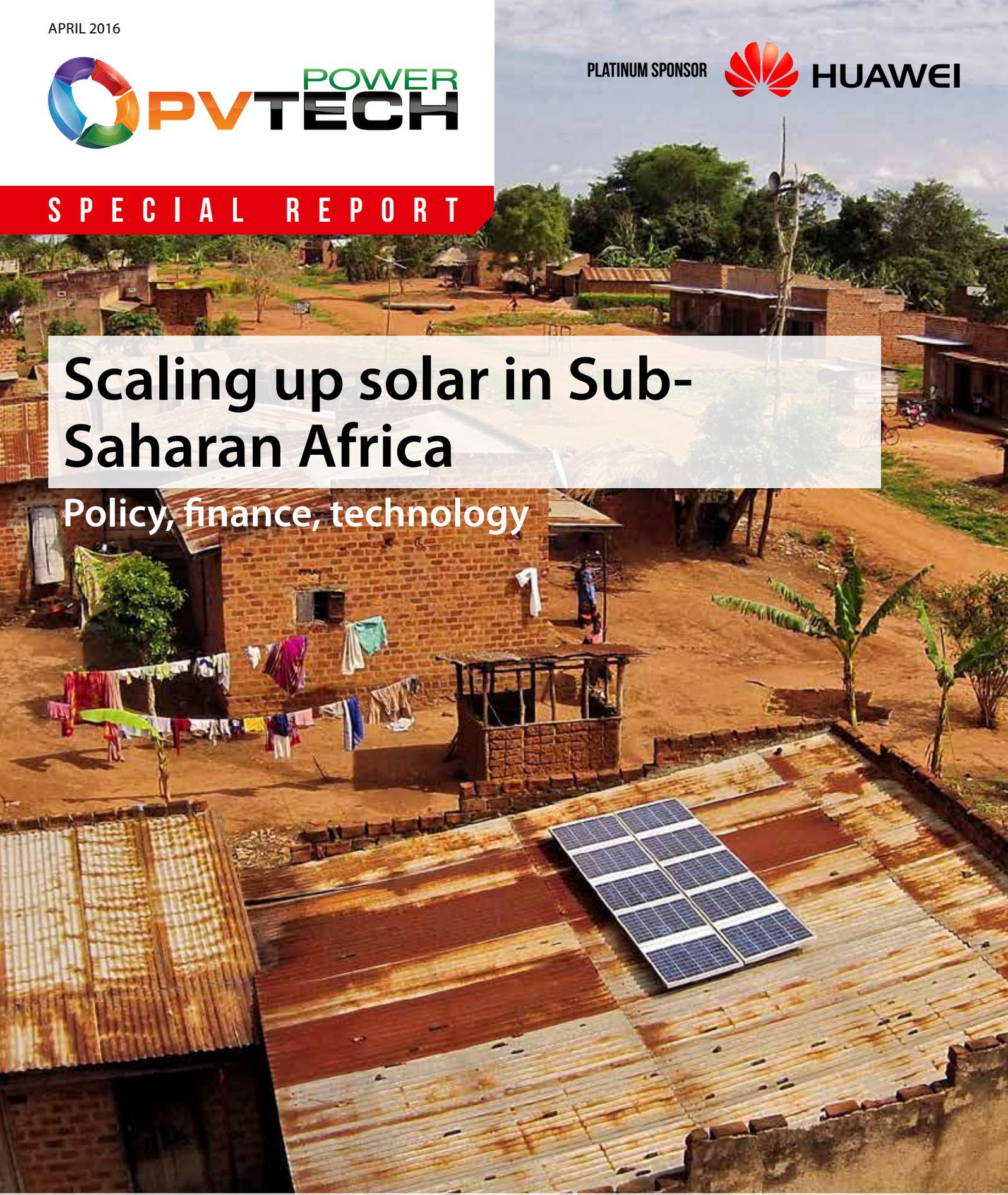




SPECIAL REPORT

Scaling up solar in Sub-Saharan Africa

Policy, finance, technology



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New models for new markets



Off grid

Moving from pilot to mainstream

Micro-grids

New technologies supporting the roll-out of distributed solar



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Cover image: A 500W solar system from SolarNow in a rural village in Uganda powers a home, drives a public broadcasting system, a barbershop and a video hall and generates new income for the business owner. Photo courtesy of SunFunder.

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INTRODUCTION



The narrative of solar in Africa is well rehearsed: rapidly growing GDP in many countries is creating pressing demand for power; at the same time, decades of underinvestment means millions of people cannot access traditional grid-supplied power. As a generation source that can be rapidly deployed, independent of the grid, solar offers answers to both these problems.

The purpose of this special report is to explore the development of the various different solar segments in Sub-Saharan Africa, document some of the successes to date and highlight the many challenges the sector is facing along the way.

On pages 8 to 11 we look at the all-important issue of finance. As authors from investment firm, Ghana Capital Partners, discuss on page 8, traditional forms of project finance are not necessarily open to developers in parts of Sub-Saharan Africa. New thinking around finance is clearly needed, and we profile some of the innovative models that are beginning to emerge particularly in the off-grid segment (p.10).

We also look at the growth of the small-scale off-grid segment itself (p.12). Here the challenge is primarily one of policy, with only a comparatively small number of governments having put in place what industry observers say is needed to help the sector flourish.

The deployment of micro-grids comes under the spotlight on p.16. Micro-grid projects have huge potential for serving off-grid communities, and we look at how new web technologies are opening up this promising field.

And finally we examine the fortunes of solar at larger scales, for grid-connected utility projects and commercial and industrial applications (p.20). Arguably these get the most attention because of their scale and capacity to generate good headlines. However, outside a handful of countries examples of built projects are scarce. We ask why and scope out prospects for future growth.

Ben Willis
Supplement editor

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An African story

Market overview | Solar in Sub-Saharan Africa has much to offer but is still a long way from living up to its potential. Ben Willis canvases opinion on how solar will shape up in Africa in the coming years

For the past several years, it seems, Sub-Saharan Africa has been on the cusp of a solar revolution. South Africa has blazed a trail for the continent, developing a procurement model for utility projects that has become the envy of other emerging solar markets around the world. There have been some other notable successes, such as Rwanda completing the region's first utility-scale plant outside of South Africa last year. And deployment of small off-grid systems has quietly continued to gather momentum too, with a number of companies now emerging as leaders in this field.

But the gap between reality and rhetoric as regards solar's place in the African energy mix has stubbornly refused to close. Despite the obvious and vast potential of solar and its associated technologies to bring electricity to the hundreds of millions of Africans currently without it, that promise has yet to be fulfilled. A few sticking points – lack of finance, perceived political risks, poor grid infrastructure – have emerged as persistent barriers to growth for solar in Africa.

Nevertheless, the building blocks for solar to play a significantly larger role in Africa's electricity future are slowly being laid. While these may not yet have translated into especially noteworthy figures in terms of installed megawatts, there is a sense that bit by bit the key boxes are being ticked that in time will spur the sector's growth in the region.

"We would have expected to see more solar and quicker deployment up till now," says Mahama Kappia, executive director of the Economic Community of West African States (ECOWAS) Centre for Renewable Energy and Energy Efficiency (ECREEE). "Nevertheless it is really picking up. Initially there was scepticism from governments because the costs were high and the technologies that they deployed as pilot projects in earlier



Credit: IRENA

stages did not stand the test of time.

"A lot has changed in the past five years. Now there is much more awareness and interest in climate issues in the region and that is pushing the PV drive now."

Although Kappiah speaks for West Africa, the same could be said of other parts of the continent. Across Africa, governments trying to reconcile growing demand for power with generally poor generating assets and grid infrastructure are recognising the opportunities offered by technologies such as solar, that are quick to deploy and can bypass the need for costly new grid extensions. Slowly, new policies are beginning to emerge, technology concepts are being proved out and new routes to finance are being opened up.

Policy and regulation

According to Karim Megherbi, who heads up the West Africa operation at Dubai-based developer, Access Power, a big step forward for solar's fortunes in Africa in recent years has been the steady realisation among policymakers that it is a genuinely competitive energy

Africa is starting to embrace solar, but progress so far has been slow.

source in the region.

"It's very recent that the solar technology is that competitive, meaning that even at low oil prices you still have a strong interest to plug some solar plants into the grid," Megherbi says. "Therefore while there are projects that have been discussed for years in West Africa, governments were really hesitant to sign power purchase agreements with high prices. And it's only now, in the last two years, that they have seen that in reality solar can play a big role in their energy mix."

That in itself is a significant development, for without buy-in from the decision makers it seems highly unlikely that projects will be particularly fast in getting off the ground. Despite complaints by many that finance – or the lack of it – has been the main factor behind solar's slow take-up thus far in Africa, some point the finger elsewhere.

"Personally I believe financing is not the bottleneck," says Stephan Diefenthal, vice president at DEG, the finance and investment subsidiary of German development bank, KfW. "I can tell you we are really very keen on Africa energy, but

it's so difficult to find bankable projects. That's our problem."

