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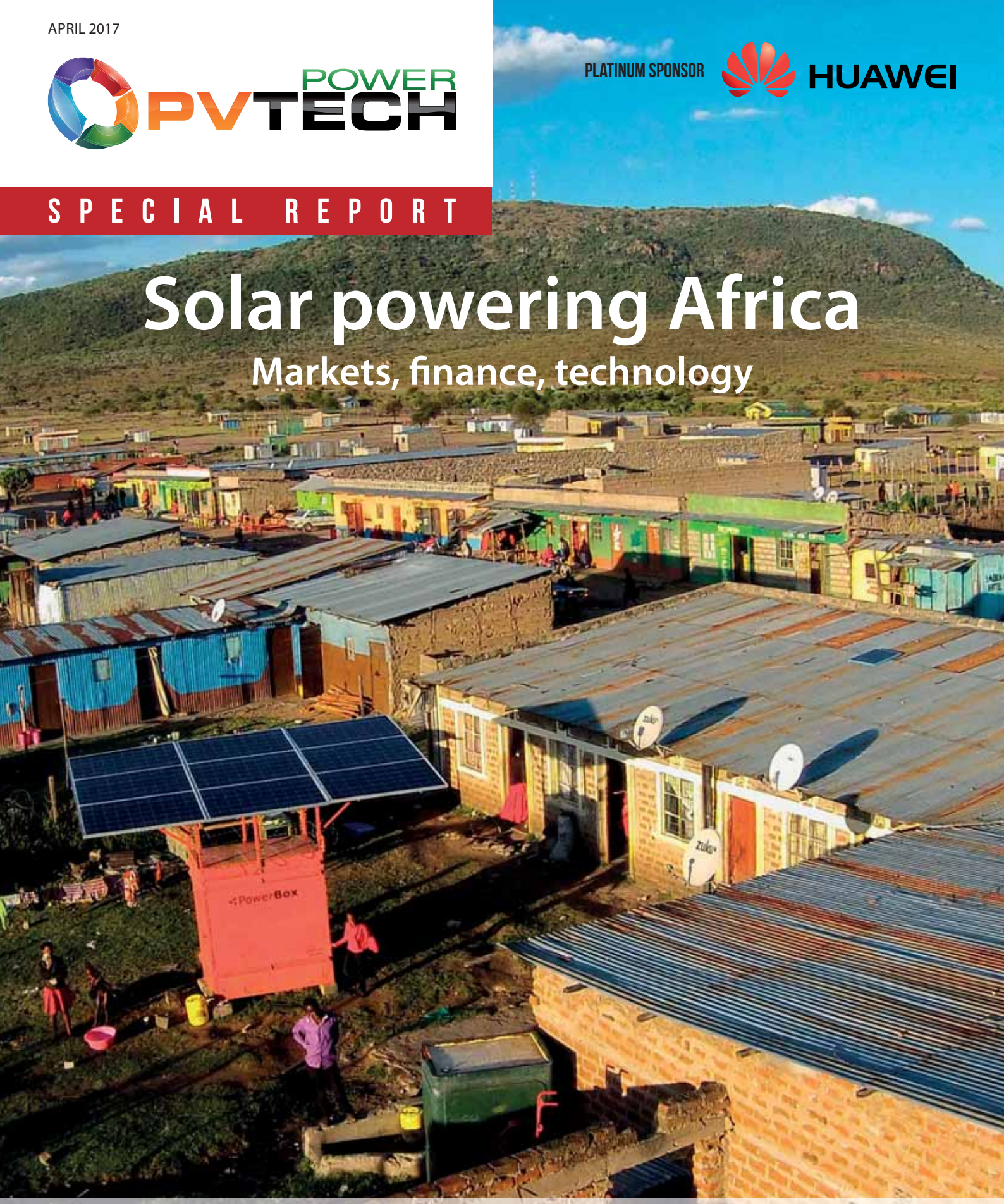
SPECIAL REPORT

Solar powering Africa

Markets, finance, technology



Large scale
Africa's utility solar hotspots

Off grid
Solar's growing role beyond the grid

Finance
Bridging the investment gap in commercial and industrial solar

Logistics
Planning, building and operating successful PV projects in Africa



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Editorial
Head of content:
John Parnell
Supplement editor:
Ben Willis
Reporters:
Tom Kenning, Danielle Ola

Design & production
Design and production manager:
Sarah-Jane Lee
Production:
Daniel Brown

Advertising
Sales director:
David Evans
Account managers:
Matthew Bosnjak, Graham Davie, Lili Zhu

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Cover image: A solar micro-grid provides power to a town in the Masai Mara region of Kenya.
Photo courtesy of SunFunder

INTRODUCTION

This *PV Tech Power* special report is a unique industry resource exploring the trends shaping the fortunes of PV in Sub-Saharan Africa, a region that harbours some of the world's most promising emerging solar markets.

Since we first published the report last year, the region has notched up a number of significant milestones, including the completion of new utility-scale plants in Senegal and Uganda, a price-busting auction in Zambia and the signing of a bundle of significant PPAs.

There has been progress too in the commercial and industrial space, with Kenya seeing its largest industrial PV hybrid plant reach completion. Meanwhile, in the off-grid and isolated-grid space PV is enjoying an increasingly prominent role as a key plank in efforts to achieve universal energy access in what has historically been the world's most power-starved region.

But many of the problems that have prevented solar fully taking off in Sub-Saharan Africa still remain. Investment bottlenecks, political and regulatory uncertainty and difficult operating conditions are just some of the challenges the solar industry continues to face as it seeks new opportunities in the region, and which are explored in depth in this report.

On p.8 we look at the progress made in the large-scale segment and why West Africa is emerging as a particular hotspot for utility solar projects. On p.12 we look at the commercial and industrial sector, with a particular focus on the new business models emerging to support it. Off-grid and mini-grid applications come under the microscope on pages 15 and 18, and on p.22 we explore some of the innovative solutions being developed to aid the planning, building and operating of PV plants in Africa.

The overall message is that solar is only just at the beginning of its journey in Africa. But bearing in mind the progress that has been made since this time last year, only the silly money would be against the region having made several further leaps forward 12 months from now.

John Parnell
Head of content

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Falling costs pave the way for African solar boom

Markets | The steadily improving economics of solar have made its case in Sub-Saharan Africa unassailable. But with regulation and investment still playing catch up, policy makers and industry have a job on their hands to take it to the next level, writes Ben Willis

The theoretical potential of solar power in Sub-Saharan Africa has rarely been in doubt. Some 600 million people on the continent lack access to electricity, with many more served by only sporadic and often costly power. With centralised grid infrastructure unlikely to reach some communities any time soon, the ease of deploying PV coupled with Africa's rich solar resources make it an attractive technology in unelectrified areas. For countries looking to bolster the capacity of their grids to keep up with burgeoning demand, meanwhile, utility solar looks like an increasingly cost-effective solution.

Indeed, it is PV's consistently downwards cost trajectory that has helped it chip away at some of the many hurdles it has faced in gaining a toehold in Africa and begin to realise some of its huge promise in the region. Falling costs across the board have been the main factor behind a marked shift in the narrative of solar in Africa even over the past two years, with significant projects hitting the ground and new players entering the scene. The most recent figures from the International Renewable Energy Agency (IRENA) suggest that total installed capacity in Africa jumped from around 500MW in 2013 to around 2,100MW at the end of 2015.

"In recent years, solar PV costs have dropped dramatically and will continue to do so with further declines of up to 59% possible in the next 10 years," said the International Renewable Energy Agency's (IRENA) director-general Adnan Amin to mark the publication of a report towards the end of last year looking at the costs of solar in Africa. "These cost reductions, coupled with vast solar potential on the continent, present a huge opportunity for Africa. Both grid-connected and off-grid solar PV now offer a cost-competitive means to meet rising energy needs and bring electricity to the 600 million Africans who currently lack access. It has never been more possible, and less expensive for Africa to realise this potential."

Sub-Saharan Africa is better placed than ever to capitalise on the opportunities offered by solar

Falling costs

Nowhere has the fall in costs been more apparent than in the utility-scale segment. Here, South Africa is held up as the role model, and the chart in Figure 1 shows how steeply that country's successful independent power producer programme drove down the prices being bid for utility PV over a relatively short space of time. For several years South Africa was the only utility PV market of note in Sub-Saharan Africa. But then in mid-2016 Zambia came out of nowhere with a record-breaking tender price for Africa of around US$0.06 per kilowatt hour, suggesting that other countries have been watching and learning, and the industry is doing its bit to educate decision makers about what it can offer if given the right conditions to take root.

Several further tenders are expected in the region soon, indicating that utility PV has now passed the proof-of-concept phase in this part of the world and is gradually reaching if not maturity perhaps, then certainly a wider level of acceptance.

According to IRENA, in 2015-2016 the cost range for utility PV in Sub-Saharan Africa is anticipated to be US$1.3-1.4 per watt. "If the projects targeting US$1.3/W in installed costs can be built to budget, this would represent a very competitive level for Africa, given the estimated worldwide weighted average for utility-scale projects of US$1.8/W in 2015," IRENA said.

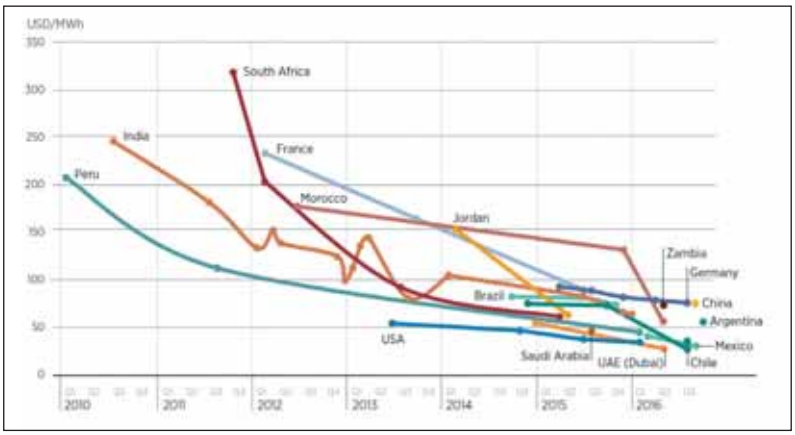
The picture is less clear for smaller off-grid and decentralised systems due to the paucity of available data but appears to be positive. Figures show a wide variance across the region in the range of prices for such systems depending on location and the technology: sub-1kW home systems can cost anywhere between US$4 and US$16/W, more if they include batteries; systems above 1kW cost in the range of US$2.5-7/W. But according to IRENA, small stand-alone solar systems providing power for individual households can be offered for as little as US$56 per year, less than the price they would pay for the generally poor quality energy services currently available.

Meanwhile, for solar mini-grids above around 200kW IRENA puts the installed cost at US$1.9 to U$5.9 per Watt, less than older systems that came online before 2012. Ongoing decreases in PV module and battery prices mean there is still plenty more headroom for cost reductions in mini-grid systems, opening the technology to new applications and driving further uptake.

Another area of promise for the region is the commercial and industrial (C&I) segment. This has seen some notable projects installed in the past couple of years, driven mainly by the smart new business models that have been developed specifically to support C&I installations. Some believe that this segment has perhaps the greatest potential in Sub-Saharan Africa given the growing demand by businesses for reliable, affordable power and the fact that projects can take place outside of any government tender or subsidy programmes.

