got new business models, and

new ways to access to finance. We have energy services companies, or ESCOs, that are dedicating to off-grid or micro-grid. And we also have the system that basically is pay per use, which we call pay as you go solar home systems, which are making basically an easiest way to access solar system for people that have low revenues, as was highlighted by my colleague Manfred just before.

So you can get the solar home system without paying the upfront cost right away. You can get it for very low base price. And of course capital is easier now with crowdfunding. Venture capital is having a stronger interest in Africa as well. Cost reduction. I won't describe that further. Manfred already illustrated that very well with the decrease of photovoltaic costs. And this is thanks to grid-connected solar. We have an industry that now is able to provide very low prices, both for the system and in terms of leverage cost of energy, or LCOE. And last point, mini-grids are developing. So this is becoming the second market for after off-grid system. And we have so many projects that are being studied or announced. We have on our site at Infinergia identified 800 mini-grid projects. And that will come online in the coming years. So mini-grid is also a solution, but just an intermediate solution between off-grid and grid.

And my last slide is for the challenges. So this is the opportunities we define, but access to finance remains the problem, and we here agreeing again with another analysis. Access to finance for poor people, but also for startups to develop this off-grid market. Second challenge will be on institutions, and local governments, to have a proper regulation quality will be a very important point. We are seeing so many products that are just not to the level of quality, and has been really a lot of effort on this thing that—on this aspect that has helped. But also it's about duties, and VAT or import duties are important aspects that need to be taken into account for off-grid systems. They of course make a system more difficult to afford. This is something states need to work on, because they will have an economic development related to the off-grid systems. And of course, all the off-grid that needs to be done with a proper planning. So an electrification roadmap, an energy access strategy, rural electrification scheme, reduction of fossil fuel.

Third point, the success and the scale-up of those new business models we've mentioned, ESCO and pay as you go, so far it's going pretty well. We are seeing lots of deployments and success for those initiatives. But there is still some work to be done. And the last one, the industrial challenge, is basically to turn this market into a mainstream market, because it's still today a huge market, but with higher quality products plus a larger offering and the education from the industry, we will have a market that will become mainstream. That's the end of my presentation. So thank you for listening. And we are now open for questions.

**Eric Lockhart** Great. Thank you both very much for those fantastic presentations. As we turn to the Q&A here, I'll just remind the attendees to submit questions in the question pane at any time here. And in the background, we'll leave up several links on the screen for quick reference for more information about Solutions

Center webinars. So we have some great questions coming in from the audience. The first one is for Fabrice. And the attendee is wondering if you could talk about why the latest installation data is from 2012, and if there's anything to consider in making current decisions with data from that time.

**Fabrice Poulin** Okay, so, yes, the data we mentioned is from 2012 indeed, and because this report was done in 2014, and basically takes around two years to compile, and gather the data on all the cumulative installations. So we basically have a two year delay in terms of market data at the time we make the report.

**Eric Lockhart** Great. Thank you. The next question is about Nigeria, and if there's an expectation that Nigeria might take a leadership role in the off-grid space.

**Fabrice Poulin** Okay, so I will take this question also. For Nigeria, it's basically one of the most populated countries in Africa. It has an interesting GDP growth that is mainly related to petro and fossil fuel. But this population is also very rural, and grid is inexistent or not so good in many parts of the country. So we basically have a good equation for the development of off-grid. And further to that, the government of Nigeria has announced and implemented some quite good action to develop the off-grid market. And recent announcements were also going into this way. So definitely Nigeria will be a country to watch in Africa in terms of off-grid market into the coming years, yes.

**Manfred Hafner** Nigeria is also a country which is one of the larger—which has the most ambitious and largest grants for on-grid PV power plants. So Nigeria indeed is a very important country, both as far as population is concerned, and as far as population which is off-grid, so far. But as far—there are very impressive plans for both on and off-grid development in Nigeria.

**Eric Lockhart** Great. Thank you both very much. The next question is about the—a few questions about the model Fabrice that you just talked through. One of them is if you have sort of more detailed underlying data than you're presenting that might be available?