Diefenthal believes it is incumbent upon countries that want to encourage investment in solar to create the right conditions to increase confidence and attract foreign investors. "Investors are quite shy to invest, so it must be a stable environment politically or legally," Diefenthal says. "Regulation or legislation should be attractive for investors. And I believe there's still something to do on capacity building – this is still missing today."

This has a knock-on effect on the capabilities of countries to handle complex processes such as negotiating power purchase agreements. That is an important factor, for as Diefenthal points out, even in mature solar markets, PPAs are notoriously difficult to conclude. Because African countries are in competition with many others around the globe, if investors find essential processes such as PPA resolution easier elsewhere, the likelihood is that that's where they'll choose to put their money.

There have been some advances on the policy front in recent years. In West Africa, for example, ECREEE has been playing a coordinating role in developing pan-regional policies on renewable energy that are hoped to set the tone for future market activity in this area.

"Finally in 2013, after several years of difficulty, we managed to adopt a regional policy document on renewable energy," ECREEE's Kappiah says. "This was a landmark achievement and based on this document we have been working with all the member states to set targets for renewable energy technologies within their energy mix for 2020 and 2030. Positive change is coming in."

The learning process

Policy coordination such as this will undoubtedly help build the sort of institutional capacity Diefenthal says is needed to create the necessary conditions for investment. Aside from that there will of course be a natural process of learning as pioneer projects get built.

That's happening already in East Africa, with Scatec Solar's 8.5MW now already operational and another one underway in Mali (see p.20). Access Power meanwhile is working on a 10MW

project in Uganda that will no doubt contribute further to the core of industry experience being built up of how to deliver solar projects in Sub-Saharan Africa.

In West Africa meanwhile, Megherbi expects the pace of development to pick up once a first "wave" of projects in sub-region reaches completion. He points to a body of projects in West Africa totalling around 100MW that have been in the pipeline for a number of years but are only now reaching completion because they are essentially breaking new ground. A second wave of projects that Megherbi says is now coming forward, totalling around 200MW, will he believes find the way cleared to a degree thanks to the efforts that went into the first round.

"The second wave of projects that are happening now will go faster, I think, because we are benefitting from... not a big learning curve, because there will not be many projects from the first wave, but there is still a lot to learn from the governments, from sponsors about how to run these projects quickly and efficiently," Megherbi says. "So the second wave will come faster and at a better price. But the first wave was necessary in order to open the door."

Away from the grid

Away from the utility-scale, grid-based projects being eyed by independent power producers such as Access Power and others, all parts of Africa of course offer a multitude of opportunities for distributed projects, either off grid or grid tied, in areas where power supply is non-existent, unreliable or currently provided via costly diesel generation.

Diefenthal believes that one area that is likely to see significant growth in the coming years is the larger off-grid project, where the off-taker is a company rather than government utility. This offers the advantage of getting around the fact that many of the state power companies that will be off-takers for IPP utility projects are often deemed unbankable by developers. "I believe we'll see coming up more and more the off-grid IPPs with mining companies and heavy industry off-takers. That will become more common and interesting," Diefenthal says.

Meanwhile, East Africa has been leading the way in commercial rooftop projects serving properties such as hotels, shopping centres and apartment blocks, and Diefenthal says this is a model that is almost certain to find its way west: "In West Africa we haven't seen it, not on a commercial level, but we have had discussions on that with some companies. It's still quite early but I believe that could also be something which could well develop in the future."

And in almost all countries in Sub-Saharan Africa, the market for off-grid solar serving households, businesses and communities is looking increasingly attractive. Once again East Africa has arguably set the pace in this segment and is the hotbed for much of the current innovation in off-grid business models and finance, explored in details on pages 10 and 12.

In West Africa, Kappiah says lack of policy direction has once again been the main frustration for the small off-grid solar sector. He singles out Ghana for not having done enough to provide policy support to the country's fledgling off-grid sector, despite launching a programme for 200MW of rooftop solar. But frustrations aside, Kappiah is confident that solar in West Africa will see "drastic growth" in the coming years, even in spite of the recent crash in oil prices and the potential effect that may have in undermining the case for solar and other renewables.

The long game

The key ingredient for solar to take off in Sub-Saharan Africa, it would seem, is the same one that has been behind most of the other advances in economic development many areas of the region have seen in the past decade – time. In many areas of business and commerce, Africa has over time shaken off clichéd perceptions to prove it's just as dynamic as other parts of the world. The same seems likely for solar.

"I think there will be many projects coming – I believe that," says Diefenthal. "It takes time, but it's normal, and in Africa it even takes a little bit more time than elsewhere. But I think it's really a unique opportunity for Africa." ■

Additional reporting by Tom Kenning

New technologies for new opportunities in Africa

Huawei, the Chinese multinational telecommunications company, is also a rising global force in the global solar industry. As a manufacturer of smart string inverters and FusionSolar Smart PV solutions, the company has recorded a rapid rise up the inverter supplier rankings, coming out top in terms of megawatts shipped in GTM Research's list of the top-10 inverter manufacturers of 2015.

As with all companies in the dynamic global solar industry, Huawei is constantly seeking out new markets, and is setting its sights on the opportunities emerging in Sub-Saharan Africa.

"We note that over the past two years, the PV industry in Sub-Saharan Africa has got into full swing," says Yidong He, general manager, global solutions, at Huawei. "Solar energy is gradually becoming a major generation source, and we're happy to see that."

According to He, one of the key drivers for the company's interest in renewable energy in Sub-Saharan Africa is the crucial need to protect the region's fragile environment. "The Sub-Saharan Africa ecosystem is one of the best-protected areas of the world," says He. "It is therefore right that renewable energy, particularly solar, is used as the main power source as it can ensure that economic development and ecosystem protection coexist, and that the old path to development followed in Asia and elsewhere, of first pollution and then governance, is not duplicated."

Smart solutions

Huawei attributes its leading position in the inverter market to its commitment to and heavy investment in research and development. Overall the company has 176,000 employees worldwide, and 79,000 of these are R&D engineers.

In 2015, Huawei's R&D investment was CNY59.6 billion (US\$9.0 billion), which accounts for 15.1% of its annual revenue. In 2015, sales revenue was CNY395 billion, an increase of 37% from a year earlier.

Huawei says it invests at least 10% of its revenue in R&D every year to maintain its leading edge in the world in terms of technologies and products. Huawei is also therefore recognised as a leader in technical innovation in the industry. The aim of innovation is to bring benefits to customers and provide cutting edge, high quality, and cost-efficient products and solutions to customers, the company maintains.

The result of this extensive investment is that the company is able to boast some impressive credentials.

"They offer high efficiency up to 99%, while multi-MPP trackers realise real-time and accurate string detection," explains He. "The detection accuracy can reach 0.5%, six times higher than traditional centralised inverters. Multi-MPPT can also effectively reduce the influence caused by shadowing and string mismatch, dramatically improving the yields. A fully closed design ensures high-level

protection based on our mature and advanced technology from communication."

"IP65 protection makes our inverter versatile for all the hostile outdoor environmental conditions, such as high temperature, high levels of dampness, high altitude, extreme cold, sand, salt and mist. We use our own chipset Hisilicon and operating system to reduce the weight and heat dispersion. They contain no quick-wearing parts such as fuses or external fans, which makes them maintenance free. Furthermore, our inverters are open, supporting inputs of different types of equipment and parts like trackers and sensors."

There has been much debate in recent years about central versus string inverters and the relative merits of each type of inverter architecture. For Huawei there is no doubt which is the better system.

"String is better," says He. "String inverter design is not simply ideal for rooftops, which has been highly recognised by the public. Meanwhile, we have made comparisons between the two solutions from different perspectives; these show the better performance of string inverters as regards safety, yields, system cost, installation, operation and maintenance, monitoring, environmental adaptability and grid connection.

"It is tested and proved not simply in theory but also in the practical application from the customers' projects, which offer yields 3% higher than other solutions. Our string inverters and solution have been widely applied for single projects over 100MW both in and outside China."

Not just an inverter manufacturer

Aside from inverters, Huawei manufactures a number of other solutions that are all designed to maximise the success of PV arrays. One is its Anti-PID Module, designed to offer protection against potential-induced degradation, a problem that affects many





PV arrays incorporating crystalline silicon modules and can cause significant power losses.

“Our patented anti-PID module can help avoid the potential-induced degradation effect without a PV-tie to ground directly, effectively guaranteeing human safety,” He says. “Power Line Communication (PLC) technology allows communication via power cables and removes the need for communication cables. The PLC is cable free and the communication bandwidth is much higher than RS485.”

The company also offers other products such as the smart array controller and smart management system. “The smart array controller integrates data logger, PLC module, Anti-PID Module and communication module,” He says. “It dramatically simplifies the system and network establishment, reducing the potential of faulty parts.”

The smart management system, meanwhile, is the core part of Huawei’s smart PV solution, He says, offering greater visibility and therefore efficiency in the management of PV assets. “Operations and maintenance (O&M) efficiency can be increased by over 50% through our smart PV solution. We have developed the advanced system for both plant and corporation levels, which can realise mobile and remote operation and maintenance globally,” He says.