Sitting behind most of the advances made by solar in Sub-Saharan Africa are of course the general dynamics familiar to any observers of the global solar industry: cheaper hardware as module and balance-of-system technologies improve, lower costs of finance, reduced 'soft' costs as processes become more streamlined and the general efficiencies that develop as businesses get better at doing what they do.

Figure 1. African utility solar auction prices in a global context



Credit: IRENA

There have also been some targeted efforts to support the take-up of solar in the region, which are now starting to bear fruit. One key intervention that looks likely to play a continuing role in the utility-scale market is the International Finance Corporation's Scaling Solar programme. This was devised as a means of unblocking some of the pinch points that have historically stymied the flow of private investment into independent power producer projects in Africa generally and solar specifically. The programme is only two years old but has already made its mark, having been a key catalyst for the Zambia tender referenced at the start of this article. Further tenders are expected as other countries sign up to the programme.

> "Cost reductions, coupled with vast solar potential on the continent, present a huge opportunity for Africa"

But there is still a long way to go. IRENA's REthinking Energy 2017 report published in mid-January 2017 suggested that to reach universal electricity access by 2030, Africa will require generation capacity in the on-grid, stand-alone and mini-grid segments to be boosted by 42%, 17% and 40% respectively. Clearly PV is just one of a number of technologies that will play a role if those targets are to be met, but if recent performance is anything to go by it will be a major contributor. IRENA estimates that by 2030 the region could be home to more than 70GW of solar, a figure that dwarfs the 2.1GW installed by the end of 2015.

Getting anywhere close to this number is going to require a concerted effort by all the key actors – regional institutions, national governments, regulators, finance and development institutions, and of course the solar industry itself. It would probably be fair to say that so far supportive policies to help solar grow have been relatively slow to come forward in Sub-Saharan Africa, or where they have been put in place have faced teething problems.

Ghana is a good example of this. In 2011 the West African country put in place what looked on paper like a generous feed-in tariff for solar to underpin efforts to get to a 10% share of renewables in the energy mix by 2020. Unsurprisingly the tariff attracted huge interest, with developers applying for projects totalling well over 3GW. This was far more than the Ghanaian national grid could handle, forcing the government to impose a temporary cap of 150MW of utility solar and to restrict individual projects to 20MW. So far there has been little sign of that situation easing, although Ghana does have two relatively modest utility-scale PV plants online.

Such difficulties are likely to be a recurring theme across the continent, particularly in the utility segment. Some argue that for this reason, solar in Sub-Saharan Africa is in fact better suited to off-grid applications where grid constraints are not an issue. But the likelihood is that solar will play an increasingly important role at all scales, and will be greatly aided when the cost of battery storage comes down sufficiently to help it overcome some of the intermittency and grid stability issues that are currently limiting its uptake.

On the following pages of this special report, we look at the progress being made by the key solar segments in Sub-Saharan Africa and the challenges they continue to face. In particular we examine in detail the technologies, business models and supply-chain innovations that are helping solar find its way into new markets and start to fulfil its potential. ■

Simple is best in Africa's challenging conditions

Supply chain | Smart inverter manufacturer Huawei, the Platinum Sponsor of this special report, is looking to play a leading role in Africa's burgeoning solar markets. Paul Pan, general manager of the company's Smart PV Business in the Middle East and Africa, tells Ben Willis where the biggest opportunities lie

In 2016, analyst firms GTM Research and IHS named Huawei the world's largest inverter supplier by shipments for the third year running. In a relatively small amount of time, the Chinese multi-national ICT company has risen up the global rankings courtesy of its FusionSolar Smart PV Solution, on the way displacing much longer established players.

After securing a firm foothold in its home market, China, Huawei made a successful entrance into Europe, Japan and North America, and is now looking to make inroads into the world's emerging solar markets. Among these is Sub-Saharan Africa, where Huawei's simple, easily deployable yet robust inverters look well suited to the region's frequently challenging conditions.

PV Tech Power: What is your interest as a company in Sub-Saharan Africa and what steps are you taking to establish a presence here?

Paul Pan: We have done extremely well in China and also in Europe, Japan and North America – so in the relatively advanced markets. But also in 2016 we made very good progress in the emerging markets like India and also started working in the Middle East. And in Africa we have made some progress and that will be our next key market in the years to come.

What we have in this region now is three offices established. Two, in Dubai and Egypt, will be our headquarters for the whole Middle East and Africa region. And then we also have an office in South Africa; from there we will cover Sub-Saharan Africa. Apart from that we have developed several channel distributors mainly focusing on the smaller projects in this region.

What are your plans for Sub-Saharan Africa and where do you see the biggest opportunities?

Africa is one of the richest regions for solar energy, but half of the population – maybe more than half in the Sub-Saharan area – is not provided even with basic electricity services. And also the grid establishment in the region is still relatively poor compared to other continents. It's also largely unbalanced, meaning some countries are pretty good and some countries are really poor. We are talking about countries having still less than 10% grid coverage, which is virtually nothing. So in that contradiction we see opportunities.

The first one comes from utility-scale projects, which mainly happen in grid-rich countries like South Africa or countries which are medium-grid-rich, like Nigeria, Kenya, Senegal or Ghana. Those countries have announced certain plans for building solar power using the PPP partnership model and that is one of the key focuses for us right now – going after the utility-scale projects.

Credit: Huawei

Huawei's FusionSolar Smart PV Solution has been used in an 11MW grid-connected project in Senegal

We also see significant demand in the off-grid and mini-grid market, which is emerging. When you go into this category normally people are comparing the cost of electricity using diesel power as a benchmark. The good news is that the overall solar electricity cost has been coming down quite significantly in recent years and this is becoming a trigger for off-grid and mini-grid opportunities in this region. We also expect that this is going to grow quite significantly.

And the third, which is rather a niche market, is those traditional support services for poor people, but now powered by solar – for example container clinics and so on. It's beneficial to use solar for these because you can get power wherever you go.

What are you doing to turn these opportunities into business?

We have made some progress in the past couple of years on this. On the utility-scale side late last year we had an 11MW plant come on grid using our inverters. This is establishing a good benchmark for us in the utility-scale market in Sub-Saharan Africa. This project is in Senegal and came online early in Q4 last year. At the same time we are engaged in multiple other projects in South Africa, Ghana and Kenya. Some of them are at final negotiation stages; some of them are at an early stage of development.

With the off-grid/mini-grid market, again we've also built a very good reference case in Cameroon. We're working

together with the government and supporting more than 1,000 villages to supply solar power to those villages. And the project has been ongoing for two years, and most of these villages have been covered – these are highly appreciated by the government and of course by the villages. In parallel we're supporting a number of projects in the continent with different capital resources and also the developers. And some of them are also linked with remote education or remote medical services.

How is Huawei's technology suited to applications in this region?

First of all it's very easy to implement. In Africa many of the plants are remote, and in terms of transportation and installation, the conditions are not so perfect – you don't have big roads, you cannot get parts easily to the plant. Our solution is small, and versus some of the traditional solutions, which are centralised, huge cabinets, you can ship it with any vehicle – maybe even a bike! You don't need big roads, you don't need big container trucks and it can also be installed very easily.

The solution also fits very well in the Sub-Saharan Africa weather conditions. In this region we see a huge variety of weather: some of the areas are desert-like and dusty; some have very high humidity, high temperatures and very salty air if they're close to the seashore. And our IP65 protection design, which is pretty much unique in the industry, gives protection against all those conditions: the dust cannot come in, the wet cannot come in and it's protected against the salty air. So you can implement it in any conditions in Sub-Saharan Africa. In the past several years we also had scattered projects here and there in the Middle East and Africa and some of them have been running for over three years; through those we have proven that we can fit into all of those conditions very well.

What feedback have you had so far on the performance of your solutions deployed in the field?

The Senegal project has not been long enough on the grid for us to have any solid data to show yet. And yet on the verbal feedback I've collected, they are very happy with our solution, for a couple of reasons. One is it's very stable, so during the installation phase there have been no failures. And two, it's very easy to maintain – so even with just a low-speed internet connection you can transmit all the data from the field to the cloud and then the expert engineers can see remotely and have visibility on all the situations on the ground. Then through this remote control and remote communication you can notify the engineers and dispatch them with the necessary action items so they can fix problems in the field.

> "Our solution is small and you can ship it with any vehicle – maybe even a bike!"

Another thing they like very much is that we have only one type of spare part in the field. So people won't get confused with tens of different modules and which one should be replaced; when a problem happens they just take the spare machine to the place and replace it, and send the faulty module back to us. So you don't need experts, there's no confusion and you can control it remotely.

Finally, on yields, the power generation, according to what we have observed now, we think we are fairly beyond the designed performance. And yet we are trying to collect more information.

What are your hopes for how the market will take off in Sub-Saharan Africa and where will you be focusing your energies?

In the near term we will have a lot of focus on the on-grid opportunities particularly in South Africa, Kenya, Nigeria, Senegal and Ghana. These are the main countries in my mind. And yet personally I still believe in the long run the off-grid and the mini-grid option is going to be the mainstream – or at least a half-half distribution of the market. So this is the area where we are now establishing the reference projects, supporting the early pilots and also at the same time understanding the market and exploring the best business models here.

Huawei's technology has been designed to withstand the harsh conditions found in parts of Africa

Credit: Huawei

Utility solar finally on the African map

Credit: Green Africa Power

Utility PV | After many years of talk, the first large-scale solar plants are reaching completion beyond regional torch-bearer South Africa. Ben Willis reports on the ongoing efforts to help utility PV take root in a part of the world where it makes perhaps most sense but still faces significant hurdles

Last June, surely more than a few eyebrows would have been raised when a solar tender in the southern African country of Zambia registered a new record low price benchmark for the region of a shade over 6 US cents per kilowatt-hour. Not only was this the first time Zambia had had any significant plans for utility solar on the table, but here were two projects attracting bids from heavyweight international players – Italy's Enel and France's Neoen in partnership with US giant First Solar – at prices previously unseen in the region.

The tender outcome has since had its share of detractors, but at the time of writing financial close for the projects was imminent and reports suggested construction could be underway as soon as the end of Q1 2017. If that indeed comes to pass, then the Zambia tender could well mark a turning point for utility solar in Sub-Saharan Africa. Despite the obvious potential for large-scale solar in this part of the world, the segment's progress in Africa has so far been characterised more by words and unfulfilled promises than electrons on the grid. But if nothing else the Zambia tender has the potential to demonstrate what is possible in a part of the world where investment in utility PV has been slow to come forward, potentially unblocking the logjam for others to follow.

"Some people thought [the Zambia tender] too good to be true, but it's certainly made a lot of people sit up and take notice," says Yasser Charafi, a senior investment officer at the World Bank's International Finance Corporation (IFC). "It's a very different thing if people can hope for prices between six and 10 cents or if they're looking at 15¢ and above. It changes the nature of the discussion."