**Fabrice Poulin** Yes. We do have data on what I presented. Basically I just presented highlights. So it's only extracts of the report. But we typically have information by country on each of the 33 countries we described in terms of installation, megawatts, in terms of rural electrification plans, and also in terms of application—if we are talking about solar home system, or more industrial system like telecom, or for example water pumping or community systems. And we also have information on programs. So definitely we have further data into our report.

**Eric Lockhart** Great. Thank you very much. And another question for Fabrice here. So how is the market split between rural electrifications systems or solar home systems and more industrial applications of off-grid?

**Fabrice Poulin** Okay. On this part, we have a very country-dependent situation. It depends a lot on the country. Some countries we will see many industrial application, and we see off-grid being mainly an industrial market. Some other countries,

we will see off-grid as being mainly a rural market. So this is where basically we have the difference, and it's very much country related.

**Eric Lockhart** Perfect. Thank you very much. So this question, the next question, is to both of you, and you both have touched on this a little bit. But the attendee is asking if you could expand on which countries in Sub-Saharan Africa specifically have been active in solar power, both at the grid level and off-grid, why they're seeing success, and which countries are most attractive for solar in the future? Again, those are for both grid and off-grid. Sort of which are the key players, why, and will those be the key players in the future?

**Manfred Hafner** So, related to on-grid power, as I showed during the presentation, the countries which have been the most active—South Africa. And Republic of South Africa. And then in North Africa, Morocco, Algeria—Algeria, which is developing very, very impressive plan, they want to reduce the dependence on natural gas for power generation. Right now 98 per cent of all the power generation out of natural as. They want to reduce that part in order to be able to export more natural gas. Morocco, as I say, is developing very important program, because they do not have any local resources. And Egypt. In addition to that, in Sub-Saharan Africa, there are—there isn't very much—there isn't a lot yet. But there are many countries which are developing like as I said, Nigeria, but also Ethiopia, Sudan, Ghana, and several others.

**Fabrice Poulin** On the off-grid side, I would say for Northern Africa, Egypt indeed has an interesting potential. Whereas Algeria, Morocco, and Tunisia are more on the application specific application aspects. But overall, Egypt is interesting for many applications altogether. On the western side of Africa, I believe Senegal and Nigeria, again, are interesting ones. But plenty of others—Ghana also is showing some interesting potential, and these are one of the countries in Western Africa that are of interest. For Central Africa, the DRC, Democratic Republic of Congo is also interesting, together with Cameroon. On the Eastern Africa, I already mentioned Ethiopia, Kenya, Tanzania, interesting, Uganda, also. And for the Southern Africa, I think South Africa still has some potential, but other countries as well. But to a lower extent to—compared to the countries I was mentioning before.

**Eric Lockhart** Thank you. That was very helpful. This next question is directed to Fabrice. And the attendee asks—who are the major micro-grid players in Africa?

**Fabrice Poulin** Today, it's a complex answer. Let's say that we have a lot of stakeholders into micro-grid. We can have the national utility. We can also have private companies. And this depends a lot on the country we're talking about. So this is let's say a complex question to answer. Let's say it's both institutions, national institutions, and private companies that—depending on the country. So today we don't have a number one company that is getting most of the market. We have plenty of companies. It's still very fragmented. But the interesting thing is that we're getting very important companies that are for example from Europe, or outside of Africa, that are the energy companies, and utilities. And these companies are looking for growth opportunities. And they are dedicating particular attention on Africa. And these are the huge utilities that we have here in Europe, several of them have a plan on Africa.

**Eric Lockhart** Great. Thank you. The next question is for both of you. And the attendee is asking about costs. Solar costs. And if the industry or consumer might be waiting for further PV cost decreases, in order to jump into the market, or if you think costs are already at a place where you think there should be a good deal of market activity.

**Manfred Hafner** Yes, thank you. PV costs have decreased indeed tremendously. And they will continue to decrease. Even so, we can imagine that there might be an industry consolidation at a certain point in time. And the decrease might not continue always in a very linear way. In addition to that, I think when we talk about PV for off-grid systems in Sub-Saharan Africa, Fabrice will complement, but I think there is a strong potential for cost decreases, because the market is getting larger and larger. And so there is a learning curve for that kind of market as well. On the one hand side, more mass production, but on the other side, there is a potential for a start of local production of the systems. Even though not necessarily dependents themselves. But the systems. And we could see further cost reductions, but I suppose Fabrice has more for this.