Huawei solutions in Sub-Saharan Africa

In the context of Sub-Saharan Africa, where climatic conditions can sometimes be extreme, Huawei says its solutions offer numerous advantages in terms of durability.

“Parts of SSA have an extreme tropical climate with high temperatures and dampness,” says He. “Also severe dust-storms are not uncommon. Huawei’s fully closed inverter design, protected to IP65, guarantees long-term operation with safety and reliability. Multi-MPP trackers enable high-accuracy detection and improve yields by over 3%. Our smart PV inverters become the brain of the plant, realising smart operation and maintenance with digital information and internet technology.”

Huawei is already active in the region, where it is focusing on how to use its smart PV technology help address the prevalence of power shortages. “Huawei attended the Africa Energy Exhibitions held in South Africa in 2014 and 2015 and has established close cooperation relationships with multiple local partners,” He says.

“Sub-Saharan Africa is one of the global economic growth points in recent years. As the requirement for power is increasing because of continuous growth of GDP, the PV industry is imperative.”

Huawei highlights the extent to which economic growth in a number of African countries has outstripped that of European or American countries, highlighting Nigeria and South Africa as two examples.

“We think that Africa has become a new worldwide economic growth centre and therefore that energy demand will increase significantly,” He says. “According to Huawei’s market analysis, it is highlighted in the entire Sub-Saharan Africa region that the development of the energy industry and speed of economic growth do not match. Governments have also realised the problem and are providing policy support. Therefore, we think that the entire region is of huge potential.”

He says Huawei is currently of the view that large/utility-scale solar energy offers the greatest near-terms prospects for growth, but says that in the future it expects distributed and residential PV systems will become the mainstream applications. “Huawei provides a complete smart PV solution suitable for various scenarios and the solution has been successfully applied all over the world. We hope that we can play the role of an excellent partner that boosts the PV industry development in Africa through continuous efforts,” he adds.

Huawei already has a team of 20 in its Africa team, which includes the sales, products and service staff. The team is set to be expanded further in line with the growth of the market and its sales in the region.

Although it’s early days for Huawei’s involvement in African solar, the company has already attracted the attention of some key stakeholders in the region, including Wisdom Ahiataku-Togobo, director of renewable energy at the Ministry of Energy in Ghana.

He says: “Huawei continuously deepens the cooperation with African countries in the ICT and electronic and electrical fields in recent years, and has made remarkable achievements. In addition, Huawei is the world’s leading smart PV solution provider. We hope that Huawei will continue the win-win, long-term, and effective cooperation with Ghana in the renewable energy field to promote the PV industry development in Africa and make more positive contributions.”

Adapting traditional project finance models for solar in Sub-Saharan Africa

Finance | The perceived risks of investing in solar projects in emerging markets in Africa is a major barrier preventing an influx of capital. As Sidney Yankson and Maitane Sagastuy write, some new thinking will be required to unlock the continent's huge backlog of much needed energy projects



Credit: Off Grid Electric

The business case for investment in renewable energy in Sub-Saharan Africa (SSA) is clear. The key issue is whether traditional project financing models are the most effective way to finance these projects, or whether innovative new models need to be developed for these opportunities.

Despite maintaining GDP growth above the global average for many years, international investors face significant challenges when it comes to deploying capital into the solar energy sector in SSA. Navigating the legal maze in multiple jurisdictions is not easy with their economic, political and commercial idiosyncrasies. SSA countries have come a long way. Some external investors feel, however, that they still have some way to go to provide enough currency stability, liquidity in their financial markets and political stability to attract the large amounts of investment needed to unlock the huge backlog of energy projects on the continent.

Financing challenges

Most long-term power projects financed in developed markets rely on some form of long-term power purchase agree-

ment (PPA) to underpin the loans that the project requires. With approximately 98% of the capital being deployed in the construction phase of a solar project, most of the risk is in this initial phase. Without a relatively high chance of receiving their money back, investors will stay away, or require a very high return to compensate them for the perceived risk.

In SSA, finding a lender with the risk appetite, balance sheet and willingness to take on a long tenor loan in a solar project can be an impossible task. Financing from local banks is sometimes available, but is costly and can rarely meet a tenor beyond five or six years. Therefore, the traditional 70% debt to 30% equity ratios of project financing are not normally feasible and most projects will require significantly higher levels of equity. Furthermore, with few exceptions, most government off-takers in SSA have poor credit ratings, which makes international lenders uncomfortable to accept their credit risk without sovereign guarantees.

In order to attract international investors, SSA solar projects have to provide returns that meet investors' expectations.

The perceived risks of investing in solar in Sub-Saharan Africa means traditional finance routes may not be open.

Some investors require the returns to factor in sovereign cost of capital, liquidity risk and currency risk, as well as the off-takers' repayment track record. One option open to investors is to invest into markets with greater domestic liquidity and a proven track record of financial repayments at the expense of lower overall project returns; it might be better to get a 7% return which you actually receive, rather than a 20% return which you don't.

The Renewable Energy Independent Power Procurement Programme in South Africa is an example of this. As the programme progressed through successive rounds, the price paid for the electricity decreased with each new bidding round, as did the equity IRRs. The market was pricing in the reduced risk as Eskom's track record showed that the utility paid the IPPs on time. The system worked.

Net economic benefits

One alternative method that international investors could consider would be to look at the risk of a project in the round. The traditional method of adding risk premiums to a return expectation model will probably produce a required price per kilowatt hour for electricity that is way above the tariffs offered by the off-taker. Instead, international investors could reference their breakeven point to other domestic alternative forms of power (the marginal cost of supply) and to the marginal price consumers are willing to pay or have paid in the past.

This can be achieved by looking at the net economic benefit, which aggregates positive externalities and the econometric GDP upside that the project will bring. For example, grid-connected projects may look at the improvements they will provide to the national electricity supply or the increase in GDP per capita that will

follow from an increase in power supply. Also, a willingness to pay can be factored into the return model. These factors may be additional reasons to invest, because the willingness to pay can be inferred from other services that have seen huge growth in SSA, such as the use of mobile telephones.

In short, net economic benefit should be factored into the calculation of marginal cost to make the business case more economically viable. This is not the textbook approach employed to project financing in the more developed markets of Europe, North America or Asia. It may, however, be one of the new project financing models for SSA. International investors should also make sure that when calculating the net economic benefit for a project their calculations are specific, measurable, attainable, realistic and relevant. Senior debt still has to be repaid and equity investors like their dividends!

Net economic benefit comes in many shapes and sizes. Many SSA countries give tax exemptions on imported products, such as solar modules or inverters. The loss in tax revenue will most likely be outweighed by the increase in tax collection by the increased GDP due to more businesses being able to use the electricity generated by the solar power plant. Therefore, the country receives a net economic benefit.

The difficulty may be in how the international investor benefits directly from this increase in GDP. Most solar energy projects will usually be heavily reliant on the creditworthiness and fiscal reliability of an off-taker. Measures to mitigate risk can be included within the PPA, such as currency protection by pricing the PPA in the same currency as the loans or by currency swaps. This does not, however, remove the external risk that the off-taker itself may not have sufficient liquidity on its balance sheet to honour its obligations under the PPA.

In this case, an alternative is to look for external partners to the off-taker, which could provide an indemnity or guarantee for the off-taker's obligations. This is easier said than done, but some examples include multilateral organisations, development finance institutions, or export credit agencies. The European Union via the European Investment Bank, the USA, via the Overseas Private Investment Corpo-

ration and increasingly Asian countries, such as the Chinese Development Bank, are becoming anchor partners whose guarantee or credit enhancement can support international investors when they deploy capital into solar power projects in SSA. If the tax payers of one country, via its export credit agency, support a solar power project in a SSA country, then it is possible that there can be increased trade between those two countries, which results in a net economic benefit for both parties.

Another alternative is to look at cooperation between consumers of power. McKinsey estimated in its report, 'Brighter Africa', that energy regionalisation could save up to US\$40 billion by increasing the use of power generation assets across regions. This would reduce the need to have to deploy costly assets across SSA. For example, a 400MW solar farm in Nigeria that sells 100MW of power via the West African Power Pool to Benin and Togo could reduce the need for Benin and Togo to spend hundreds of million of dollars on their own solar farms. The rationale seems to be: why build your own plant when you can buy reliable power from a neighbouring country at a lower cost? The same could apply to solar projects in the calculation of net economic benefit. Solar energy producers could explore ways of cooperating with corporations or even other solar projects to use economies of scale to increase net economic benefit across a region and reduce the need for lots of smaller plants. It is well known that it is more economical to build a single 1,000MW plant than 100 10MW plants. This, of course, would have to be balanced against the transmission losses and the additional infrastructure cost to distribute the power.

Off-grid projects have to obtain net economic benefits too, unless there is an anchor consumer, such as a mine, supporting the project. It can be costly and challenging to set up a distribution network and sell electricity directly to households in remote places. Moreover, how do you model a system with customers without a credit score or bank account? It has been well documented that the African continent has revolutionised payment models using 2G mobile phones. Some off-grid pioneers are selling electricity to networks of 5,000

or 10,000 people in mini-grids. The real challenge is how we can make these mini-grids achieve scale to remove the 600 million from energy poverty in SSA. The key for the international markets is to find an economic model for these off-grid projects that is sustainable and not grant dependent.