Senegal's 20MW Senergy 2 project is one of a growing number of large-scale PV plants now reaching fruition in Sub-Saharan Africa

One reason for optimism is that the Zambia tender was in a large part made possible by the fact that it fell under the IFC's Scaling Solar programme. This was launched in 2015 with the aim of helping utility solar take off in Sub-Saharan Africa by creating the right conditions for private investment to come forward. Zambia is one of the four-strong first wave of countries to

sign up to Scaling Solar – the others being Senegal, Madagascar and Ethiopia – but more are showing an interest in being part of the programme, and Charafi is confident grid-connected solar is now something firmly on the radar of government decision makers across the continent, particularly since the Zambia tender.

"We've had calls from key stakeholders in electricity sectors that would not have even wanted to hear about solar PV and were adamant it was a distraction from their stated objectives," Charafi says. "We have teams travelling every week to respond to initial discussions from governments. I don't know of any country [in Sub-Saharan Africa] at the moment that is not seriously looking at options for solar PV right now one way or another."

Indeed, the Zambia tender was just one of a number of events in 2016 and the latter part of 2015 that, together, suggest the wheels are finally beginning to turn for utility PV in Sub-Saharan Africa. Notably, the number of countries in the region joining the utility-scale solar club grew last year; beyond South Africa, a well-established utility PV market, and Rwanda, where an 8.5MW project was completed in 2015. Ghana, Senegal and Uganda all saw their first multi-megawatt grid-connected installations completed last year. Behind these, a swathe of PPAs has been signed for projects in a number of other countries by reputable developers with a track record of delivering projects in Africa. West Africa has emerged as a particular hotspot for utility solar PV (see box, p.10).

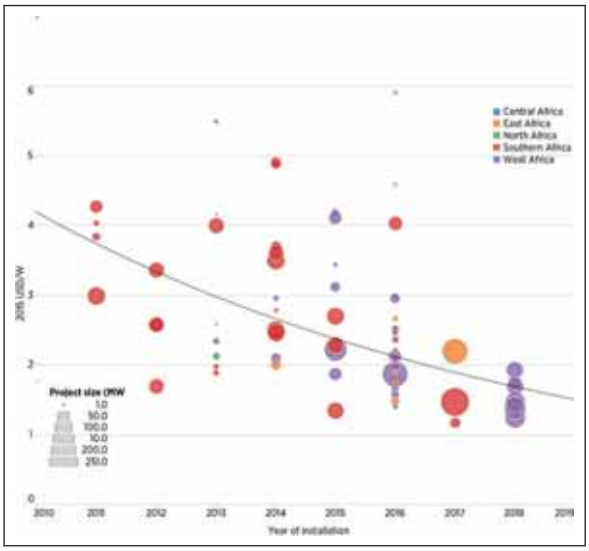
Among the more active developers in the region is Scatec Solar, the Norwegian independent power producer that has built several projects in South Africa and co-developed the pioneering Rwanda project with Dutch firm Gigawatt Global. Scatec has a pipeline of several hundreds of megawatts in size for projects across Africa, including Nigeria, Mozambique, Mali, Senegal and Burkina Faso, some of which are well advanced in the development process.

According to Scatec Solar's chief financial officer, Mikkel Tørud, the process of establishing a market for utility PV in a challenging region such as Sub-Saharan Africa has been a necessarily slow and painstaking one, in which developers have had to educate sponsor governments in how the IPP business works. But that work is now beginning to bear fruit.

"It is of vital importance that governments understand what is needed in terms of contract structures, PPAs and government guarantees backing the programmes to make them bankable," Tørud says. "I think we see that maturing in terms of an understanding of [what is required]. We are of course trying to be active in advising governments. It's a responsibility for all stakeholders to provide sound advice and also to ensure there are realistic expectations of what can be put in place."

A further responsibility for companies that, as Scatec Solar does, see themselves as pioneers has been the need to prove the concept of utility solar in the region before it can enjoy any wider rollout.

"It's important to demonstrate the viability of some of these projects now and get them off the ground," Tørud says. "And I think governments see that that is required before they launch larger programmes and invite the broader set of investors in. There's always a discussion on when to go for tenders, for instance, and that is typically the second wave for some of these countries; to get into that they have to prove the concept first and we like to be part of that, but it's not for everyone."



Credit: IRENA

IRENA's projections for utility-scale installed costs by project size in Africa, 2011-2018

"Some people thought the Zambia tender too good to be true, but it's certainly made a lot of people sit up and take notice. It's a very different thing if people can hope for prices between six and 10 cents or if they're looking at 15¢ and above. It changes the nature of the discussion"

Nevertheless, through the few concept projects now built, and more recently through the work being done under the banner of the Scaling Solar programme, utility PV does finally seem to be finding its feet. And that process looks set to continue. According to IFC's Charafi Senegal is shortly expected to invite initial expressions of interest for a 200MW solar tender that has ensued from its involvement in Scaling Solar. Madagascar and Ethiopia, meanwhile, are also drawing up plans for tenders that should be revealed this year. Zambia itself has signed up for a further 500MW under the Scaling Solar programme. And of course, other countries are poised to join the programme, Charafi says, suggesting it is only at the beginning of what it could achieve for the continent.

Ongoing challenges

Yet there are still plenty of reasons not to get too over-excited about the progress large-scale PV has made in Sub-Saharan Africa. One is that in proportion to the number of projects being announced, the number actually reaching financial close is still relatively low, suggesting a number of ongoing obstacles for the industry to surmount.

Peter Hutchinson is executive director of Green Power Africa (GAP), a UK-based investment vehicle that helps finance renewable energy projects on behalf of the donor-financed Private Infrastructure Development Group. GAP finance played a make-or-break role in allowing Senegal's first utility PV project,

Why West Africa is the newest hotspot for solar

Karim Megherbi of Access Power, the Dubai-based developer behind Uganda's recently commissioned debut utility PV plant, Soroti, discusses the project and why attention is turning to West Africa as the next utility solar hotspot.

PV Tech Power: Explain more about Access Power's latest project in Uganda
Karim Megherbi: Uganda was a very interesting project for us, 10MW connected to the grid, awarded through the Get FiT programme managed by [German development bank] KfW. We were able to develop this project in only 12 months between the award and the start of construction, which is amazing for Africa! After that we constructed the plant in a few months and now we are producing the electricity and everything is going well.

You have said West Africa will be the top spot for IPP projects between now and 2020. Why?
West Africa is a very dynamic region in terms of GDP growth so it's all about economy and demand. It seemed that there was a huge pipeline of projects that was just waiting for the right economy conditions and also favourable environment in respect to policies etc. Now you have almost all these ingredients. So you have the first projects that went online in Senegal and in Ghana and a stream of projects in Nigeria, Mali, Burkina Faso, Ivory Coast and Ghana as well, and the majority of these will be renewable energy projects.

Is there any advice, or anything that you would pinpoint as key, for investors or developers who want to get involved in the African market?
There is a notion that doing business in Africa comes with bureaucratic delays and inefficiencies. But when you step outside of the cloud of these notions you realise that there are ambitious and knowledgeable parties to engage with across the entire continent. There is no shortage of skills and entrepreneurship; what is lacking are the investors and developers that are willing to take early stage risk and turn the many laudable concepts into bankable projects.

By Danielle Ola

Uganda's 10MW Soroti project was completed in late 2016

Senergy 2, to be built last year after a deal between its developer Greenwish and the African Development Bank fell through. Hutchinson is of the view that the large amount of PR-driven "misinformation" put out through the media about the number and size of projects about to be built in Africa masks the reality on the ground – namely that the utility solar business in Africa is still a tricky one.

"There's a whole raft of difficulties that arise in terms of getting a fair allocation of risk in order to be able to put together a project financing," says Hutchinson. "The problem is you've got the underlying complexity…within particular countries, where in a lot of cases governments are sceptical about private sector involvement and ownership, and don't trust incoming investors not to rip them off."

The low number of financed or completed projects in the region is a clear indication that "none of them is easy", Hutchinson adds. One significant issue in his view is that the size of projects being pursued in Sub-Saharan African countries is in many cases too large. Not only is this potentially problematic in terms of the stability of national grids – which are as a general rule quite weak in African countries – but can also be a headache from a financing perspective.

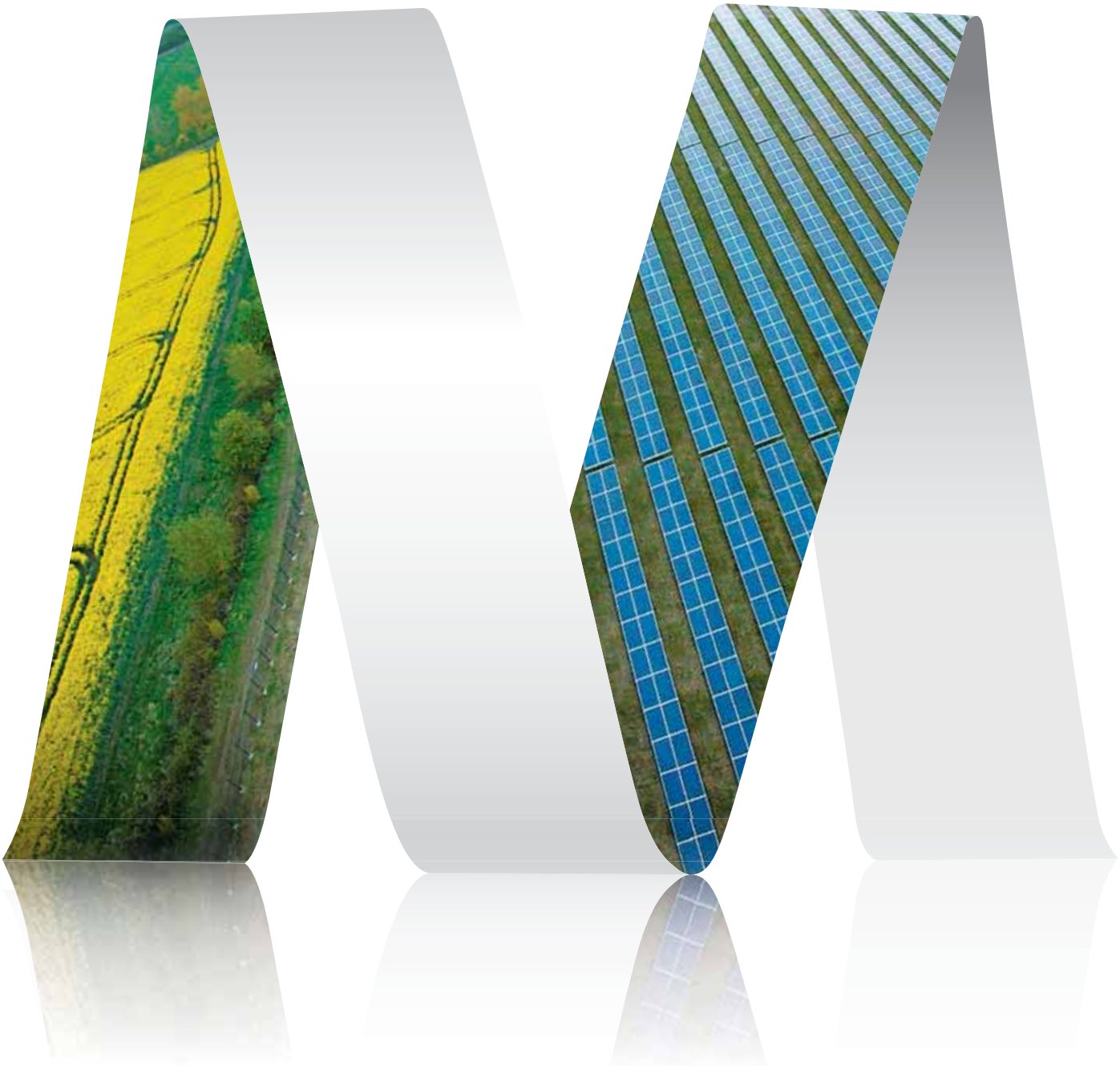
"The larger a project becomes, the more interested parties have to be involved in the financing," Hutchinson explains. "And when you start adding more players into the mix the complexity becomes ever more pronounced and that just slows the whole process down."

