
Photo: Huawei


Photo: Huawei


Photo: Huawei

Markets & Trends

Applications

New Products

pv magazine special

DEVELOPED IN PARTNERSHIP WITH HUAWEI


Photo: Huawei

Smart solar: Convergence powers PV

HUAWEI

Huawei Global

170+
Countries

180,000
Employees

80,000
R&D Employees

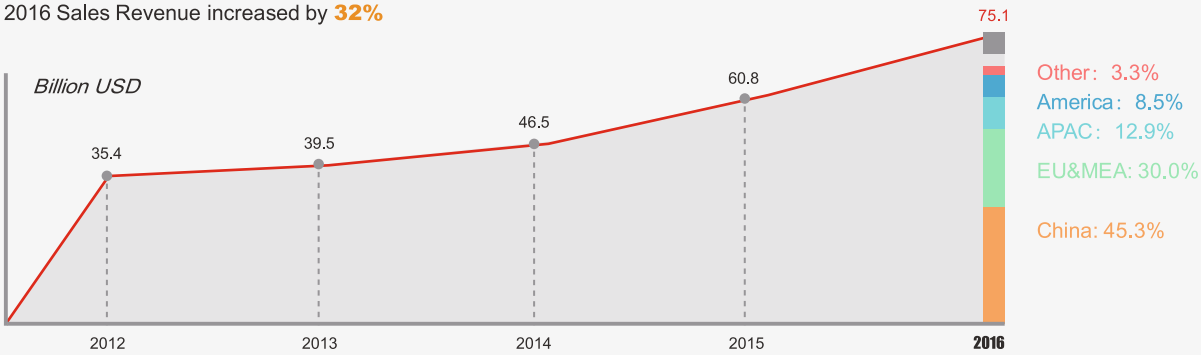
15
R&D Centers

72
Best
Global Brand

129
Fortune
Global 500

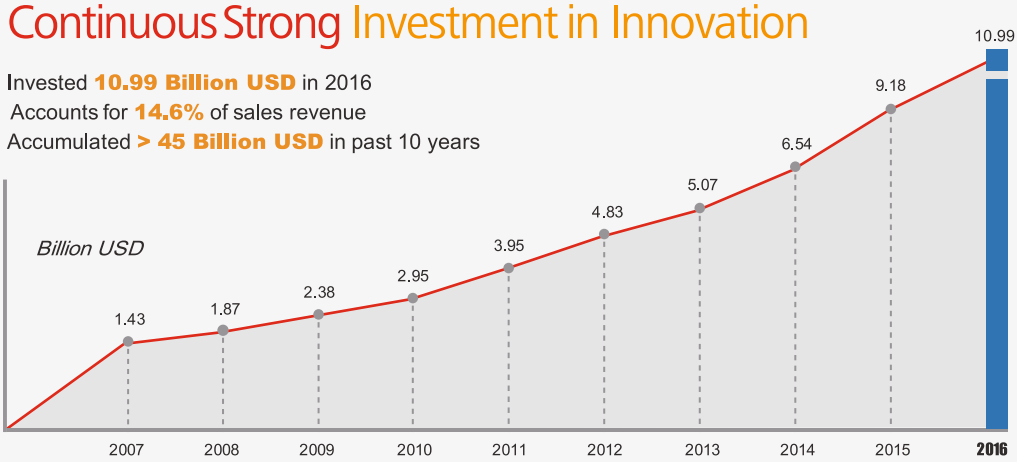
Sustained Business Growth

2016 Revenue **75.1 Billion USD**
2016 Sales Revenue increased by **32%**



Continuous Strong Investment in Innovation

Invested **10.99 Billion USD** in 2016
Accounts for **14.6%** of sales revenue
Accumulated **> 45 Billion USD** in past 10 years