The financing of small stand-alone systems can be even more challenging. The price of electricity tends to be competitive against traditional sources of energy like kerosene, but the initial outlay for the kit can be unaffordable. Solar systems are already being paid in instalments by customers through early adopters like M-Kopa Solar. M-Kopa Solar currently serves 200,000 households in East Africa. The data collected by these mobile phone payment systems may become a business all of its own. Consumer spending habits are big business in more developed markets. Why not in SSA?

In conclusion, financing solar projects in SSA is not plain sailing. A change from the traditional project finance model to a net economic benefit analysis could allow more international investors to increase their investment into solar power projects. It's clear that SSA will need lots of electricity in the future if the continent is to move forward. The question will be how traditional project finance models can be adapted for the different challenges posed by SSA solar projects, and how can international investors be attracted to invest. Time will tell. ■

For further insights into innovations in off-grid solar finance turn to page 12

Authors

Sidney Yankson founded Ghana Capital Partners in 2012 as a boutique project developer and private equity investor focussing on investments in Africa. GCP is now developing a wide range of projects including solar PV and wind in various African countries. Prior to founding GCP he worked in finance for 16 years and is a qualified barrister in Hong Kong.



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New paths to unlocking off-grid solar finance

Off-grid finance | The challenges associated with sourcing capital for off-grid solar in Africa mean innovative new approaches are required. Ben Willis looks at some of the pioneering models being developed

As the article on the previous pages made clear, despite huge opportunities, financing solar in Sub-Saharan Africa is no cakewalk. For developers of large-scale projects, a variety of risk-related factors makes the cost of capital much higher and thus closes down some of the traditional routes to project finance. Meanwhile, for smaller off-grid systems the market is still relatively new and unknown, meaning capital at the levels needed to make a meaningful impact is still comparatively hard to find.

Nevertheless, some models are beginning to emerge specifically to support the uptake of smaller-scale solar in off-grid and grid-deprived parts of the region. The common themes uniting efforts to unlock the global capital markets for the off-grid solar sector in Africa are scale and predictability – scale to attract the attention of larger investors and predictability to give investors assurance that their money is being well looked after and will generate the expected returns.

Below we profile some of the innovators in the off-grid solar finance space and how they are seeking new ways to bring much-needed capital into emerging solar markets in Africa.

SunFunder: Building scale

California- and Tanzania-based SunFunder began life as a crowd-funding platform that raised small amounts of capital to invest in solar deployment in off-grid or poorly connected parts of Africa. But even at that early stage, the company recognised that if it was to make a meaningful difference it would need to scale up, so evolved its strategy to raising private debt from privately accredited individuals and institutions.

According to SunFunder's vice president of portfolio, Andrea Griffin, the company is shortly expecting to close on what will be its largest fund to date, a US\$50 million facility which has the backing of a major international investor.

Griffin believes that the evolution of SunFunder reflects a shift in attitude within the investment community towards solar. "I do think that solar in frontier markets in Sub-Saharan Africa is much more on the radar than it ever was," she says. "There's still a lot of learning and understanding of the different segments and the different risks in each of the segments; we're still learning how these companies are evolving and their needs are evolving. But I think this is now attracting a broad group of types of investors internationally."

Another sign of the off-grid solar finance space evolving, Griffin notes, is in the sophistication of the kind of investment models emerging. As companies serving the pay-as-you-go solar segment in Africa scale up in the coming years, so their capital requirements, both debt and equity, will increase, meaning demand for new kinds of investment. This is something she says SunFunder has already started to see and to respond to.

"Our typical product has been things like inventory financing for equipment, for example; we've worked with a number of companies on that product, and that was our bread and butter, that's what we started doing. We also did a term financing product for companies that needed equipment as well as financing for the receivable, if they had a client that had credit for example," Griffin explains.

"And now what we're seeing the market demanding are separate



Credit: SunFunder

SunFunder has seen a broader spread of investors taking an interest in off-grid solar.

off-balance-sheet vehicles to finance the receivable of the asset over the course of the receivable tenor. We call them SPVs for asset-backed financing. And that's now beginning to be not only a product in demand, but more and more companies are starting to get into the space and are also seeking ways to finance that in ways that are sustainable."

Griffin says SunFunder is about to close its first SPV with a customer. "We're going to see those facilities will be very much in demand and will also need a substantial amount of capital going into them over time," she says. "One of the ways that investors could work together could be on investing in the facilities alongside each other."

Off Grid Electric: Offering predictability

US and Tanzania-based Off Grid Electric has a mission to create what its CEO Xavier Helgesen describes as a "modern energy lifestyle" in off-grid areas of Africa. "So that's not just a phone charger, but more aspirational ways to live in your home and run a business, and to make that affordable and accessible to as many people as we can," Helgesen says.

Credit: Off Grid Electric



Through its 'M-Power' platform, OGE offers a full distributed solar service for off-grid households at a price that equals or is less than what they would spend on average to meet their energy needs. According to Helgesen, having developed and trialed the system in Tanzania, the company is now serving customers in that country and in nearby Rwanda, and growing its customer base by 10,000 a month, he claims.

The key to OGE's growth has been its efforts to achieve high and predictable payment rates from its customers. "This allows us to finance against them, because what finance needs above all is predictability," Helgesen explains.

Such has been OGE's success in this that the company recently closed what Helgesen says was the first off-balance-sheet financing for off-grid solar. "What you have today is some impact investment trying to prove a concept. And I think ours was the first to take it one step further and say we don't just have an impact here, we have an investment vehicle where people can put money in to fund off-grid electrification and they can get money out at attractive rates of return," he says.

The facility put together by OGE totals US\$45 million. USAID pump-primed the fund by putting in a grant element, which in turn cleared the way for other investors to come in.

The fact the facility was put together on what Helgesen says were "commercial terms" he believes indicates a certain softening of attitude among commercial investors towards investing in off-grid solar in Africa. But he also cautions that it is still early days for this sector and stresses that development finance will still be needed to oil the wheels for some years to come, before the sector can become a

An Off Grid Electric service centre in rural Africa. The company is looking to rapidly ramp its customer base in the region having tapped new sources of finance.

truly market-driven enterprise.

"We were able to work with lenders one on one who wanted to see this succeed and didn't just look at this compared to any other loan they could possibly do," he explains. "So I think what you going see is the next stage is going to be development finance – the CDCs, the IFCs, the OPICS – financing bigger projects. And that's still going to be impact investment, but it's going to be scaled impact investment. And eventually this is going to be something the commercial banking sector will pick up."

But that could be another 10 years away, Helgesen adds. In the meantime he says it will be important for businesses servicing the off-grid sector to mature, understand their customers better and finesse their operations accordingly. That may well lead to some kind of standardisation along the way.

"I think the market is going to zero in on certain offerings, certain levels of service, certain payment rates that in some ways are more uniform across the market rather than specific to any one company. Because right now everything is very specific to the hardware people deploy and the service model they provide and the country they operate in. And so I think that will start to homogenise."

BBOXX: Off-grid securitisation

UK-based BBOXX offers its proprietary solar systems to customers in off-grid locations around the world, and at



BBOXX is using future revenue from its payment contracts to secure investment.

the end of last year completed what it claimed was the first off-grid solar securitisation deal.

Under the US\$500,000 deal, part of

a larger US\$15 million funding round, the company pooled around 2,500 of its customers in Kenya into a note which it sold to Dutch investor Oikocredit. The value of the note is backed by the future payments BBOXX expects under these contracts and, according to the company, will allow it to realise revenue from its payment plans up to three years early, money that can be reinvested into building its operation.

"The main thing is that we're unlocking our balance sheet, that's a fundamental driver in all of this," says Anshul Patel, BBOXX's vice president of special projects. "And it should definitely open up the doors to companies returning their capital faster than they had planned."

Patel says BBOXX now plans to offer around three or four notes of increasing value to the market each year. Although the first one was in Kenya, BBOXX is shortly expecting to close a similar facility in Rwanda. Looking further ahead one option the company is considering is to list its notes on the Kenyan stock exchange.

According to Sudeep Desaraju, vice president of debt finance at BBOXX, the securitisation route should open doors that were previously closed in terms of commercial finance. "Banks have the largest balance sheets here in East Africa, but the issue with banks is that they are typically more risk averse," he says.

"That goes to the whole point about securitisation. The point about doing this, to unlock our balance sheet, will only enhance our discussions with banks, because it will provide the banks with comfort that we can repay their principal by flipping the portfolio out into asset-backed notes, and therefore transform this capital-raising process from a bilateral mechanism to an all-the-capital-markets mechanism. And as soon as we get banks interacting with each other on behalf of BBOXX, that's the game changer right there."

And as Patel adds, securitisation also opens up possibilities for other forms of finance to come into the sector. "As soon as you talk about having asset-backed notes, you can also have derivatives off the back of it," he says. "And that is going to be another game changer – that will be the next instrument in the industry which will change the narrative." ■

Scaling up small, off-grid solar in Africa

Small-scale PV | The growing number of companies offering small solar solutions in off-grid areas of Africa is testament to the huge potential of this segment. The big prize is now getting the right policies and investment frameworks in place to fuel the next phase of growth. Tom Jackson reports

Africa has a power problem. The African Development Bank (AfDB) says almost 620 million people on the continent lack power, McKinsey that the region is “starved” of electricity.