Unless this process can somehow be sped up, Hutchinson says "it's hard to see how you ever get to a stage where you can build enough plants fast enough" in the context of the ever-growing demands for power in most African countries.

"At which point one starts to think a little about how electricity became readily available. And in almost all Western countries I'm aware of they all started with localised mini-grids and the national grid came much later. Maybe the answer for Africa is going to be to use the same path and not to go for grid-scale production, but to go for mini-grids. That again would play to the idea of smaller projects being easier to get off ground and may end up being a way forward which can go alongside the big grid projects – a combination of the two which forms part of the overall solution."

That may indeed be the model countries follow as they seek ways to reconcile the very real potential solar has to offer them with the realities of poor grid infrastructure and financing complexities. For now though, after several years of plenty of talk and little concrete action, the utility solar segment in Africa is on the cusp of taking some meaningful steps forward.

As to whether it fully lives up to the huge potential it offers Africa, that question remains unanswered for the time being. But it seems there are now at least the interest, willingness and knowhow to give it the best chance possible. ■



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Credit: Solarcentury

Bridging the finance gap

Finance | Commercial and industrial end users in Sub-Saharan Africa arguably have the most to gain from solar, which can act as a buffer against costly and unreliable electricity supply. But as Danielle Ola reports, getting the right financing in place remains a challenge

Commercial and industrial (C&I) solar in Africa is still very much a market in its infancy, and yet much of the focus on distributed solar in Sub-Saharan Africa is in this sector, where private developers are starting to flourish and money to flow.

Self-generation accounts for as much as 20% of installed generation in some Sub-Saharan Africa countries, according to the World Bank, with most businesses heavily reliant on expensive diesel generators and yet still suffering an average of eight power outages a month. However, as the cost of solar PV equipment rapidly declines, the technology is increasingly an attractive option for businesses

"In West Africa, the price of electricity is quite high, you start to see a lot of C&I projects make economic sense because customers are saving money on a monthly basis on their electricity prices. That's particularly important for the commercial and industrial companies who pay an exorbitant amount of their costs towards energy," says Andrea Griffin, vice president of global business development at solar finance business SunFunder.

It is not only the falling of PV prices that will help this segment take off, but also developments and innovations in financing and credit – as this has historically posed the biggest barrier. To this end, solar financiers and developers are working to introduce and implement various business models that will serve to widen access to financing, lower transaction costs and raise total investment costs.

On-grid versus off-grid

The C&I segment typically encompasses solar projects of around 200kW-5MW that power businesses, generally in the form of rooftop systems atop commercial and industrial buildings or at mines and farms. It is split into both the off-grid and on-grid market, with both sectors coming with a different business case.

Agriculture, commerce and industry are all potentially significant beneficiaries of solar

On-grid solar plants at business sites make commercial sense in Africa versus more developed markets because these customers are still often using diesel for between 10-20% of their energy because the grid is unreliable.

"Even for on-grid customers, we are integrating fuel-save controllers and the ability for solar to work in tandem with the grid and diesel; part of this is not just savings against the grid, but savings against the cost of running the diesel generators," says Jake Cusack, managing partner at CrossBoundary and CrossBoundary Energy – pioneer investment and economic development consulting firm in C&I. "The off-grid model is a bit simpler: there is no grid, so you are just integrating with the diesel and reducing consumption of that."

Energy storage

The main difference between the two would usually be the introduction of battery storage for off-grid projects, to

allow for a smooth displacing of diesel generators, even at night and in adverse weather conditions.

"Battery storage is the perfect partner for solar because storing energy generated during daylight hours, ready for use at night, means that system owners can further reduce their reliance on grid and/or diesel generators. Utilising more solar electricity by consuming solar electricity at night that has been stored in the battery also helps the system owner to get more value from their solar investment," says Andrew Crossland, storage specialist at Solarcentury.

"Energy storage systems can also intelligently protect against grid outages and unstable voltage and frequency. This prolongs the life of electrical equipment, keeps business running without interruption and makes life easier for all of us."

Whilst the cost of storage doesn't yet always make commercial sense for this segment, the cost of equipment is falling, just like solar did many years ago. However, particularly for off-grid, energy storage is proving essential for such projects.

"I personally think that the C&I market cannot work without an efficient storage product tied with it," says James Irons, CEO of SolarAfrica, a C&I specialist. Irons explains that because many commercial premises are not occupied for maybe two days a week, without storage they cannot reap the full value of a solar system.

"An office park would be great for solar five days a week, but on Saturday and Sunday there isn't sufficient energy usage on the site to warrant installing solar system," he says. "If we have the ability to tie energy storage to that product we are now able to offer that office park a viable solar solution because we are able to store the energy on the weekends and have that energy available during the week. It opens up the market and I think that we are certainly getting close to being able to do projects on that basis."

Barriers to finance

C&I solar's main challenge in Africa comes in the form of financing. A lack of access to finance has been the major obstacle for the segment for years and continues to stand in the way. The bitty and patchwork nature of C&I only exacerbates finance access issues, as it has traditionally been rare to find a portfolio with enough projects in it to attract investment.

Lower-value, third-party contract projects are rife in this space, and generally are too small to be individually assessed by the development banks that back utility-scale solar in Africa. Equally, small-scale developers are often insufficiently robust to raise project financing and shoulder the appropriate risk.

"There are still too many risks that sit with the end user as opposed to the financier," says Irons. "The financier wants to get into the system but they are looking for 5MW projects that have a multinational off-taker who's going to pay whether you use the energy or not. Those projects are nice and there is financing available but that doesn't grow the market; there's only a handful of those."

> "The challenge with C&I projects is that each is relatively small, so to organise finance on a case-by-case basis can be quite expensive and the transaction costs – overwhelm the potential returns"

"The challenge normally with C&I projects is that each is relatively small, so to organise finance on a case-by-case basis can be quite expensive and the transaction costs – the cost of putting it together – overwhelm the potential returns," agrees Cusack.

According to Griffin, developers have particularly struggled in finding financing that matches the long-term returns offered by solar. "You can construct your project and once you have, you can either sell it for cash, you can provide a lease or loan to the end user, or do a PPA with a developer or a fund who can take ownership of that. If it's the latter two you have to arrange for that long-term financing and that's where a lot of the developers in certain markets have had some difficulty – finding that financing," Griffin says.

Financing solutions

Financial innovation is widely viewed as the key to unlocking Africa's C&I segment. As credit is so expensive in the region, businesses often fund capital expenditure in cash and expect capital improvements to yield quick paybacks. But such a timeline does not lend itself to solar as has been explained. To overcome this, developers are offering C&I projects to customers under different financing mechanisms such as a PPA or a lease, allowing for minimal down payments and for project savings to be developed over the long term.

CrossBoundary's inaugural dedicated C&I fund of US$8 million was set up to finance US$20- 30 million in projects, to help the sector and carve out a new asset class. SolarAfrica too was developed to allow local developers to offer a fully financed PPA.

"The origin of CrossBoundary Energy was working with very small and mid-sized businesses in Africa and seeing that the two biggest challenges for them were access to finance and access to cheap, reliable energy. We thought there was an opportunity to bring the commercial and industrial solar PPA model to Africa and allow these businesses to get cheaper and cleaner energy without having to bear any upfront or take any technical risks," says Cusack.

The CrossBoundary approach was not to raise funds on a case-by-case basis, but have the equity in bulk available to deploy, allowing the company to spread the costs across an array of projects in several different countries.

CrossBoundary is also elevating the traditional PPA model by using it to also tackle currency risk. Traditionally PPAs are linked to US dollars or the euro, which does not work for every company considering revenues are often in local currency, leaving exposure to whatever the difference between the two currencies is. "Thinking through the ability to manage currency risk and offer long-term PPAs in local currency could help unlock the sector," says Cusack.

Enabling local currency PPAs widens access as it is typically blue chip off-takers that have the balance sheet to weather a currency fluctuation that can take on that risk. Local currency options enable developers to trickle down and start providing solar solutions to SMEs and smaller businesses that may not be able to take on that risk.

Standardisation and bundling

SolarAfrica is taking a different approach to surmounting C&I's chronic financing problem.

East Africa's largest industrial solar system

SolarAfrica recently commissioned one of Kenya's largest solar hybrid systems, in Malindi. The 991kWp system is a PV-diesel hybrid project developed for Kenyan salt producer Krystalline Salt (Kaysalt). The system will generate 1.6GWh of clean electricity annually, saving Krystalline around 22% of its electricity costs.

The project was developed in collaboration with SMA subsidiary SMA Sunbelt, using its Fuel Save Controller, which complements the diesel generator and manages solar's fluctuating generation profile. The project was installed by local Kenyan installer Harmonic Systems, which managed to commission the project two months ahead of schedule. In terms of funding, the project was made possible through the government of Japan's Joint Crediting Mechanism (JCM) financing programme, which facilitates low-carbon technologies in developing countries.

This is SolarAfrica's latest commercial project in Africa, as the company continues to strengthen its market position in the C&I space that is traditionally difficult for developers to penetrate. According to CEO James Irons, the key to such projects is ensuring sufficient savings.

"You need to get to a point where savings are sufficient enough for your end user to warrant the time and effort that goes into bringing a project to fruition. You have to make the sale as simple as possible. This means bringing the choice down to one or two factors as opposed to 100 factors that your end user needs to consider. In the case of Kaysalt it was highly savings driven. Once savings were effectively set for them, they were ready to do solar.

"Also, working with a local installer is the only way that we see you can bring down the cost of installed electricity, which is essential to be able to realise the savings that are necessary to make a project work."

Credit: SolarAfrica

Reducing electricity costs was the main motivation behind the 991kW hybrid system at the Kaysalt facility in Kenya

"We started off trying to aggregate C&I projects on a standardised basis that can overcome the barriers to accessing financing," says Irons. "We try to bridge the gap by creating say 10 different projects all done very similarly: the legal agreements are similar, the technology is similar and how each project is tracked is very similar so that the investor can access the projects in aggregate and meet their minimum investment size."

As there still is no one standard contract at play in the field and very little understanding of an established funding model or how this should work, setting up standard contracts brings a much needed certainty. SolarAfrica also works with a set network of installers that have to use certain technology and implement a project under a certain agreement so that any project originated through SolarAfrica is executed to a predetermined acceptable standard.

Meanwhile, to overcome the scale issue in financing C&I solar in Africa SunFunder has found that bundling is an effective solution.