**Fabrice Poulin** Yes. So for I would say the answer is I think it's the right time for photovoltaic today, all around the world. This is just the—photovoltaic has been clearly a very interesting economically it's challenging already fossil fuel, even the fossil fuel are quite low. If we take a long term approach. So taking into account that the system will be amortized on several years from now. So we have already an economic equation that is very interesting for photovoltaic alone. So the time is today. But photovoltaic into off-grid is only one of the elements. We have also let's say the power electronics and batteries. And for batteries, well, we do have some solution already that are in the market for many years that are basically LED acid batteries, but we have the new technology of lithium that is bringing some extra benefits, but is let's say following a curve, but is similar to photovoltaic, but to photovoltaic as it was five or ten years ago. So we expect a lot of decrease of battery and battery price into the coming years. So if we take into account batteries, it may be interesting. We will see some cost, further cost decrease, in the next five to ten years. And there, we definitely have the two major aspect, plus of course the board electronics. We will have the two key elements of the cost that will make off-grid system interesting on economically speaking.

**Manfred Hafner** Competition, competitiveness of these systems is not only due to their own cost, but also to the cost of the alternative sources. Alternative sources depend also on the fuel costs. Fuel costs—international fuel prices are low, or have been low, during 2016. What really counts is the market price at the end of the day. And there what is important is to see subsidized or not. And I think more and more governments are realizing that they need to as far as possible to get rid of universal subsidies. If necessary, have some targeted subsidies, but to get rid of the type of subsidies we had in the past. And this will favor renewables as well.

**Eric Lockhart** Great. Thank you both. The next question is directed to Fabrice. And the attendee is curious about how local regulatory frameworks, permitting,

licensing, etcetera, enter into the model, and how much they drive the rankings.

**Fabrice Poulin** Okay, so I have an easy answer to that. Mini-grids are not part of our model, because they are so specific. So as I mentioned, mini-grids are outside of our study. I mentioned them as a reference, because we believe they have an important role to play in the coming years. But indeed, they need basically their own model. It's so specific. And they have indeed a lot of let's say impact, the local regulation framework has a lot of impact on mini-grid development. So I just can agree that local regulation has an impact, but I cannot say how strongly it has affected our model, because it does not take into account mini-grids.

**Eric Lockhart** Got it. Makes sense. Thank you. There's another question about the model and how it's put together, and where the underlying data comes from, primarily, if it's from international organizations, or how you manage the input data for the model.

**Fabrice Poulin** Yes. Basically this is a combination of macro-economical aspects. Most of them are coming from international organizations. But not only for example for electrification issue, we've got so many source of information for electricity access statistics. And we are basically cross-checking various sources, and taking the most reliable source out of these, and we also confirm that with field let's say interviews, so that we make sure we have the proper data. But definitely GDP or corruption index is taken from international organization.

**Manfred Hafner** Maybe I can also add to our model, which we use to do the scenarios which I have presented. So we do have really internal modeling expertise, and we do—which I forgot to say at the beginning—we have a whole branch at Enerdata which is related to market research, and which provides data *(1:18:12) [inaudible]*. And most of our input data for our modeling exercise is based on our own in-house data capability, which is both reliable and up to date.

**Eric Lockhart** Thank you for that response and that addition there, Manfred. The next question goes to both of you as well. And the attendee asks what kind of local capacity building might be needed in terms of expertise, tools, or delivery systems? And how are those being developed, or should they be developed?

**Fabrice Poulin** Okay, on the off-grid aspect, this is a topic that we have studied on our side. First of all, in terms of capacity building, we need to make sure that there is a strategy that has been defined. So it starts with an assessment of the situation, and a construction of rural electrification strategy. So without this rural electrification strategy and scheme, basically we are quite sure that we won't have any good results. So first is a proper planning, and making sure that we have the proper institutions that will help to make the *[inaudible]* with international organization, and that we also help building the credibility of the country, with regards to financing and also strategy, knowing where the money is going to be used properly. So I will mention in particular this planning and strategic planning aspect that seemed to me as really important.