Much of this shortage is attributable to the failure of grids. Southern Africa has installed grid-based capacity with 58GW. West Africa has only 20GW, East Africa 8.1GW and Central Africa 4GW. These grids primarily serve urban populations, with rural areas often in the dark.

“Since independence they have been saying that it is going to go everywhere, and it hasn’t happened. And it’s not going to happen. Even if they can extend the grid and distribute capacity, they don’t have enough generation capacity,” says Nate Heller, co-founder of PEG Ghana, which provides solar home systems on credit to households.

The potential of small-scale, off-grid solar

The failure of grids means many regions are turning to off-grid solutions as a means of providing power, especially solar ones. Koen Peters, executive director of the Global Off-Grid Lighting Association (GOGLA), says the industry has grown from a “near standing start” less than a decade ago to more than 100 companies focusing on small-scale off-grid solar.

“By the middle of last year, these businesses had collectively sold 20 million products globally. Such products are very effective in enabling access to basic electricity services – for an estimated 89 million people across Africa and Asia,” he says. “They help



increase income levels, assist with business ventures and educational development, and they improve health and safety.”

There are cost benefits as well as social ones, with African consumers saving on average US\$3.15 for every dollar spent on pico-PV products, according to GOGLA.

Set to boom

Further growth is expected, with the International Energy Agency (IEA) saying 220 million people in rural areas will gain access to electricity by 2040 through off-grid and mini-grid solutions. A recent report released by the World Bank Group and Bloomberg New Energy Finance (BNEF), in collaboration with GOGLA, said sales of off-grid solar products in emerging markets are expected to reach US\$3.1 billion by 2020, providing access to improved energy for 99 million households.

With these figures in mind, annual investments into the industry rose to US\$276 million in 2015, a 15-fold

The concept of small-scale solar has been proved in Africa. The next step is to deploy it at scale.

increase since 2012. Heller says investors are seeing huge return potential in the sector.

“Sub-Saharan solar is in a place now where mobile phones were in the 1990s. Solar panels are getting cheaper, LEDs and batteries are getting better and better. It keeps improving: the size and price of batteries and what they can power,” he says.

This had led to evident growth at a company level. Lars Krückeberg is co-founder and CTO of Berlin-based SOLARKIOSK. The company’s E-HUBB is an energy and business outlet for solar products, fast moving consumer goods and energy services, and has been rolled out in Ethiopia, Kenya, Rwanda, Tanzania, Botswana and Ghana.

“Our numbers are ever increasing,” he says. “And we know we just scratched the surface in most countries, as in many places the products never reached the people and they simply do not know about it and have to be educated, why it makes sense.”

Scratching the surface

Yet if companies like Krückeberg’s are to do more than simply scratch the surface and actually deliver small off-grid solar solutions at the scale needed to make a meaningful difference, and please investors, there are a number of issues that need to be addressed.

Peters says scale is necessary in order to reach economies of scale, with solar providers hindered by costs around marketing and distribution.

“In very rural and dispersed communities, distribution costs are very high. The marketing and distribution cost per

product are lower if you have higher volumes. This then has impact on the end-user or customer, since the retail cost will be lower for them," he says.

Krückeberg agrees last-mile distribution, especially at the bottom of the pyramid, is the biggest bottleneck faced by firms in the sector.

"That is why there are almost no companies that are tackling this problem. Last-mile distribution and ongoing customer relationships will probably become even more important value drivers and determine who will be the few successful brands."

Yet for last-mile distribution to take place and for companies to scale sufficiently, finance is necessary. As seen above, investment is happening, with the likes of Kenya's M-KOPA Solar and Tanzania's Off Grid Electric raising large funding rounds last year. Heller says PEG Ghana is in the process of raising its third funding round. It currently has 8,000 customers and is targeting 40,000 by the end of the year.

Business models

Giving investors what they want is key to attracting investment. PEG Ghana was originally working through microfinance banks, but found itself restricted by limited scope if the organisations it was working with had sprung from an NGO, or the restrictive KPIs imposed by larger institutions. The company switched to a pay-as-you-go model on the advice of its first investor.

Peters says this is happening across the board.

"Barriers to entry in the market are not too low. As a result investors are less keen on models where the business is selling direct to the customer, or simple distribution models, since these can easily be copied," he says.

"There's a move towards investment in PAYG models – where it's initially more complex to set up, and therefore more challenging for competing businesses, but it's easier to claim margins, and maintain more predictability. These are considered safer long-term investments."

The switch to pay-as-you-go has other benefits as well. One hindrance to the uptake of solar, in spite of the long-term savings it creates, is the

Azuri Technologies – an eye on scale

Present in a number of African countries, UK-based Azuri combines solar and technology, and claims its business model enables users to save up to 50% each week and local entrepreneurs to build new revenue streams. Azuri solar home systems use pay-as-you-go technology, with a cloud-based distribution management system allowing customers to pay for their solar and access to training and systems information in real-time from a computer or phone.

The company's model is to work with an ecosystem of distributors, service agents, installers and local entrepreneurs. Azuri believes this end-to-end value chain incentivises all actors to ensure the systems work for the customers.

Azuri CEO Simon Bransfield-Garth says developments in off-grid power mean new distributed generation techniques have the ability to leapfrog conventional approaches. Whereas the cost of solar power systems previously limited adoption, the rapid growth of mobile money services and pay-as-you-go solar power are enabling even the lowest income households to access basic power.

"Over the past five years the costs of batteries, LED lights, and photovoltaic cells has dramatically decreased," he says.

"This means the technology is available, and can be manufactured at a realistic cost. The next step for growth is investment. The technology and business model have been developed to offer these off-grid solutions; it now requires large-scale financing to deliver them to market in high volume."

Deployment at scale remains a challenge, due to factors such as finance, logistics, distribution and customer education. Yet growth is happening regardless, and companies are putting in place the resources to address these challenges.

"The key to scaling is combining global finance and expertise with local knowledge, people and connections," Bransfield-Garth says.

"Azuri's business model is built around in-region partners with extensive in-country networks that facilitate rural reach, and provide a distribution network of local entrepreneurs. Through our partnerships, Azuri has reached isolated rural communities that would otherwise have been inaccessible."

Bransfield-Garth says an example of this was one of its sub-distributors In Kenya, which has grown from a single entrepreneur to a team of six full-time and 50 part-time sub-dealers, installers and top-up card sellers in the space of 18 months.

More finance is necessary, and Bransfield-Garth says the investors that are needed for the sector are those looking for a "compelling return" but also the opportunity to make a difference and accelerate the rate of development in Africa.

"However, in order to move from pilot projects to scale, investors want to see a proven product and business model, from development stages right through to delivering to market, and infrastructure to provide after sales support. The business as a whole has to be commercially viable, not just a particular aspect of it," he says.

He says enabling or supportive policies must be put in place to assist these businesses, such as a zero rate on solar home systems duty and VAT.

"In addition to this it is important that the sector is not constrained by energy sector regulations, enabling the market to grow and expand at its natural pace," Bransfield-Garth adds.



The growth in mobile money and pay-as-you-go solar services in Sub-Saharan Africa is helping low income households access power.

Phaesun – providing continuous power supply

Phaesun, headquartered in Memmingen, Germany, specialises in the sales, service and installation of off-grid PV energy systems worldwide. Given its global presence, the company has reached economies of scale that allow it to operate in seemingly less profitable places.

One example is Eritrea in East Africa, where the local Phaesun subsidiary partnered with German non-profit organisation Archemed to provide a maternity hospital with an Off-Grid Connect System based on Studer components.

The need for a solar solution was typical of the need across much of Africa. The part of the hospital that deals with children's paediatric cardiac surgery and neonatology was previously specifically sensitive to power failure, with the hospital often struggling with blackouts.

Phaesun installed one of its Off-Grid Connect Systems, a PV solution backed up by the grid and the extra diesel generator, and designed to provide 60kWh of daily production. The inverter charger was designed to provide the 42kW peak load. This way, the system can provide around seven hours of power during operation daily without grid or diesel generator, and four hours without sun.

According to Phaesun, the Off-Grid Connect System helps bridge power blackouts with a bank of OPzV lead acid batteries that offers 124kWh storage capacity. This is additionally solar fed with a 14.4kWp PV-generator consisting of 72 200W monocrystalline solar modules. For the power management, components from Swiss manufacturer Studer are used: three Studer VarioTrack 80 MPPT charge controllers, six inverter/chargers Studer XTH 8000 and a remote control guarantee a reliable energy management.



Credit: Phaesun

Phaesun's solar-plus-storage system helped bring reliable power supply to a hospital in Eritrea.