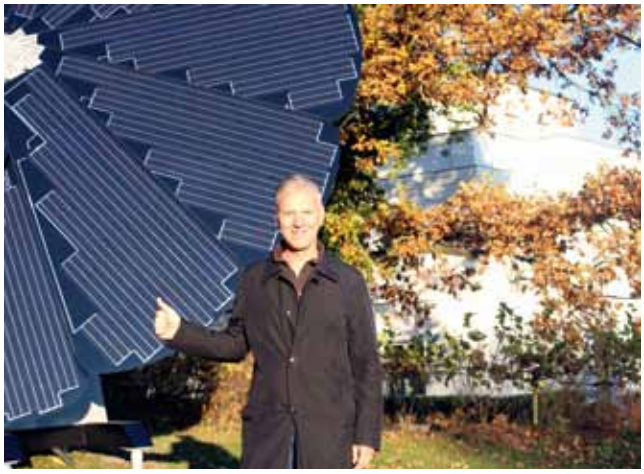


Photo: pv magazine

pv magazine Managing Director Eckhart Gouras with his Smartflower PV array at his home in Germany.

Huawei's special solar story

China's ability to scale new industrial segments is almost without rival. I have witnessed this first hand since working for three years in mainland China in the 1990s. This is especially true of two particularly dynamic and impactful sectors: ITC and solar PV. In recent years Huawei has emerged as an impressive leader in both, and there is much to learn from its strategy, execution, and ambition.

In December I was lucky enough to visit Huawei's headquarters in Shenzhen – a city that itself is an example of rapid growth and scale largely unprecedented in modern history. While there I learned not only of Huawei's ambitions to increase its inverter shipments to solar markets outside of China, but also of its technological developments, designed to continue to deliver the cost reductions required of the increasingly competitive PV sector, but also in ensuring optimum PV performance.

Looking to markets, the impressive progress Huawei has made in internationalizing its PV business is well demonstrated in this special edition of **pv magazine**. And the experience of some of Huawei's key partners is enlightening.

In the U.K., Huawei is now working in step with developer Anesco to move beyond subsidy-driven models, (pp. 10 – 11). In the dynamic Middle East and African markets, Huawei has partnered with the Phanes Group, which has itself made impressive headway in pursuing high-value distributed and utility-scale projects (pp. 20 – 21). In Southeast Asia the time appears to be now for solar to shine, and Huawei partner Sunseap has taken an innovative approach to tapping the potential of rooftops at scale (pp. 28 – 29). In the U.S., one of the high performance markets of 2016, Huawei partner Strata Solar has expanded from its home market of North Carolina to be active in more than 10 states this year (pp. 18 – 19). And in China, Huawei boasts a 50% market share in Phase I of the Top Runner program, and a 70% market share in Phase II.

What is interesting in hearing from these Huawei partners is the way that it is not only the inverter supplier's pricing, partnership model, and products that have allowed each of these companies to pursue its unique pathway to success. Operational performance, quality, and effective O&M have also played a major role in each company's decision to partner with what is today the largest inverter supplier globally.

Huawei's history as an ITC company has helped shape its DNA in a way that has allowed it to deliver the "smart solar" solutions. From its FusionSolar Smart PV system (pp. 24 – 27) to its advanced fault detection and analysis capabilities (pp. 12 – 16), communication and computational technology is what makes a difference 'under the hood' of a Huawei solar solution.

Having myself worked in telecommunications for some years, it is gratifying to see smart ICT solutions making an impact in today's PV market. And, as our ever increasingly connected homes attest, such smart solutions need not only be applied on an industrial scale. The smart home, with electricity load analysis and management, coupled with e-mobility, and (of course) rooftop PV, is looking increasingly likely to become the norm in homes in many parts of the world. Here too, Huawei is moving (pp. 30 – 31), and its solutions demonstrate the power of technological convergence.

And of course, when technology is the driver of change, progress, and success, R&D is the axis on which things turn (pp. 38 – 39). Huawei understands this deeply, and in April 2017 I visited the company's Global Compliance and Testing Center along with other members of the **pv magazine** team (pp. 4 – 5). The investment made in the facility, which serves a number of different Huawei business units, demonstrates the importance the company places on quality and innovation. And a visit to the facility tells a story about the importance Huawei places on quality, reliability, and innovation.

So it is with pleasure I present this **pv magazine** special edition, developed in partnership with Huawei.