"We are starting to work with developers on bundling projects – not just standardising the suite of documents, but also as much as possible trying to increase the number of projects that we finance in a single investment. Bundling is another way to keep transaction costs low and total investment costs high," says Griffin.

Market reception

It is evident that the sector still has some significant headway to make in terms of unlocking much-needed financing. As developers still struggle to create project portfolios in a piecemeal market, investor interest is piquing but remains hesitant.

"We see a lot of interest. In terms of bigger institutional players, a lot of people are interested to speak with us," says Cusack. "The challenge right now is again, it's early days and the space is small. The opportunities are there to come in and do US$50 million or US$100 million worth of projects. We're trying to help grow the market so that that investment interest can be accommodated. Right now there simply aren't good, bankable, well-developed C&I projects that are aggregated. That's the primary challenge."

Aside from financing, supply chain optimisation is another key prerequisite for the segment, and here there is a sense of optimism. "Africa is extremely efficient (certainly South Africa and the rest of Africa is following) for cost of installed watt," says Irons. "If we had to benchmark against international pricing I would say that on a C&I installed cost basis we are quite competitive there, or certainly the installers we work with are very competitive. That comes down to leveraging some of the IPP work that is happening in South Africa - the existing delivery infrastructure, local stockholding, aggregating purchases."

As the market expands, it is set to move towards a situation where contractors have sufficient work to be able to lower the actual installed cost. In the beginning, contractors were doing one project a year and had cover overhead for a year on that one project, which quickly became a costly exercise; in a portfolio of multiple contracts, the installed cost for all those projects is significantly less, making solar more accessible.

Evidently, the more accessible C&I solar becomes, the more projects there will be in the segment. So in time it will be self-fulfilling. ■

Beyond the grid

Off-grid | From small household systems to mini-grids providing power to communities and industry, off-grid solar has a huge range of possible applications in Africa. Tom Jackson reports on the business models and technologies supporting its growth in the region

Credit SunFunder

Some 1.6 billion people across the world lack access to electricity, with around one-third of those in Africa. Indeed, according to the African Development Bank (AfDB), almost 620 million people on the continent lack power.

Given the inability of traditional grids to reach rural populations, the off-grid solar sector has been filling the gap. According to the 'Off-Grid Solar Market Trends Report 2016' from Bloomberg New Energy Finance (BNEF), an industry that had a near-standing start less than 10 years ago now has more than 100 companies selling solar lanterns and home system kits to those without power.

The impact has been tremendous. In Kenya, for example, BNEF estimates more than 30% of people living off the grid have a solar product at home. It says the pioneers have helped to create a vibrant market.

"Because technologies such as solar and storage are modular and scalable, they can be distributed and installed at a much faster pace than many other technologies that require larger scale," says Bloomberg analyst Itamar Orlandi.

"At the extreme, they are just sold as a consumer product in the form of solar lights or home systems. Because they can be put in a box and sold directly, they can reach customers much faster than large power generation projects that require multiple stakeholders and face lengthy development cycles."

The impact of light

Simon Bransfield-Garth is chief executive of Azuri Technologies, which sells home solar systems across Africa. He says electricity, historically, has been only for people in cities. Yet now, with the development of solar power, it is possible to access power anywhere. This has an immediate impact.

Business models such as pay-as-you-go have helped propel the growth of off-grid solar in Africa

"On average, children spend up to two hours per night extra on their studies and families often use the extra time in the evenings to increase their incomes," he says.

"Shopkeepers are able to keep their stores open longer and farmers can process crops in the evening and be first to market in the morning. Everyone can keep their phone on all the time, without worrying about the cost of charging it up."

As of June 2016, 100 million people have moved off kerosene and other fossil fuel sources for lighting, resulting in US$4.33 billion in energy-related savings. Ned Tozun, CEO and co-founder of pan-African solar provider d.light,

says solar-powered portable products and home systems offer safer, more affordable and higher quality energy solutions compared to kerosene, candles and generators.

"In just eight years, transformations in off-grid solar have led to a significant improvement in the delivery of energy access in developing nations," he says.

"We believe this will catalyse a chain of events that move the developing world into new forms of energy access, financial inclusion and Internet connectivity, significantly increasing GDP in turn."

Developing technologies

Off-grid solar is advancing rapidly beyond simply lighting and phone charging. BNEF says cost reductions, consumer demand and a sales-driven push for higher-margin products means solar home systems capable of powering appliances such as TVs and fans are likely to capture an increasing market share in the future.

"About 7 million off-grid households will use solar-powered fans and 15 million households will have a solar-powered TV in 2020, according to our estimates. Similar systems will also provide services to small businesses," the report says.

Developments in storage will also play a key role in maximising efficiency and bringing down costs. While solar production peaks during the day, energy consumption is highest in the morning and evening. Storage solutions allow solar home systems to save energy produced for when it is needed most.

Daniel Boucher, public relations lead for micro-grid provider Powerhive, says in the context of residential electricity demand, storage is key. "When the sun sets early in the evening as it of course does around the equator people need storage to be able to use electricity when they come home from their farms. Lighting remains a huge driver of residential demand. But people also like to do other activities after dark that require electricity, such as watching TV or listening to the radio," he says.

Orlandi says developments in storage, alongside improvements in PV and LED lighting, support the advance in solar: "They all reinforce each other. As a result, the cost of comparable systems dropped from almost US$1,000 in 2009 to between US$200 and US$300 now," he says.

"The improvements in larger scale storage are more recent than in PV, and this is likely to have an impact on kilowatt-scale installations in the coming years."

Thomas Hillig of TH Energy consulting highlights some of the other development in the off-grid space.

"We are seeing gensets that are made for hybrid applications, so-called low-load gensets, local weather forecasting that allows for optimal operations of gensets and storage, and finally moveable solar power plants that are a solution when the off-taker does not pay the bill. For rural electrification, there are also smart metering and mobile payment solutions," he says.

> "In just eight years, transformations in off-grid solar have led to a significant improvement in the delivery of energy access in developing nations"

Paying as you go

One of the initial hurdles solar providers in Africa had to overcome was the high upfront costs of purchasing a solar home system. This has been solved across the continent by the adoption of pay-as-you-go (PAYG) business models, where home and business owners make small regular payments to acquire the systems over time, often via mobile money.

Tozun says PAYG financing has proven an extremely effective way to get solar home systems and other solar powered products into the hands of more people.

"Once the system is paid off, it's unlocked forever. This intersection of PAYG mobile payments, affordable home solar power and pent-up demand in the developing world will create new, dynamic paradigms of energy access empowerment and personal financial identity for billions of people at the base of the pyramid," he says.

Hugh Whalan, CEO of PAYG solar firm PEG Africa, agrees PAYG has been crucial in enabling solar in off-grid areas.

"It is providing the rails along which solar is receiving investment and support to reach poor consumers," he says. "PAYG allows a company to remotely manage assets in the field, allowing us to profitably serve distributed and remote customers who would be impossible to service otherwise."

Bransfield-Garth says the decentralised approach of powering each household individually dramatically reduces the rollout time to new customers, allowing new PAYG solar communities to be created in weeks rather than years.

"The gap for what you can provide with stand-alone power and the cost of connecting people to the grid is growing. The PAYG model of distributed power is becoming a genuine alternative to the grid," he says.

East Africa, with its high mobile money uptake, is the continental leader in this space, and Boucher says PAYG is "everything".

"Obviously companies like it because it ensures full payment. It's also important because behaviour among low-income consumers is such that they consume frequently and in small amounts," he says.

"PAYG seems to be the best way to match consumer behaviour. I think it's fair to say that in Kenya people like it primarily because it gives them control over their spending."

Funding scale

This business model has helped make African solar firms more attractive to investors, with BNEF saying PAYG companies have attracted four times as much investment in half the time as those selling products for cash. This is a significant change to how infrastructure investments have traditionally worked.

"Historically, sizeable investments in energy have funded centralised infrastructure, like government-backed grid expansions. However, in today's emerging markets, the most efficient and scalable business model is decentralised energy delivery," says Tozun, whose company d.light is one of a handful of Africa-based solar firms to have secured multi-million dollar funding rounds.

"Many technological, social and

business trends are making it easier to provide high-quality, affordable solutions in emerging markets. d.light is just one of many companies with sustainable models providing energy products and services to off-grid families. We've demonstrated that it's possible to build socially driven, profitable businesses that deliver financial returns to investors on par with conventional investments."

The off-grid solar industry is now also catching the attention of more traditional investors. Revenues have increased 18% to US$139 million, largely attributed to the sales of larger products, which retail at a higher price. More investment is necessary for the industry to truly scale, however.

"As the market grows exponentially, more working capital from traditional funds is needed to provide greater numbers of people with energy and economic opportunity," says Tozun.

"Upfront capital is one of the greatest barriers to broad expansion, which is why the industry needs more institutional investors to take advantage of the rapidly approaching inflection point in off-grid solar."

Orlandi says PAYG solar currently has more traction than any other business model to reach the millions of people living off the grid, but in order to do so firms in the space need more of the funding afforded to the likes of d.light, Off Grid Electric and M-KOPA Solar.

"In terms of customers reached it is however still dwarfed by companies that simply sell solar lanterns for cash, which have shipped more than 24 million units to date," he says.

One area of potential growth is in larger-scale solar applications for sectors such as agriculture and mining, which is a development Dr Hillig says is at its very beginning.

"By now, the technology has matured, financing is coming, but often good marketing and sales approached are missing. Many renewable energy companies have an engineering rather than a marketing and sales focus," he says.

Bransfield-Garth says there are huge untapped opportunities for solar to transform the agricultural sector in Sub-Saharan Africa, where less than 6% of farmland is under irrigation.

"Solar-powered irrigation enables farmers to switch from expensive and polluting diesel-powered water pumps to more sustainable, renewable power," he says.

And bringing together all of these potential applications is the prospect of mini- or micro-grids serving whole communities not currently connected to the central grid. Some big-name players such as Caterpillar, First Solar and ABB have all shown an interest in the segment, and the International Energy Agency estimates 220 million people in rural areas will gain access to electricity by 2040 through off-grid and mini-grid solutions (see p.18). Adoption will speed as innovations in technology and business models bring down the cost.

"Micro-grids are an important piece of the puzzle in bringing electricity to everyone, says Dan Porras, vice president of impact and communications at Powerhive. "They can provide higher voltage power to enable business creating in rural areas. Most countries in Africa are trying to develop their policy regimes with relation to private micro-grid developers and in that respect it is a very interesting time to be in this business."

"Untapped opportunity" is a phrase that aptly describes the state of Africa's power sector. But as firms develop ever more innovative technologies and business models that allow for the rollout of distributed solar in cost effective ways, the financing is increasingly becoming available to ensure his does not remain the case for long. ■

Tom Jackson is a freelance journalist.

See p.18 for further insights into how mini-grids are bringing power to communities in rural Ghana

Storage a key enabler in the expansion of off-grid solar

Energy storage systems (ESS) for solar are growing in importance globally to deal with the instability and unpredictability of systems and match them to demand. This is especially valuable in Africa, where weather is often variable.

Solar customers in Africa have a wide variety of usage patterns, while the quantity of available sunlight varies depending on season and cloud cover. Conventional systems have therefore struggled to perform at an optimum and efficient level for every user, a fact storage is well placed to address.