Phaesun said integrating the solar power system with the existing electrical installation of the hospital was the main technical challenge of the project. Specifically, its engineers had to separate the critical loads and make them independent when powered from solar, but still be part of the system during normal operation from the grid. But with these complications eventually resolved by the company's technicians, Phaesun says the system now offers the two hospital wards secure and uninterrupted power supply.

immediate up-front cost. Companies like M-KOPA Solar and PEG Ghana, therefore, allow users to pay over time, in much the same way as they would do with kerosene. It comes with the additional benefit that users are able to build a credit history, often for the first time.

Financing is not the only aspect that needs to be got right, however. Jackson Machuhi, managing director of Barefoot Power, which provides solar lighting and phone charging products, says all aspects of a company's value delivery system must be "optimally mixed" if a business model is to succeed.

He says Barefoot Power has pioneered the Light Up A Village (LUAV) delivery model, which integrates the right product with financing, community mobilisation, installation, user training, support and maintenance, and recycling strategy.

"The absence of one of these elements will hamstring scale at one point," he says, adding that traditional business and distribution models have not yet proven useful in scaling small-scale solar solutions.

"Every successful distribution has included an aspect of process innovation. For example, one distributor of

solar lanterns achieved short-term volume success through schools – a non-traditional channel. Pay-as-you-go is another."

Also key, he says, is transforming the consumer's needs for solar products to wants. "In this analysis a need is a gap, such as light, not compelling enough to make a customer to invest emotionally in a solution," Macuchi says. "A want – such as entertainment or lifestyle – is a much stronger cognitive driver for action."

Barefoot Power has seen a "sharp and sustained" increase in the demand for solar home kits, which bundle television and other lifestyle appliances to the base lighting solution, while M-KOPA Solar has started rolling out solar-powered televisions.

The need for enabling policies

Given the great societal problem being tackled by small off-grid solar solutions, all actors are agreed African governments must implement enabling policies to smooth the process. Peters says it is important off-grid is established in national energy access policies, and that import duties and taxes are removed or frozen to create a more level playing field.

"We'd like to see more VAT and import-duty holidays. In East Africa, namely Kenya and Tanzania, these have definitely helped to grow and support the market," he says.

Machuhi agrees these policies have been helpful in that they lower the end-user price and make uptake more likely, but he feels more needs to be done across the board.

"It has taken too long for governments to embrace distributed solar as mainstream in areas where it is uneconomical to transmit grid power," he says. "One cannot rule out confusion brought about by mini-grid solutions which compete for relevance with small solar solutions."

Some governments look set to go further than Kenya and Tanzania, with Rwanda motivating for a government-guaranteed rural off-grid solar lighting programme. In West Africa, meanwhile, Ghana has been one of the leaders in embracing the potential of small-scale solar in rural areas. The sector may still face some challenges in scaling up in Sub-Saharan Africa, but there can be little doubt that it is gathering a healthy head of steam. ■

Tom Jackson is a freelance journalist.

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Opportunity for micro-grids to light up Africa

Micro-grids | Technologies that allow the connection of whole communities to new generation sources such as solar offer the promise of fast-tracking the electrification of areas not yet served by central grid infrastructure. Tom Kenning assesses the prospects for micro-grids in Africa

There are 1.2 billion people without access to a power grid worldwide, representing a major opportunity for micro-grid developers to take hold of this untapped market. Distributed generation solar systems are emerging as the key technology for bringing electricity to remote, rural and island locations in the world's most under-developed nations. Meanwhile, micro-grids hold the key to supplying this renewable energy across whole communities rather than just to individual households or businesses.

Challenging landscapes and poor grid networks particularly in Sub-Saharan Africa mean that connecting isolated villages to existing grids via massive extensions to transmission lines is often too costly an option. These national grids also tend to be overburdened, which makes decentralised generation an attractive alternative. As a result, the African region has to be a prime target for micro-grid developers. Electrifying communities, which until now have been left in the dark, in a manner that combines renewable energy and micro-grids also immediately brings energy independence to these societies through bypassing any ties with monopoly-holding utilities and network operators; the scourge of many a traditional energy consumer in the developed world.

The 'Off-grid Solar Market Trends Report 2016' from the World Bank and Bloomberg New Energy Finance (BNEF) said the off-grid solar industry is likely to grow fastest in Africa, with 44 million African households forecast to be using an off-grid solar system by 2020. More importantly for a micro-grid developer,

the off-grid population is expected to continuously grow here. The plunge in the cost of renewable technologies has also opened the door for new sources of power for micro-grids, meaning that the reliance on traditional diesel-generators can be curbed. With fantastic solar irradiation in many African countries, solar PV is still likely to be at the forefront.

Benefits

Micro-grids will be the most cost-effective option for electrifying 40% of the world's remote communities, while stand-alone renewables systems are the most economic option for 20% of these populations, says Dean Cooper,

"Off-grid solar is likely to grow fastest in Africa, with 44 million African households forecast to be using an off-grid system by 2020"

chair of the steering committee for the Sustainable Energy For All (SE4All) Clean Energy Mini-Grids High Impact Opportunity Group. SE4All is an organisation that was launched by UN secretary-general Ban Ki-moon in 2011 to promote sustainable energy across the globe by improving energy access, clean energy and energy efficiency. As it happens, micro-grids are capable of helping progress in all three of these goals.

Integrating micro-grids with renewables also mitigates pollution problems for communities that rely on burning kerosene lamps inside their homes and

using disposable batteries for mobile phones.

"If you had to pick a continent where micro-grids make the most sense, you would pick Africa," says Chris Massaro, senior vice president of Maeci Solar, a division of Management and Economic Consulting, which set up a project in Equatorial Guinea (see box). "However, to build micro-grids in Africa is particularly challenging."

In terms of power infrastructure, Africa is mostly virgin territory, says Massaro, so it represents a genuine opportunity to apply long-term thinking to the region's energy security and its rapidly growing demand for power. Relying on cheap gas power in the short term is easy, but in the long run it would devastate the African continent economically, environmentally and in terms of infrastructure, he adds.

The attractiveness of micro-grid projects also increases when they extend beyond the promise of simply lighting up homes, adds Massaro. An integrated approach means power from such grids can be invested in agriculture, commercial fishing projects and manufacturing plants. The micro-grids therefore allow communities to create their own power centres and create business opportunities.

Supportive policy

Such a novel market requires policy drivers and financing, while a stable policy environment is the most critical factor for financial investors, says Cooper. Investment in any sort of renewable energy technology is capital intensive and the upfront cost of solar PV on the basis of making savings over an extensive period between 10-25

years means that investors want to be absolutely sure that the pricing of feed-in tariff subsidies and other supports will stay in place for the duration of any contract.

Government activity can pose a risk. For example, Cooper worked with EDM, the national utility in Mozambique, on a project that had to be delayed during elections and has still not seen any movement on the ground despite two years of planning.

One way of addressing that upfront risk for investors, who are deterred from unknown African or Asian markets, is to encourage public sector funding to offset the upfront costs, says Cooper. Providing a basic electricity service to a rural population should also justify such government contributions.

"If you get a public sector kick to start things off, then it does seem possible for the private sector to take over and implement a commercially viable business model and that gives it sustainability," he adds.

Another positive for the sector is that larger financing organisations such as the African Development Bank and the World Bank are beginning to get involved in micro-grid schemes, however scalability of micro-grid

opportunities remains a key issue for attracting private investment.

Scalability

Technology venture Powerhive's micro-grid project in Kisii, Kenya (see case study, below), which was financed by US-based developer and manufacturer First Solar, was able to collect end-customer usage data digitally over a period of two years using a pay-as-you-go (PAYG) model. This was a key factor in bringing transparency to micro-grid applications and it allowed the operators to demonstrate the benefits of the system to the regulatory bodies.

"In Kenya there was not a ready-made policy framework," says Marc van Gerven, First Solar's vice president of global accounts and strategic marketing, "but the data-richness of the Powerhive project showed enough capacity, promise and satisfied customers that the regulatory bodies were able to act relatively quickly [...] to put in place the requirements for Powerhive to go the next level of scale."

These requirements included obtaining a utility licence from the regulators and a concession. The project was then sold to Enel, which was then Enel Green Power, allowing for further scalability.

The consumer

Many micro-grid developers are looking at the market from a top-down perspective, which does not necessarily prioritise the needs of the potential consumers, warns Cooper.

Villages in Africa often have single areas of dense population with the rest of the village spread out. This makes a micro-grid located at the centre of the community the most cost-effective option, with stand-alone systems for many of the outliers.

"There is no point in putting a mini-grid into a community which serves the needs of 50% of the population but alienates the other 50%, or causes displacement of the population," warns Cooper. "Everybody wants to get connected so everybody tries to come into the middle space."

As a result, there may be a need for an international body to investigate what the true needs of locals are and to develop a model incorporating a customer-driven approach, Cooper adds.

Technology advances

In any case the potential for introducing new technologies is plentiful. Powerhive's sole focus is on remote

Powerhive's data-driven approach in Kisii, Kenya

Powerhive has focused its micro-grid solutions on small rural communities in western Kenya. It recently completed over two years of field testing while pioneering the delivery of locally generated electricity in Kenya's Kisii province, where over 90% of the population does not have access to electricity.

Under its pilot programme, customers were able to pre-purchase electricity for commercial and residential use through mobile banking services.