Eckhart Gouras

Photo: Huawei

Photo: Huawei

Contents Huawei Special

Markets & Trends

Markets & Trends

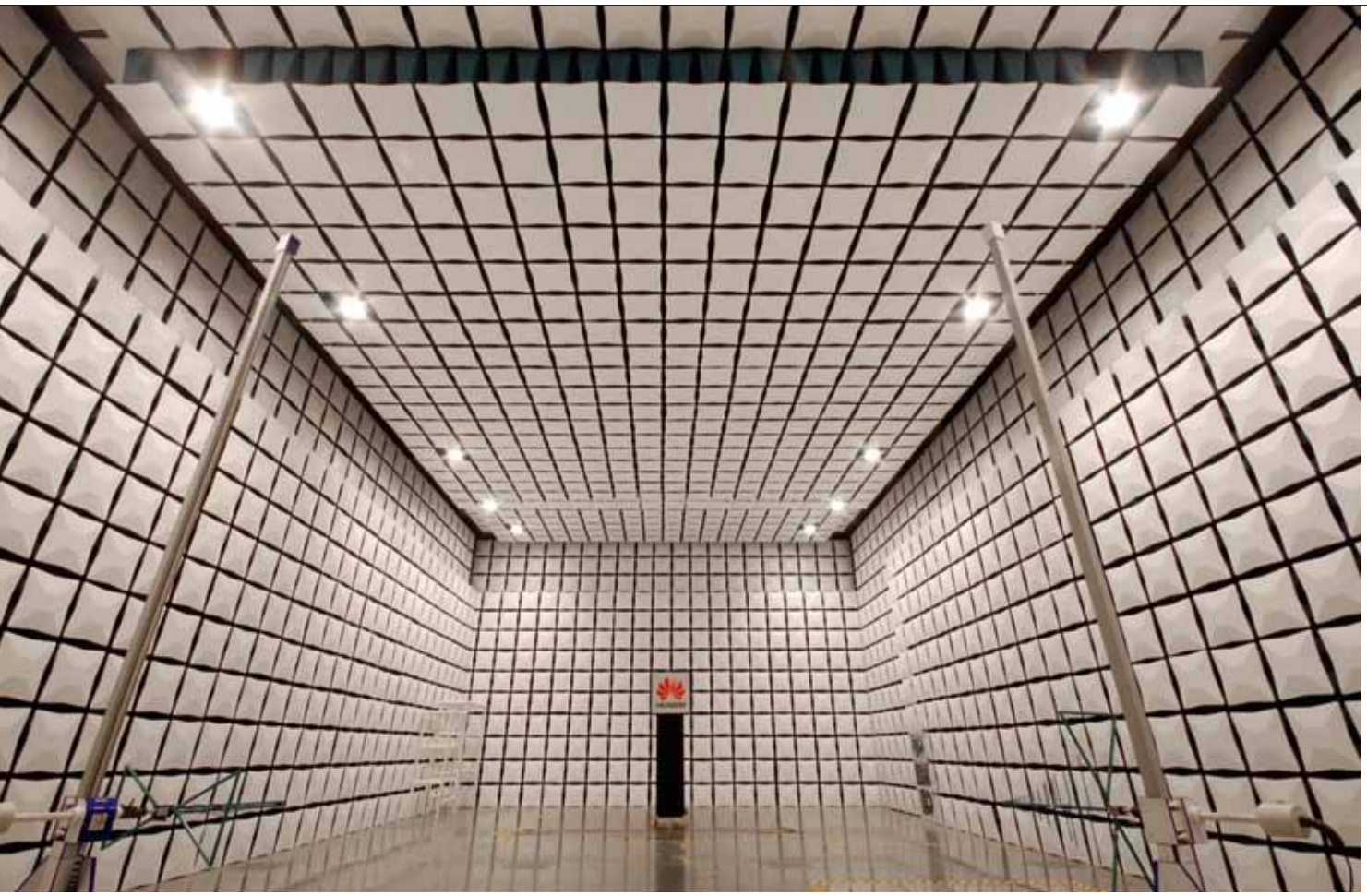
Photo: Huawei

Photo: Huawei

Applications & Installations

Technology

Publication details



Photos: Huawei

Huawei's 4 x 10 meter semi-anechoic chamber in Shanghai.