One company that has adapted to this reality is Azuri, which has rolled out HomeSmart technology that "learns" a customer's power usage patterns. The solar system then optimises light brightness, battery charging and load conditions to ensure the best possible match to the customer's daily requirement given the level of available sunlight.

"Many off-grid customers use a standalone solar home system for power. A standard solar home system has a panel on the customer's roof, connected to an energy storage system with a battery, which then drives appliances such as lights," says Azuri's Bransfield-Garth.

"These work well in sunny climates, but historically they have all suffered from the problem that if the previous day was cloudy, insufficient power can be stored to run the lights all night. This means that customers never know how much light they can expect each night."

The HomeSmart artificial intelligence manages the power in the system. Instead of the lights going out early following cloudy days, the system will continue to work even when there was limited sunshine. For example, if a customer typically uses the system both in the morning and the evening, the system will automatically slightly dim the lights in the evening on days when there is less sunshine, ensuring there is still power available in the morning.

Storage is a key enabler for the efficiency of solar power in Africa, but as with all aspects of the technology prices need to continue to fall for it to become commonplace. The average cost of batteries is determined partly by the cost per kWh of storage, and business models such as PAYG remain central to ensuring it is accessible.

Credit: Azuri Technologies

Storage has a growing role to play in the increasingly smart technologies being developed for off-grid applications

With efficiency levels rising and developers understanding the need to move from dumping power on to a grid to a utility-aligned model, progress should accelerate. The likes of Tesla and Panasonic are ensuring the market for battery storage is growing rapidly.

Ghana turns to mini-grids for electrification of isolated rural areas

Mini-grids | A government electrification programme in Ghana is using mini-grids powered by solar and wind to bring power to rural areas. Christoph Peters and Christina Imboden look in detail at one of the systems in the pilot and how it could be used as a model for other off-grid communities in Africa

Global access to electricity is a key priority for most developing countries to reach social advancement. The availability of modern energy is beneficial in many aspects of life, ranging from lighting in the evenings and storage of fresh food or medicine in cold rooms or refrigerators, to the powering of pumps for drinking water or irrigation of fields to grow better crops. Cities are the first electrified areas, followed by nearby villages in rural areas. But what about the electrification of isolated rural areas far away from the public grid?

In Ghana the government has decided that the answer to that question is mini-grids, after a successful pilot project with installations in five different locations.

The electrification of Ghana is growing steadily. The national electricity rate has increased from 45% in 2000 to 80.5% in 2015. The Ghana policy and renewable masterplan states that Ghana aims to reach 100% by 2030. To achieve that goal they need to focus on rural electrification in isolated areas in particular. In 2016 Ghana's population was 28.9 million people, of which 46% live in rural areas.

The ever-increasing demand for energy has put a strain on Ghana's public grid and made its energy supply inconsistent. In addition, the public grid is, to a large extent, powered by hydropower and as recent years have been dry, without much rain to fill the dams, it has caused power outages.

Credit: Trama Tecno Ambiental

The Pediatorkope mini-grid combines wind and solar power with batteries and diesel back-up

Credit: Trama Tecno Ambiental

The mini-grid supplies up 160kWh of electricity per day

So, with the public grid already heavily charged and due to the high costs of extending the public grid to isolated areas, the Ghana Energy Development and Access Project (GEDAP) is focusing on rural electrification of isolated communities by means of renewable energy through mini-grids or off-grid installations. This strategy is also in line with their objective to increase the contribution of renewable energy sources to 10% by 2020 by blending hydro, wind, biomass, solar and tidal wave energy.

Pilot mini-grid project

As a pilot project the implementation of five mini-grids was mandated by GEDAP, part of Ghana's Ministry of Power, for specific rural areas. This project is the first of its kind in Ghana and emphasises the key role renewable energy-based mini-grids play in the country's transition to a low-carbon economy and the supply of electricity to rural remote areas. In total these mini-grids produce 200kW of PV power (STC) providing access to modern electricity and enhancing income-generating activities to 3,500 residents. They supply up to 650 kWh/day of renewable and reliable electricity.

The mini-grid on the island of Pediatorkope, in the Greater Accra Region, has become a showcase for other West African countries. The island's 860 inhabitants are mainly employed in fishing, farming or basket weaving. In the last 10 years, several projects to provide off-grid electrification have already been tested here, for example in the form of playground roundabouts generating power for lamps so that children can study after sun down or a village solar kiosk where the inhabitants can charge batteries.

The new mini-grid installed in February 2016 has the capacity to serve a total of 144 clients: 130 households, four shops, and nine institutions such as health centres, schools, churches and mosques.

The mini-grid solution

The centralised PV and wind mini-grid was designed, supplied and installed by Trama TecnoAmbiental (TTA), a Barcelona-based engineering and consultancy firm with more than 25 years of experience in renewable energy technology, and in close collaboration with the GEDAP team. This

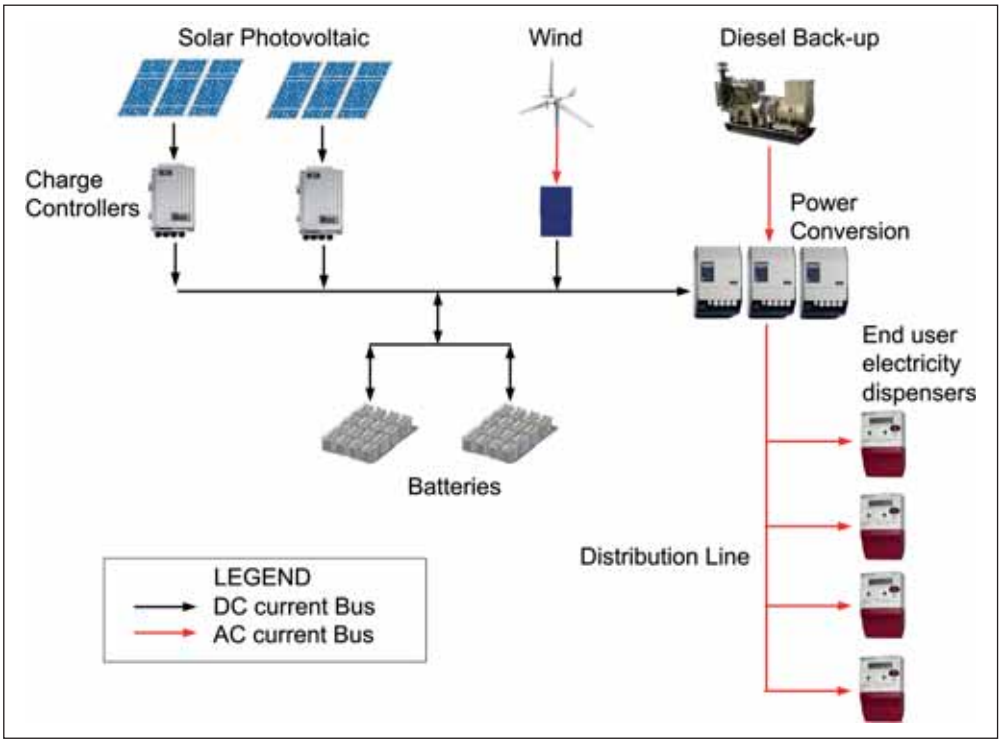


Figure 1. A schematic diagram of the mini-grid system on Pediatorkope

close collaboration allowed for effective quality control, quick decision-making and smooth processes. Local key partners, namely AEA and GTS Engineering Services, were also involved in the project.

The design is based on detailed studies of the future customer's energy demand and willingness to pay for electricity. This analysis was made in order to accurately dimension the power plant including additional capacity for short-term demand increase and additional space for a future long-term expansion of the generation plant.

The mini-grid's load management (demand-side management) is ensured by the 'Energy Daily Allowance' (EDA) concept, which guarantees each user a minimum amount of energy within their needs and budget. The allocation of electricity is controlled by an electricity dispenser that can be programmed according to the different tariff levels. Six different tariff subscriptions are offered to the households, shops and institutions (see Table 1).

The installation

The mini-grid on Pediatorkope supplies up to 160kWh/day of renewable and reliable electricity, available 24 hours per day. Figure 1 shows a schematic of the system.

The centralised, low-voltage distribution grid consists of a three-phase backbone feeder with single-phase laterals connecting single-phase loads at each customer's premises. A dedicated line feeds 30 high-efficiency LED street lamps throughout the village.

The power plant has a rated AC capacity of 48kVA, a PV array of 39kWp (STC) and two wind generators with a total capacity of 11kW. The 156 PV modules are mounted on a metal pergola that provides not only shading for the powerhouse but also for community meetings to take place, which is well-appreciated added value. Moreover, the V-shaped pergola mounting structure allowed for easy shipping and assembly by local craftsmen.

Tariff level	Energy allowance, Wh/day	Typical uses of electricity
Basic (T01)	275	Lighting, phone charging
Low (T11)	550	T01 + small appliances
Medium (T21)	1,100	T11 + TV, fan
High (T31)	1,650	T21 + small fridge
Mid power (T42)	2,200	Lighting, TV, fan, fridge
High power (T53)	2,750	T42 + small machinery

Table 1. The mini-grid on Pediatorkope offers six tariff levels each of which sets a daily energy allowance.

Battery storage

The intermittent renewable electricity is partially stored in a battery bank of 170kWh at 48V. This battery bank is connected to six inverters of 8kW each that convert the electricity to standard alternating current at 400/230 V. A diesel genset of 30 kVA provides back up in exceptional cases when renewable energy is lacking.

Remote access

All components are of first-class renowned brands, fulfilling the highest international quality criteria. The energy management system by Studer Innotec allows remote monitoring and control from TTA's offices in Spain.

Local integration

The system was delivered turnkey and for the first two years it will be monitored and serviced by TTA. The long-term economic sustainability is guaranteed through the implication of the national grid operator as responsible for handling the mini-grids after the contractual operation and maintenance phase. Local staff and users have already been trained and are actively taking care and supervising the installation, following the operation and maintenance protocols and schedules.

By not only providing renewable energy but also empowering the local community, the installation generates various job opportunities in plant operation, customer relations, service fee collection, service card recording, trouble shooting and energy efficiency assessment services.

Growing demand

In most of the communities, requests for service upgrading started immediately after the start-up phase. A 20% extension of the grids is already agreed and in the process of formalisation.