Deployments in four villages were operational during the field tests, with a total generation capacity of 80kW, benefitting over 1,500 people. Users included residents and small businesses carrying out services that were previously unavailable such as maize milling, welding, incubating chickens and hair salons.

Having learned from its initial experiences, Powerhive has managed to bring its platform from mostly smart metering functions to be able to perform load balancing and grid management solutions as well as detecting theft.

Powerhive's portfolio now includes the Honeycomb cloud-based remote monitoring and control platform, the Asali smart meter and the Site Wizard for Analysis, Reconnaissance, and Mapping (SWARM) project development tool.

Rik Wuts, co-founder and vice president of business development at Powerhive, explains that the firm can now provide internet to its customers. Meanwhile it is currently working on predictions based on weather patterns in order to manage the grid accordingly.

Wuts says: "We have a huge amount of data that very few people in



Powerhive has used its technology to start gathering potentially invaluable data on customer power consumption habits.

this industry actually have as to how people consume: how much and at which points of the day and which kinds of devices they use. This is super useful in terms of modelling and designing the actual grid infrastructure at the same time."

After its successes, Powerhive became the first private company in Kenya's history to receive a utility concession to generate, distribute and sell electricity to the Kenyan public last February. The company now plans to expand its coverage to over 200,000 households in Kenya.

Wuts adds that energy storage is expected to come increasingly into the micro-grid space and it is an industry that Powerhive is following closely.

rural areas, where in most cases locals only have access to 2G internet or none at all. Only very few already have 3G internet. Consequently, the firm is looking at providing high-speed internet at very low cost in combination with the micro-grid, says Rik Wuts, co-founder and vice president of business development at Powerhive.

The firm focuses almost entirely on solar although reliable diesel generators can be used for backup. While the option of batteries is currently very expensive, the prices are coming down consistently and the technology is improving.

The main technological innovation being applied in the Powerhive system is the PAYG billing and net metering and a software tool used for siting the project locations, says Van Gerven. The software uses a Geographic Information Systems (GIS) algorithm to find locations for the grids. The data richness coming from these PAYG platforms also allows the operator to demonstrate having a secure off-take even without a central power purchase agreement (PPA). So the main value of PAYG systems is really being able to understand the customer requirement by gathering data.

"The market has to be transparent," adds Van Gerven. "There cannot be subsidies around that mask the true cost to the end customer."

How the micro-grid market pans out across Africa may depend on the various policies from different governments. Cooper says SE4ALL is focusing its efforts on Kenya and Tanzania, which are supportive of solar home systems. Elsewhere, Mozambique's Department of Energy and Development is working on the micro-grid sector and Ghana and Senegal have also shown promise. Meanwhile, South Africa acts as a strong location to demonstrate new applications of the technology.

Ultimately this technology has the potential to provide both energy security and energy independence to some of the most underprivileged societies in Africa, right from their very first encounter with electrification. But as a nascent market, its trajectory is unclear for now. ■

Largest self-sufficient solar project in Africa at Annobon Island

Residing 315 miles off the African mainland, the 5,000 inhabitants of Annobon Island, part of West Africa's smallest nation, Equatorial Guinea, are used to receiving just four hours of electricity per day. As a result, the government was considering running a US\$2 billion cable from the mainland all the way to the island. However, a micro-grid project connected to solar PV is set to transform the island into a 24-hour powered trade centre at a fraction of the cost.

In 2014, the government of Equatorial Guinea selected Maeci Solar, a division of Management and Economic Consulting, in collaboration with GE Power & Water and Princeton Power Systems, to install a 5MW solar micro-grid system on the island aimed at supplying 100% of the island's energy needs.

This island has strategic importance for Equatorial Guinea as offshore oil drilling is located nearby and there are plans to support commercial fishing on the island by introducing suitable refrigeration capacity, says Chris Massaro, senior vice president, Maeci Solar. To do this, the island's ageing power generators must be replaced.

Major challenges included having to have all the equipment delivered from overseas and the lack of flat terrain, which made installation difficult.

"We have had to ship everything that you could possibly think of," says Massaro. "There is no home depot hardware store. Everything we have had to think about in advance from boots for the workers to components from GE."

The firms also had to factor in a lot of duplication as there is nowhere to source equipment spares should something go missing or get damaged.

The grid will be situated in three main locations – at an airport, a hotel and on a mountain. The locations mean that if there is higher demand on one side of the island, power can be redistributed accordingly.

The battery storage devices from GE should enable the micro-grids to produce power 24 hours a day, but generators will be used to back up the entire system in the event of an override of power, says Massaro, although an override is not anticipated. Using the batteries can bring the system capacity from just 5MW to 10MW overall.

Massaro adds: "Equatorial Guinea is an oil-producing country. They've had their budgets slashed from US\$100 a barrel to US\$30 so it is challenging for them to continue to finance high-priority projects, because of the rapid drop that is very similar to what's happening in Russia, Angola and Venezuela – any country that produces oil. They are all having that budgetary squeeze."

"The whole philosophy of the government was to power a renewable energy project with oil revenue which is an interesting model; we are going to use our oil to establish an economy and power source that will be there after the oil reserves are exhausted."



The micro-grid project in Equatorial Guinea has helped avoid the need for a costly new grid extension project.

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Managing large-scale expectations

Utility and commercial PV | Big promises and big ambitions have clogged up the utility-scale solar pipeline in parts of Africa. The commercial-scale sector has found success by choosing the best off-takers and now with grid improvements underway and a policy re-think, bankable projects are on the way. John Parnell reports



Credit: Gigawatt Global/SunFunder

Solar deployment in Africa has been dominated by rural electrification, solar lamps and pay-as-you-go systems. But in an era of rapid urbanisation, and with developing economies across the continent increasingly hungry for power, larger projects have a lot to offer.

Challenges in the form of grid constraints, accessing finance and developing effective procurement programmes at a state level are among the challenges faced by developers looking to deploy commercial and industrial (C&I) or utility-scale solar PV, particularly in West Africa.

Governments have been broadly praised for their efforts to create solar-friendly legislation, particularly for enabling power purchase agreements (PPAs). That said, earlier attempts to kick-start solar have also inadvertently created headaches, some that are still

being righted now.

Perhaps the most acute example of this is in Ghana. The announcement in 2013 that the country would offer utility-scale projects a feed-in tariff of US\$0.21 kWh, comparable to the UK's residential FiT at the time, triggered a deluge of projects. According to UNEP's Green Economy and Trade Opportunities Project (GE-TOP), the country's energy commission was sitting on 76 provisional licences for renewable energy projects, 52 of them for solar. These added up to more than 2.5GW of capacity. The total installed capacity of Ghana's entire electricity grid in 2014 was around 2.4GW. At the same time, grid constraints mean new solar PV capacity is capped at 150MW.

So far, just one 20MW project is under construction.

"What the government of Ghana did after it received a lot of applica-

tions is that they turned their FiT into more of a competitive tender system in order to accommodate the 150MW cap for solar PV," says Lennart Kuntze, from UNEP's trade unit, and who leads GE-TOP work on Ghana. He points out that the FiT, like any other similarly structured incentive, doesn't account for what capacity the grid can accommodate. This means looking at that first and working backwards can be a good approach.

"Looking at that larger picture, knowing what can be integrated [on the grid] can really inform how many provisional licences can then be turned into approvals to move ahead with certain projects," he says.

Kuntze's project believes the Ghanaian grid could accommodate 220MW of solar PV by the end of the year with little or no additional improvements, an advance on the government's cap of 150MW.

"Then gradually, in the next few years, through these grid improvements, you can further increase that share of solar capacity," he explains.

"As additional base load and dispatchable generation is added to the existing installed capacity, it is expected that the grid will become sufficiently robust to accommodate more variable renewables," he adds.

The damage from these early teething problems is still being undone. Tassos Christakis is project director at Solarcentury Africa. He argues that the misstep with Ghana's FiT and its effective closure, before any successful companies could develop projects, has had wider implications.

Scatec Solar's 8.5MW Rwanda project is so far Sub-Saharan Africa's only utility PV plant outside South Africa. But other countries are expected to join the utility club soon.

"That effectively killed the credibility of the market and that's why for instance in Ghana, there has not been much development in the last three or four years, or installed capacity as such," he says.

Grid first

Ghana is the hub nation of the West Africa Power Pool, a project to develop a regional grid through a series of inter-connections. Improvements in Ghana itself will increase the grid's capacity by a factor of four (see box).

Paul Francois Gauvin heads up developer Scatec Solar's France and West Africa unit. He agrees that the grid is a crucial constraint but argues the fate of a project's future is determined by another factor.

"Generally, the key and critical point for a project in West Africa is the availability, quality and capacity of the grid to absorb large-scale [solar]. That is clearly something that is an issue and a limitation to the expansion of renewable energy in West Africa. It is the second issue, after the bankability of the off-taker," says Gauvin.

He says that the regulatory framework in West Africa has greatly improved. PPAs are gaining support in most energy markets, and Nigeria, the biggest economy in the region, is in the final stages before it is ready to offer "recognised PPAs".