Exacting standards

Global Compliance and Testing Center: Huawei's research campus in Shanghai performs a myriad of tests and performance analyses on the company's highly-regarded solar PV inverters, setting a high level of quality and world-class standards that have underpinned its impressive global growth in such a short space of time.

Chinese ICT giant Huawei is set to make a splash this spring when it announces its entry into the IEC-standardized inverter markets of Europe and Australia at Intersolar Europe in late May.

The launch will be the opening salvo in its three-stage push into the global market for residential PV inverters. The Shenzhen-based company — a leading international supplier of string inverters for utility-scale solar plants — will follow this announcement with the official unveiling into the North American residential inverter market at Solar Power International in September, followed by an announcement into the Japanese market, likely in early 2018. It sees Europe/Australia, North America and Japan as its three core target markets outside of China.

"All markets are very important," says Steven Zhou, Huawei's general manager of residential smart PV solutions. "We can't say one is more important than the other. Each residential market is different in terms of technology requirements, power ratings and the different solutions."

In Japan, for example, Huawei has long known that simply retooling its offering for the European market would not suffice, given the country's distinctively different JET certification standard. However, it understands local electrical requirements from its experience selling mobile phones and telecommunications equipment in the country, and it has an established sales and service network on the ground. So while its Huawei FusionSolar inverter will remain the core of its planned offering in Japan, it will be tooled to Japanese standards in three configurations, including a battery interface and optional optimizers.

Backed by its cloud monitoring service, sensors, 4G communication technologies and chipsets supplied by its HiSilicon unit, Huawei is capable of halving O&M costs for PV systems, according to Zhou. He declined to comment on pricing for its residential string inverter packages, beyond saying that they "will not be the cheapest" on the market.

Outside of the lab, Huawei puts its string inverter prototypes through their paces.

The push into the residential inverter space is also supported by Huawei's massive investments in R&D, with $10.99 billion of spending in 2016 bringing cumulative investment to $45 billion over the past decade. R&D expenditure last year alone (for the entire company, not just solar) was 14.6% of the group's annual revenue of $75.1 billion. Zhou says Huawei "continuously" works to fine-tune its technologies.

Put to the test

The Global Compliance & Testing Center (GCTC) in Shanghai is one of 15 R&D centres that Huawei operates throughout the world, on top of a facility to test inverter topology and algorithms in Sweden, an inverter architecture and design hub in Germany, and a chipset R&D base in California. But the work done at the GCTC — tucked away in a series of basement labs below Huawei's sprawling research campus in Shanghai's Pudong district — is dizzying in its scope.

The GCTC — which employs more than 180 people — conducts accelerated-life tests on Huawei's inverters, as well as tests for vibration, icing, heat dissipation, salt corrosion, low pressure in high-altitude environments and resilience to impact and temperatures ranging from -55°C to 80°C.

The facility also assesses the electromagnetic compatibility (EMC) of the company's inverters, including their electromagnetic susceptibility and emissions. The tests are conducted in accordance with the ISO/IEC17025 standard on top-shelf equipment supplied by companies such as Yokogawa Electric and Rohde & Schwarz, the latter of which is "supposed to be like the Mercedes-Benz of testing equipment," according to Hariram Subramanian, Huawei's CTO for PV inverter solution sales and marketing in Europe.

The GCTC includes absorbing chambers, which use bizarre-looking triangular foam protrusions on the walls to trap sound and eliminate echoes. The tests are key to ensuring that Huawei's FusionSolar solutions do not emit noise in residential installations.

"The sound is trapped … what they get is only what is coming out of something," says Xavier Daval, CEO of kiloWattsol, a Lyon-based PV yield-assessment firm that provides consulting services to Huawei. "So you have a pure analysis of the source — not the ambient result."

The Shanghai research campus that GCTC is part of tests all of Huawei's products, from solar inverters to mobile phones. The company's commitment to R&D has underpinned its rapid advances in the PV inverter market, and extensive testing of its products continues to create the confidence it needs to expand into new global markets, according to Daval.

"A company like Huawei cannot guess if something is going to be good. They have to check it," he explains, adding that the group's background in communications technology made it a "no brainer" for it to expand into the PV inverter market.