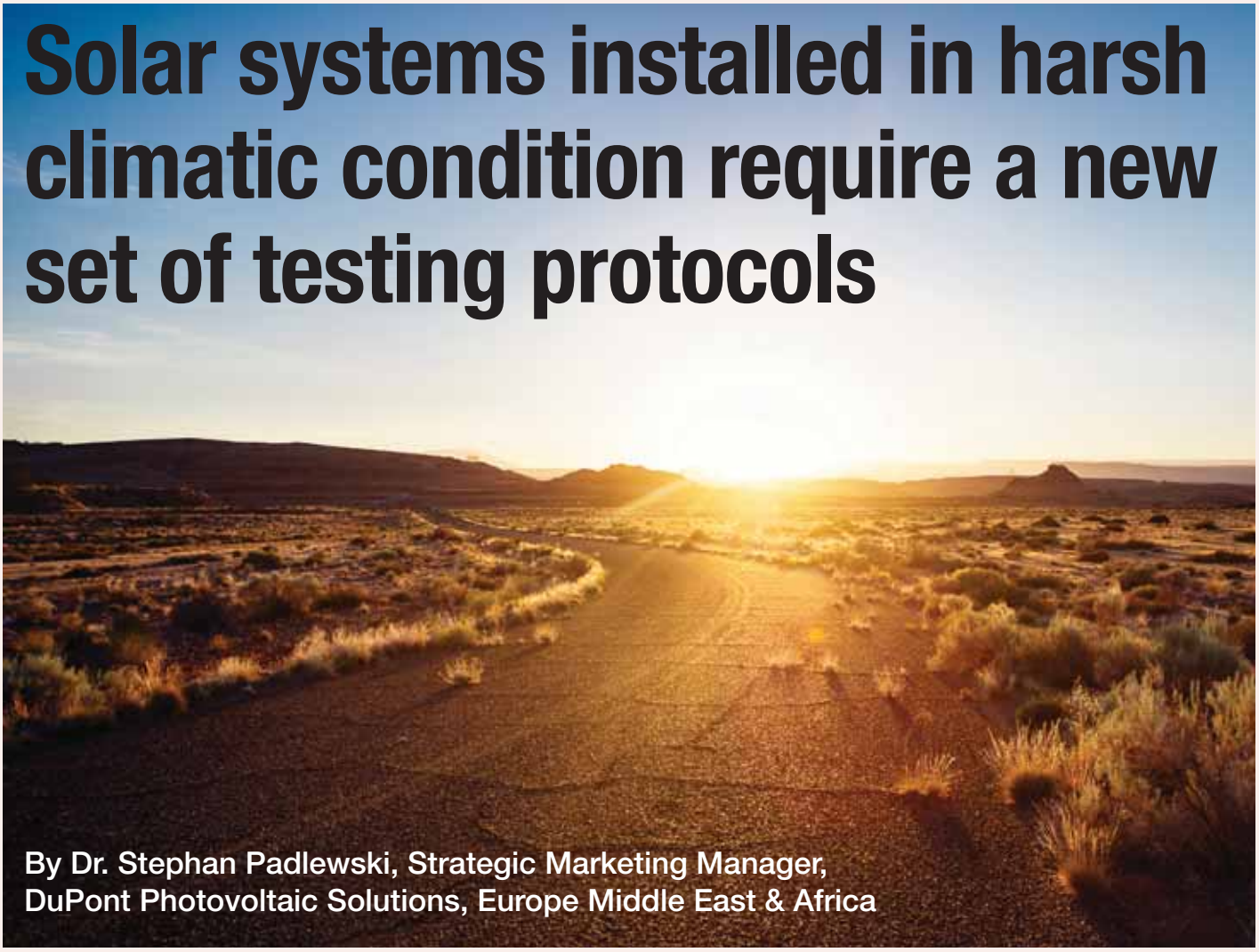
The success of this pilot project has led to the elaboration of a programme for 80 further mini-grids. ■

Authors

Christoph Peters is an energy consultant and project manager at TTA, specialised in renewable energy-based rural electrification and energy efficient building design.

Christina Imboden is marketing coordinator at Studer Innotec SA. She has an MSc in business administration and is an experienced industrial marketing professional.

Solar systems installed in harsh climatic condition require a new set of testing protocols



By Dr. Stephan Padlewski, Strategic Marketing Manager, DuPont Photovoltaic Solutions, Europe Middle East & Africa

DuPont Photovoltaic Solutions (DuPont) will be a sponsor of Clean Energy Summit Africa in Accra, Ghana, 4-6 April 2017, which will bring together government stakeholders, investors, financiers and industry leaders to discuss how to contribute to the energy debate in Africa, by outlining policies and programmes to support universal access to power and the development of solar energy across the continent.

Government and private sector ambitions for the solar industry in Africa need to be carefully balanced by appropriate standards to ensure the quality, reliability and durability of solar panels and systems installed in the region will withstand its harsh climatic conditions.

The PV system cost reductions seen in recent years are set to continue, but savings must be balanced without adding risk to get the best long-term investment returns from a system. A focus solely on lowering the system's cost per watt can reduce the system's expected power output over its actual lifetime, therefore increasing the levelised cost of energy (LCOE). Consequently this can impact the overall return on investment of PV projects and potentially damage the integrity and credibility of the industry.

The backsheet material, for example, should protect the panel from the elements and provide electrical insulation for the 25-year expected lifetime of the panel, but not all backsheet materials will withstand higher exposure to the UV and thermal stress of African climatic conditions. In order for the region's solar energy industry to continue to grow, it is important for solar investors to understand what impact materials selection has and which materials will help

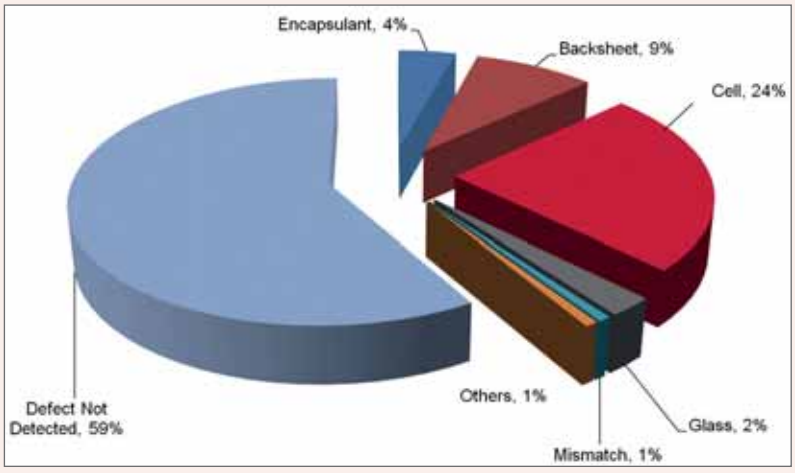


Figure 1. 41% of inspected modules exhibited some visual defect. Source: DuPont global field module survey of 71 installations (912,000 modules at 203MW) in North America, Europe and Asia Pacific.

ensure reliable panel performance.

DuPont is the world's leading supplier of specialty photovoltaic materials, including films for backsheets, with more than 30 years of proven performance in the field, and photovoltaic metallisation pastes that have helped enable solar cell improvements that have yielded 30% higher cell efficiencies in the past 12 years. The company has long been an advocate of risk mitigation strategies and has been advising system owners and financiers on best practices to help improve their return on investment and lower the cost of solar electricity.

The backbone of this effort is a global and extensive field testing programme that examines panels in various stages of use and in different climatic conditions to identify causes of premature ageing. The programme has surveyed more than 71 installations in a range of climates from hot and arid to temperate in North America, Europe & Asia Pacific, totalling more than 200MW of installed power and almost a million solar panels from 45 different manufacturers (see figure 1).

The findings show that 41% of inspected modules exhibited some kind of visual defect, were less than five years' old, with 24% of the defects affecting the cells (snail trails and busbar corrosion) and 9% being backsheet-related with defects ranging from frontside and rearside backsheet yellowing to backsheet delamination and cracking. The latter was deemed a "particularly serious defect" by Germany's TÜV Rheinland, one the world's leading providers of safety and performance testing, and market certification for the photovoltaic industry. In contrast, none of the surveyed panels made with DuPont™ Tedlar® polyvinyl fluoride (PVF) film-based backsheet showed any signs of premature degradation (see Figure 2). These findings indicate that materials choices are essential to how well and how reliably panels perform over time.

So what is going on? Current quality standards are designed to detect early failures of solar panels, not their long-term performance or that of the materials in real outdoor conditions. Today's IEC testing protocols involve a single stress test at a time and do not adequately address the durability of materials to UV exposure, weathering and the synergistic effects of multiple stress factors. For instance, polyethylene terephthalate (PET) and polyvinylidene fluoride (PVDF) based backsheets would successfully meet the IEC standards. But according to our field inspection programme, we found that about 24% of the panels protected by PET and 11% by PVDF displayed some signs of visual degradation after less than 5 years in operation. Backsheet failure caused by cracking and delamination represents a serious electrical safety hazard where panels need to be replaced. Such replacements have a significant impact on the financial returns of solar systems, as the panels account for approximately 40% of the total system costs.

We believe the solution is the broad adoption of Module Accelerated Sequential Testing (MAST), which is the better predictor of long-term reliability, simulating real-world conditions by repeating multiple field-ageing stresses (UV, heat, humidity, thermal cycling), as illustrated in Figure 3.

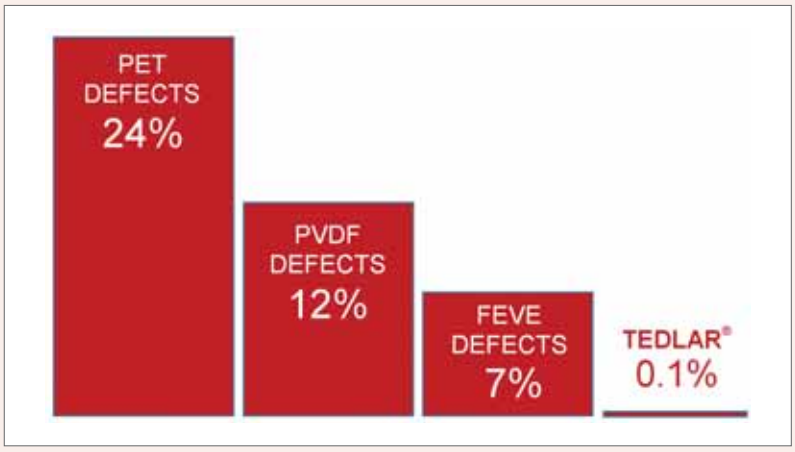


Figure 2. Defect Rate by Backsheet Type. Only 0.1% of the DuPont™ Tedlar® based backsheets showed defects. PET = Polyethylene terephthalate. PVDF = Polyvinylidene fluoride. FEVE = Fluoroethylene vinyl ether. Tedlar® PVF = Polyvinyl fluoride film.

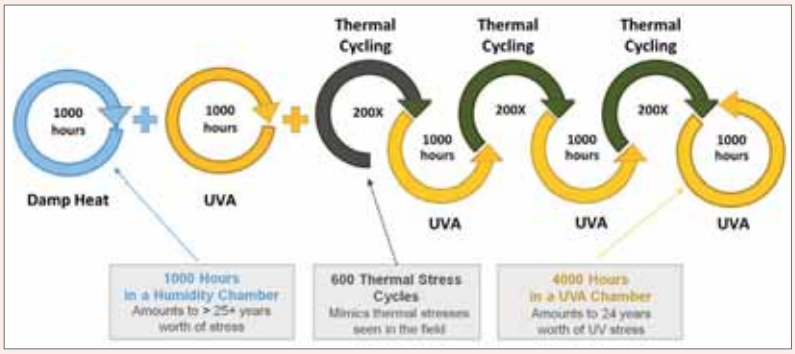


Figure 3. Module Accelerated Sequential Testing, where repeated sequential stress mimics field degradation not detected by single tests and current industry standards.

DuPont provides recommendations on industry-standard bill of materials, and provides panel manufacturers with materials technology that can best match power output and expected lifetime goals of solar installations.