"Recognised means bankable in a way. Everything has to be bankable. It is one thing to have everything available through a [policy] framework or the willingness of governments or state policies on renewable energy but the key word here is bankable. This is our master word when we are in all of those countries," Gauvin says.

Bankability

Finding finance for a project is reliant on all parties' confidence that the end customer will be able to fulfil the terms of a long-term PPA. Investors will be looking at risks associated with currency, the state itself as well as the creditworthiness of the purported off-taker.

Just as flabby FiT offerings attracted companies to markets in which they had little chance of developing a project, finding a PPA partner before

doing the rest of the pre-development work is another way that companies with less chance of bringing a project to fruition can clog up governments' capacity and muddy the waters for bona fide developers.

"When you announce something, even if you sign PPAs, it doesn't mean you have signed a bankable PPA. We have examples almost every day when we see a PPA has been signed but you can tell very quickly if it is bankable or not," says Gauvin.

So what about the myriad memoranda of understanding (MOUs) that emanate from Africa, India and other emerging markets?

"MOUs!? That's the worst! There are still some ministers and ministries that like to have announcements with MOUs and I am not sure if they know or maybe they do know that this will not be followed by an actual project; that is difficult to understand. It's a pity because it is against the credibility of the solar sector and the whole renewable industry."

Scatec Solar expects to start construction on a 33MW project in Mali later this year with a number of factors helping it to achieve bankability. One major factor is the relationship it has with IFC InfraVentures, part of the World Bank Group. The project is expected to be the first utility-scale solar project in West Africa.

"Development banks remain absolutely key," says Gauvin. "Development banks recognise developers of a certain quality and you can move together with the development banks to structure the deals to make it bankable."

In the case of the Mali project, Scatec will take a 50% share in the project, IFC InfraVentures a 32.5% stake and local developer Africa Power 1, a 17.5% share.

"This project will represent three to five percent of the capacity of Mali's on-grid electricity production so it is quite significant. We believe it is very much a learning process for the whole sector, off-takers, grid operators, also lawmakers and so on," Gauvin adds.

Commercial and industrial

Like utility-scale projects, the commercial and industrial sector is reliant

on the bankability of the off-taker, but in their case, those off-takers are substantially smaller than state-run utility companies. Before bankability problems can be solved, Solarcentury's Christakis says there is an element of customer education that must be done.

"The smaller projects usually have a local business as the off-taker so there is sometimes a lack of understanding on solar that protracts the process," says Christakis. "Most of the time the difficulty there is in the contractual arrangement, because most of the businesses do not have the money to pay up front so they want a lease or a PPA. But a PPA is typically 20 years and that can make them uncomfortable because they are used to short leases, so how do you make it work?"

David John Frenkil is the managing director and founder of Centennial Generating in Rwanda, where the market is more stable than in West African nations. The company has just completed a commercial system that will provide power for the Rwanda Genocide Memorial in the capital city, Kigali.

"The real challenge we find is educating the customer on solar PV. Right now the understanding of solar to the average consumer is that it will heat your water. The idea that it can be evenly distributed throughout your facility instead of being limited to one of two things, either your hot water heating or your lighting, is really just a consumption education process that we will have to go through in the next few years," he says.

The Rwandan market offers a number of lessons for West Africa as it looks to develop a C&I solar sector. In particular, Frenkil has worked to develop bankable PPAs in order to find financial backers for installations.

"You need creditworthy PPAs in order to have bankable deals. We work with an insurer that actually provides an insurance product that helps to mitigate the credit risk. What that product also does is it standardises the credit risk because you're working with the same credit-worthy insurer," explains Frenkil.

"So the insurer has its own method for determining the creditworthiness



Credit: Centennial Generating Co.

of customers who are local. These typically are not multinational companies that have investment-grade ratings and they certainly aren't US individuals with FICO [credit] scores."

An additional benefit of using the same insurer to bolster contracts is the effect it has in making those contracts more uniform.

"The reason it is important that it is standardised is because we are aggregating relatively small systems ranging anywhere from 15kW up to megawatts. Individually, a project is not interesting to investors because they are looking to invest seven-figure sums but in the aggregate these are actually pretty interesting portfolios that we are creating. That's why standardisation is important because we aggregate projects to synthetically function as one project at the portfolio level. To do that we need standardised documentation, the credit profile that we use in our process for the installation and also the O&M," Frenkil adds.

Top-down policies

Between the US-sponsored Power Africa programme, the UN's Sustainable Energy for All and the trickle-down effect of climate pledges made in Paris, not to mention the several sustainable development goals that touch on energy issues, there are a lot of high-level initiatives looking to stimulate renewable power development in Africa.

"At Centennial," says Frenkil, "we

hope to see more emphasis from Power Africa on two areas: first, projects which improve energy access that also treat the utility as a complementary partner as opposed to the competition; and, second, job creation that endures even after a project's commercial operation date."

Scatec's Gauvin praises the initiatives aimed at rural electrification but believes that the complexity of larger projects and the issues he highlighted earlier, such as the bankability of the off-taker and grid constraints, don't disappear.

"For large-scale projects it is a bit different; of course if you bring additional money to the financing of those it is always good, but you can see through what I said that countries have quite a few issues with bankability of the off-takers and the grid. To have more large-scale resources to deal with these issues will not yield immediate results."

Momentum in the region is undoubtedly building and while the absence of headline-grabbing FiT rates and multi-MW project announcements might create the illusion that there is little activity, the reality is that essential background work is creating the platform for future deployment.

Resilient grids serving cross-border markets, the successful operation of the first projects and ongoing efforts to educate commercial end-users will all sow the seeds for the region's solar future. ■

The PPA model behind Centennial's commercial system in Kigali, Rwanda offers lessons to other parts of the continent looking to execute similar projects.

Making the West African Power Pool a reality

One central piece of work carried out by UNEP could go some way to delivering the grid infrastructure required to support solar's development in West Africa.

Lennart Kuntze will present the findings of the GE-TOP strategy proposal at the Solar & Off-Grid Renewables West Africa conference in Ghana on 20 April 2016. The proposal is set to examine the technical and financial requirements for grid infrastructure projects in the region and present best-practice guidance on the development of further "solar-ready" transmission projects.

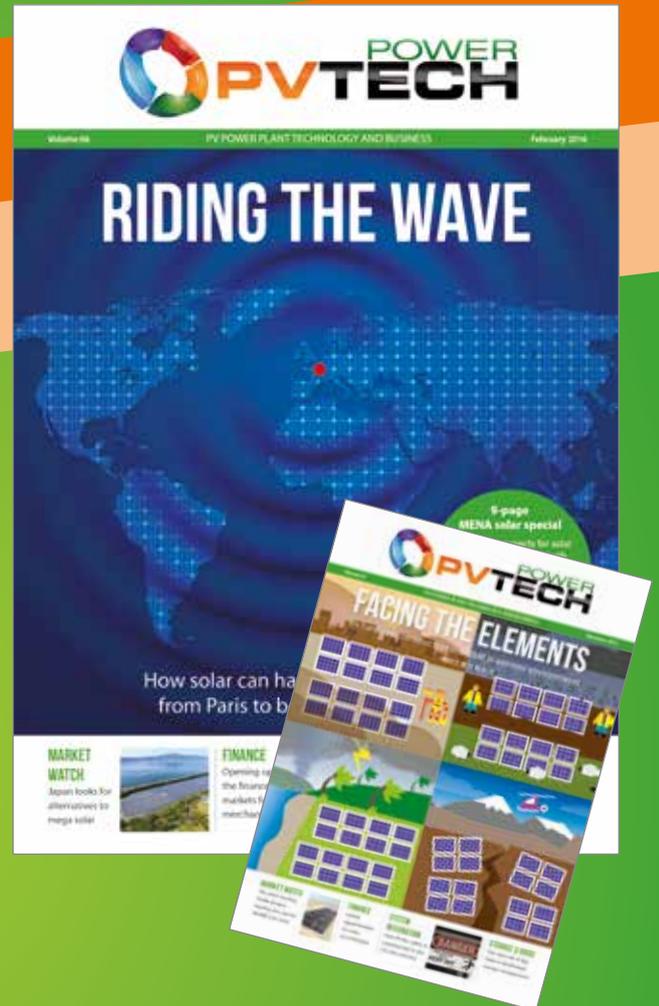
"The West African Power Pool (WAPP) vision is to develop a regional power market and to develop joint supply infrastructure between the different sites," explains Kuntze. "The WAPP includes numerous cross-border projects including the 225kV line that is being built between Ghana and Burkina Faso and will greatly increase the transmission capacity between the two countries."

The 225kV line, from Bolgatanga to Ouagadougou, is expected to be operational at the end of 2017, according to Kuntze, and, jointly with another planned 225kV line, would be able to transmit 400MW of power between Ghana and Burkina Faso. He describes Ghana's energy exports as the lynchpin of the WAPP plan. There are currently five cross-border connections between the two countries but the GE-TOP study has estimated that this currently amounts to the equivalent of 10MW of power capacity.

The report will also include recommendations for solar deployment for the benefit of the grid such as construction close to hydropower plants that offer the opportunity for balancing.

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