"You can't succeed in the time range that Huawei did without the back-up of a real global structure, logistics, factories and so on. It cannot be just the product — it's the product plus supply chain. Huawei is a very special company — they are Chinese but they are very much an international brand." ◆

Inverter competition in 2017 appears fiercer than ever. Above is a 700 MW solar PV plant in Ningxia, China, built using Huawei FusionSolar Smart PV Solution.

The 2017 global inverter landscape

Trends and markets: With 2017 now fully up and running, how are the leading inverter suppliers faring globally, and which markets and technologies are pushing boundaries? **pv magazine** explores the global inverter landscape.

Consolidation is the name of the game. Over the first half of 2016, GTM Research's latest report revealed that 80% of the world's PV inverter market was controlled by the top 10 companies, with data for the second half of the year likely to show even greater entrenchment of the sector.

Indeed, GTM's data also showed that the five leading market players in terms of revenue accounted for more than half of global inverter shipments in the first half of last year. These data are echoed by those produced by IHS Markit, which showed companies such as Huawei, SMA, Sungrow, SolarEdge, and ABB tightening their grip on both revenues and shipments.

Based on GTM Research's 1H2016 data, Huawei shipped 17% of the world's inverters over that period, putting it in the driving seat for shipments, while Germany's SMA held on to its position at the top of the revenue charts due to its solid market share in higher price markets such as North America, Europe.

By region and by sector, there are notable leaders. For example, SolarEdge has cornered a vast share of the U.S. residential rooftop space, while in Japan's utility-scale sector it is TMEIC that is dominant. In some of the more stable European markets, on the other hand, localization is beginning to yield profitability for smaller, more focused suppliers that have intentionally restricted their client base. The wider trend, however, appears to be one of increasing consolidation, which suits the strengths of larger multinational suppliers such as ABB, Schneider Electric, and Huawei – companies that have the resources to enter new and emerging markets confidently, while also proving a disruptive presence in mature markets, where there has been a long-established hierarchy of suppliers.

Pressures and trends of 2017

The trend for installing string inverters in large-scale solar plants has emerged as more customers realize the benefits of higher yields with equivalent capex to central solutions. This trend has driven sharp cost reductions in central inverter prices globally as suppliers try to remain cost competitive. This trend has been most evident in the U.S., where central inverter prices fell by as much as 10% in 2016.

More widely, the expected slowdown in growth of the global solar industry in 2017 is forecast to have an impact on global inverter sales. GTM Research has

Photos: Huawei

reported that global inverter shipments reached a record 63.5 GW last year, but expects a 5% contraction in 2017 as demand for solar PV in China, the U.S., and Japan wanes ever so slightly this year.

Revenues are unlikely to contract quite as much, GTM Research believes, falling by a mere 1.2% globally as module level power electronics (MLPE) bring their premiums – and profits – to a wider audience. Uptake of MLPE products is expected to grow globally in 2017 as power optimizer specialists SolarEdge and microinverter company Enphase Energy continue to roll out their full home energy systems to new markets. Competition in this space is also expected to become even fiercer in the second quarter of the year as Huawei enters the global residential solar space with its long-awaited residential solution, including both a DC power optimizer and microinverter. In Japan, SMA is poised to bring its successful power optimizer partnership with Tigo to the growing residential and commercial solar markets, while ABB is banking on its leading position in the growing Indian solar market to enable it to maintain good shipment and revenue levels throughout 2017.

2017: Huawei's year?

For the past 24 months Huawei has not so much as crept up on the blind side but shot past in the fast lane, rapidly becoming not only the world's leading supplier of inverters, but also one of the most profitable and innovative too. Its FusionSolar Smart PV Solution delivers a central point of control for utility plant owners, while offering the performance benefits, high yield, and ease-of-maintenance of string inverters.

"Pressure has increased with the added international attention that Huawei has been receiving," a Huawei spokesperson told **pv magazine**. "Our FusionSolar Smart PV Solution has been making an enormous impact globally, because it implements automatic operations and maintenance (O&M) for PV plants, allowing higher energy yield and smarter O&M."

Thrust into a global leadership position, Huawei's strategy appears to be one of comfortably occupying the apex of the inverter landscape, seeking ways to increase the pace of product innovation that has perhaps not yet been seen in the sector.