And we could witness that, because we have studied that, also, for those 33 countries. We could witness that the countries that have defined such a strategy, that have made a plan, but have a roadmap for electrification, those countries have succeeded to properly develop off-grid market.

**Manfred Hafner** Yes. Enerdata gives advice to governments, companies, international organizations and development banks on energy and climate planning, and also capacity building to these people in order to assess energy demand and the most appropriate supply solutions. So in order to implement both on-grid or off-grid systems, or renewable systems, or all kinds of systems, we are, together with our colleagues from Infinergia, well positioned to provide advice and capacity building to operators and decision makers in politics, governments, and private industry, to accompany them to implement these kind of solutions.

**Eric Lockhart** Great. Thank you both. We've got time for just about one more question here. And for those questions that we didn't have time to get to, we'll connect with those attendees offline after the webinar. So there are a couple of questions about engaging with the private sector. I wonder if both or either of you could speak a little bit more to the partnerships between the private sector financing sources and development banks or national development funding.

**Manfred Hafner** These are of fundamental importance, as I stressed in my conclusions. Public private partnerships are very important because at the end of the day we think the private sector can do a lot of things. There's a lot of money in the private sector to do a lot of things. But by themselves the private sector will not do what is needed to be done, because, as I said, the clients are not solvable, are not necessarily bankable. So we need the leverage of the international organizations. We need the leverage of development aid. We need the leverage of development banks in order to not only create the conditions, the institutional conditions, but also to bring in the needed money, in order to, together with some—with some innovative financing schemes. The one Fabrice has mentioned. To leverage private investments.

Fabrice Poulin: Yes. And I will add further to what Manfred just said. That in my opinion, public and private, we need the proper balance between the two. Only public or only private won't be sufficient, as was mentioned by Manfred. I think we need to have a balance, and a bit of all of them, a bit of public, a bit of private, and it's interestingly—it's an interesting fact to notice that basically historically upgrading Africa was mainly a public aspect, and in the past five years, I would say, or three to five years, we're seeing private being involved more and more. And this is a good thing. So we were going the right way, *[inaudible]* further investment from the private sector, together with the public one.

**Eric Lockhart** Great. Thank you. And as I said, for questions we didn't get—didn't have time to get to, we'll connect with those attendees online. Before we close, I just wanted to turn it to the two of you, to see if you have any closing remarks to share.

**Fabrice Poulin** No. I'd like to thank you, all the attendants, and you, Eric, and Stephanie, for hosting this discussion. And giving us the opportunity to present the knowledge that we have gathered. And as mentioned, we have interesting prospects for Africa, in terms of photovoltaic market and solar market as a whole. Both for grid and off-grid. And I think the years to come will show some interesting prospects, and interesting developments. So thank you again for attending.

**Manfred Hafner** Yes. Thank you. I'm personally convinced that Sub-Saharan Africa will develop. Not only needs to develop. We need to put the right conditions in place. And renewables and solar in particular are one way in helping the region, the continent, to develop their energy access, and therefore their economic and socioeconomic development. And we are—have the tools, and have the knowledge to accompany players who are willing to play a part in it. Thank you very much.

**Eric Lockhart** Great. Thank you again to both of you for your great presentations, and for that very informative Q&A. Thank you as well to our attendees for participating in today's webinar. We appreciate your time as well, and hope in return that there's some valuable insights that you can take back to your ministries, organizations, departments. And we also invite you to inform your colleagues and those in your networks about Solutions Center resources and services, including no-cost policy support through our Ask an Expert service that I mentioned. I invite you to check the Solutions Center website as well if you'd like to view the slides and listen to a recording of today's presentations, as well as any previously held webinars. You'll also find information on upcoming webinars and other training events there. And we're now posting webinar recordings to the Clean Energy Solutions Center YouTube channel about one week after the webinar. Finally I'd like to again just ask you to kindly take a moment to complete this short survey that will appear when we conclude the webinar. Please enjoy the rest of your day, and hope to see you again at future Clean Energy Solutions Center events. This concludes our webinar.