Reducing the effective system lifetime by five years can increase the LCOE by over 20%. It is particularly critical to select the most robust materials under combined thermal and UV stress factors, a key recommendation to help mitigate financials risks of PV projects developed in Africa.

For more information visit: **photovoltaics.dupont.com**

Author

After completing a PhD in physics at the University of Cambridge in 1991, Dr. Stephan Padlewski joined DuPont, where he has primarily been involved in new technology and market development initiatives in the electronics industry, with applications ranging from printed circuit boards, integrated circuitry packaging, organic light emitting diodes and photovoltaics. He is based in Geneva, Switzerland where he leads the DuPont Photovoltaic Solutions business development & marketing activities across Europe, the Middle East and Africa.

Plan, build, operate

Supply chain and logistics | Terrain, weather conditions and local workforce capacity are just some of the many factors developers must consider when planning, building and operating PV projects in Africa. Tom Kenning looks at the solutions being used to overcome the region's many challenges

Credit Gigawatt Global

The successful execution of PV projects in Africa presents some unique challenges for the industry

Financing is arguably the biggest challenge for developers looking to build projects in Sub-Saharan Africa. But with finance secured, they then face a swathe of logistical headaches around transporting parts, finding and training a local labour force, operating and maintaining projects, sourcing spare parts and keeping projects safe from possible vandalism or theft. Bad roads, frequent lightning and lost cargo all stand in the way of a well-executed PV project.

Regulatory environments have historically been a source of uncertainty and therefore continued stasis in the African PV market, but inertia was brushed away last year, heralded by a flurry of major PPA signings in the region, the completion of several utility PV plants and a record-breaking tender in Zambia. However many developers cite the 'creeping risk' of political upheaval or sudden regulatory changes that hangs over many African developments. All in all it is a region that presents plenty of challenges for the industry to contend with, from planning through to profitable operation.

Pre-construction

After choosing a project location, a developer will typically install on-site weather stations to assess the climate. However, sources in the public domain of Africa such as solar maps and the output from national weather stations that measure irradiation, temperature and wind speed are all scarce.

"In Africa there are solar maps available but most of them are unverified," says Riaan Meyer, managing director of GeoSUN Africa, a South African firm that specialises in on-site solar resource assessments. "The moment you want to take the next step and get data from the weather services or maybe a university, there is next to nothing available."

For this reason the World Bank has been funding wind, solar, hydro and biomass atlases for various African nations with solar maps being made specifically for Zambia and Malawi. Furthermore, a new map called "Potential Electricity Production or 'PVOut' is now available for all African countries showing the annual electricity yield of a typical solar panel, while taking both tilt angles and temperature into account. Elsewhere, the German development agency GIZ is also sponsoring a mapping project in Namibia.

"This opens a whole new world since it eliminates the need for site specific PV simulation to a large extent in the prospecting phase," adds Meyer.

To install pyranometers to take irradiance readings, GeoSUN typically sends out one technician, which can be tricky in the less secure regions of Nigeria, Chad and Mali, so local partnerships are sought after. Partners can be flown to Cape Town for training before being sent back to various sites.

Getting the supply right

At the stage of shipping PV equipment to project locations, local partners are no less important, given the various risks of damage in transit, delays and poor directions.

"We normally try to reduce that risk by teaming up with a company experienced in that field in managing the logistics in Sub-Saharan countries," says Said Istambuli, head of international business development at Madrid-headquartered EPC firm Gransolar, which is developing projects in Nigeria, preparing EPC for a plant in Mozambique and is experienced in O&M services. "This is a crucial aspect of the whole supply chain and the whole planning of a project."

Poor road infrastructure is also a concern for any EPC contractor that intends to import panels, but Africa has well-established trade processes and well-organised ports, says Jon Sarpong, president of Toronto-based renewables firm Avior Energy, which is developing a 20MW project in Ghana. Thus, getting the modules in country and transferring them to site is one of the more simple aspects of a project. However, Avior Energy also has the fortune of working in Ghana where there are a number of quality roads. So if you are in a country

Credit GeoSUN

Resource and weather data is in short supply in parts of Sub-Saharan Africa

with particularly poor transport infrastructure, what can you do?

This is where a company such as Hellmann Worldwide Logistics can step in with its experience and knowledge of transporting goods from multiple industries across many parts of the world. The most important thing is keeping all the data surrounding a project – particularly equipment orders – as transparent as possible so that communication is clear between developer, EPC provider and deliverer, suggests Holger Meyer, renewable energy manager at Hellmann.

EPCs are sourcing equipment including mounting systems, inverters, cables and modules from multiple suppliers. Thus data quality is key for big projects. If for example a developer has 250MW spread over five to 10 different sites, teams have to make sure the right containers are going to the correct site. Multiple banks can finance just one project and each bank will do an audit at the factory for their own specific modules. Therefore, different containers coming out of the same factory might have been bought and financed by different banks and destined for separate locations.

"If you have a logistics partner who is not aware of these processes, they will see the same cargo and send it to the [same] jobsite as the containers arrive within the port," says Meyer. "For them, the product looks the same. Therefore it is important to have a global partner who is able to ask the right questions and deal with all these important subjects in the back of your supply chain."

It can all go horribly wrong if the right precautions are not taken. Meyer knows of one competitor that had to ship 80 trucks a distance of 5,000 miles after miscommunication and a lack of knowhow led to equipment heading in the wrong direction – all at a cost of US$145,000.

Meyer adds: "The bigger the project you are having, if you don't have a robust supply chain, you are dead."

He also estimates that on average 30-40% of projects get delayed in Africa due to weather conditions, cash flow, transfer issues or cargo holdups. Having back-up plans and accounting for potential problems in project timelines is important.

Credit Hellmann Worldwide Logistics

Transportation of components to site can be affected by difficult terrain

Hellmann conducts a road analysis in all locations before delivering goods, including driving a car across the terrain. It also provides a product that allows tracking of containers and goods around the clock while also indicating where and when damage has occurred, if at all.

"In general the road conditions in Africa are not as good as in the US or in other regions, so the key is to train the drivers and explain to them this is a product with a device attached to it and we can measure if you are driving too fast or if you are driving unsecure."

Normally once a truck driver has driven off from a port, his cargo enters a temporary blind spot until the destination is reached. EPCs need to know when exactly a product will arrive on site, how long drivers have been at the wheel or whether someone opened the back of the container when the driver was eating or sleeping. Thus, along with a tracker, Hellmann also attaches a second system that measures shocks to the cargo and changes in humidity. Thus once the truck reaches a site, the EPC can immediately see if there has been significant jolt during transport.

Kenya is an example where modules arrive at the main entry port of Mombasa and must be transported many kilometres to potential PV sites on bad roads, says Riaan Meyer. The modules can easily suffer micro cracks that cannot be seen with the naked eye, so that's where mobile testing would come in handy, which is a service now offered by two German companies.

Bad roads are unavoidable at times so it is also important to package the modules as securely as possible, adds Holger Meyer. In the worst case scenario, bad weather combined with poor driving and poor packaging can result in cargo being pushed a few centimetres to one side and the whole truck flipping on high-speed corners.

Construction

When it comes to building projects, there are differing views on how skilled the local workforces are. Said Istambuli says in some locations you may need to prepare seminars for people to understand how to work on the PV projects

Mobile irradiance measurement

Most plants have permanent weather stations installed on site and they need to be calibrated, but people on location in Africa for now are unlikely to have the skills or knowledge to refit the specialist equipment, says Riaan Meyer, managing director, GeoSUN Africa. The next problem is that the closest labs are in South Africa or Europe, a far cry from many areas of Sub-Saharan Africa. The process of sending instruments over for calibration often requires a six-week turnaround with potential damage in transport. Furthermore, some large-scale plants need multiple weather stations.

As a result, GeoSUN saw a gap in the market, which was this need for on-site calibrations. Subsequently, it created what it believes is the world's first mobile pyranometer lab that sits within a trailer.

"People sometimes joke with us and say are you selling hamburgers and chips out of this thing," says Meyer. "But we've actually got the majority of the market using our service."

Weather stations are critical as they can measure how many kilowatt-hours are generated compared to the amount of sunlight over a certain period.

"If those weather stations are not functioning well you can't do what is called a performance ratio," adds Meyer.

Meanwhile, a new IEC standard soon to be released will actually recommend on-site calibration as good practice, which Meyer says has never been vocalised before. The standard will also recommend annual calibrations.

Mobile irradiance testing is now offered in lieu of local weather stations

and it may require using local subcontractors, with your own team to come in and supervise execution of the work.

Sarpong says the Sub-Saharan region has a wide range of skillsets on the EPC side: "When we talk about the on-the-ground workforce I think that the national locales are more than capable of supplying the required labour. There's an abundance of that specifically in Sub-Saharan Africa. What will make financiers comfortable is a bridge between established EPC companies, whether they be from North America or Europe, and local expertise and local companies to enact the construction and commissioning of these plants."

A partnership with a local firm is absolutely necessary, he believes. Moreover, in a region where security is paramount, Sarpong claims it is easy to overlook the value of having a good relationship with the local community. If neighbours believe that the developer is there to benefit the community, bringing jobs and knowledge transfer instead of coming there just to take resources and leave, the community is more apt to support the initiative and also do its own sort of local policing around the site.

Operations and maintenance

When it comes to operating a plant, O&M teams need to have a mix of spare parts in the right place, local maintenance teams and remote monitoring capabilities. They also need to provide data to utilities.

"Each utility in each country has got a different requirement," says Riaan Meyer. "But most PV plants are required to give a yield forecast on a continuous basis unto utilities."

GeoSUN provides this service through a partnership with Slovakia-based company SolarGIS. Meyer says Namibia's utility has its own forecasting equipment, but it is not effective, so the PV operators need to provide a "guesstimate" of weather and output, whereas in Kenya the utility wanted real-time access to the weather station, so the strictness of utilities can vary.

Another challenge, especially in West Africa, is a weather phenomenon called the Harmattan, which is a very dry, dusty easterly or north-easterly wind on the West African coast, occurring from December to February. The Harmattan will have an effect on the output of PV panels and will soil the panels.

GeoSUN addresses this on its prospecting ground stations by including soiling measurements. This is then used in the financial model of the PV plant accounting for effects on output and how often the panels must be cleaned.

"Africa, especially Central, East and parts of West Africa, also has significantly higher occurrence of lightning strikes compared to Europe," adds Meyer. "This is something that is often forgotten when developing PV projects."

In areas of high lightning density such as Uganda and Kenya the whole plant design has to cater for it. Lightning can even pose a threat to the staff working in the field of a PV plant.

"Lightning damages PV panels," Meyer says. "I know of a plant in South America where a single lightning strike damaged 400 panels. Those panels needed replacement. Lightning also damages the communication system inside the PV facility such as the communication lines for data from inverters, weather stations and combiner boxes."

Setting up and operating a PV project in Africa is clearly a complex operation that requires care to be taken at every level and throughout the entire supply chain, but the opportunities have never been as abundant as they are now.

Indeed, Avior Energy's Sarpong says: "The PV situation in Sub-Saharan Africa will grow and there's a tremendous opportunity for foreign companies to engage and I encourage them to do so." ■

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