"Huawei is now cooperating with upstream and downstream industry-leading manufacturers to establish an open and mutually beneficial smart PV ecosystem," the company said. One of the company's key aims is to accelerate the process of cost-effective grid-tied solar PV energy yields, taking a broader approach to that perhaps seen by previous sector leaders.

String strength growing

As solar markets mature, the typical trend is to gradually switch focus from large-scale solar installations to smaller, fully digitalized, decentralized solar arrays atop homes and commercial buildings. In countries such as Germany, Italy, and Japan, this evolution is largely evident, while in India, for example – a country that is expected to become the world's third-largest solar market in 2017 – rooftop solar is just a tiny percentage of current growth.

AT A GLANCE

- The global inverter landscape is becoming ever more consolidated, with the top five suppliers cornering more than half of the market.
- Huawei shipped 17% of the world's inverters in the first half of last year, and finished 2016 as the leading supplier in terms of shipments.
- SMA remains the market-leader for revenue, given its exposure to higher-priced markets in the U.S., Europe, and Japan, with SolarEdge also performing strongly.
- Trends for using string inverters at scale are bringing additional cost, performance, and innovation pressures to the industry, which will likely bring about further consolidation in some markets.

Photo: Huawei

Using string inverters at scale is now a widely accepted approach in most leading PV regions, including in Germany. Pictured: the 20 MW Krempendorf solar farm in Germany, fitted with Huawei inverters.

But in those mature markets there is still scope for large-scale installations, albeit ones that are often smaller and located in less than optimum sites, such as in remote, humid, or mountainous regions. Equally, mature solar markets tend to have less generous support schemes or incentives for PV, which serves to apply additional cost pressures on developers.

These trends are playing into the hands of inverter companies able to offer string inverters at scale, where the longer-term operating expense is generally lower than that offered by central inverters.

There will still be opportunities for central inverter suppliers in all major solar regions, but the trend is evident – and it is one being driven by technological advances, as much as wider market maturation.

"The Huawei string inverter has a maintenance-free design that guarantees 25 years of reliable system running, partially thanks to its IP65 rating," says the Huawei spokesperson.

"The interior and exterior of each inverter is separated, ensuring components operate in a stable environment and reduce the impact of external environment risks."

This offers peace of mind for system owners operating solar plants in hard-to-reach regions, and also means that Huawei and other companies that offer similar assurances will be the inverters of choice in emerging regions in hot and humid locations found in Southeast Asia, Latin America, and MENA.

Allied to improved reliability and durability, accurate and user-friendly remote maintenance is a key feature offered by leading providers of string inverters – and this is an area in which Huawei, which has a strong background in ICT, has a distinct advantage over many of its peers.

"Smart modernization is implemented in the existing PV power generation, ensuring that an inverter functions not only as a power generation component but also as a smart PV controller that incorporates power conversion, remote control, data collection, online analysis, and environmental adaptation," the Huawei spokesperson explains.

String inverters installed at scale using the Huawei FusionSolar Smart PV Solution are connected via a network that enables a digital highway of plant information, which is instantaneously uploaded to the cloud for storage and easy analysis.

On the hardware front, the system reduces the need for DC combiner boxes and other components such as fuses and external fans – an approach that aids the overall speed of delivery and installation, as well as ease of maintenance in the coming years.

Then, from a diagnostic and monitoring perspective, the Huawei architecture significantly improves O&M efficiency via its I-V curve diagnosis technology.

"This is a highly useful tool in the O&M market," states Huawei proudly. Assuring extensive and industry-leading after-sales service is no easy task, and it is something that inverter firms must not lose sight of if they hope to stay relevant in this increasingly competitive space.

"Huawei's smart I-V curve diagnosis technology can monitor all PV strings at a plant and estimate performance online with high precision, accurately identifying faults and generating automatic fault reports for all strings within 30 minutes," says the Huawei spokesperson. The chief benefit for the system owner is greatly reduced operating costs and increased uptime – two facets of PV plant operation that are becoming increasingly vital as costs are squeezed.

The threshold for using string at scale has increased year-on-year as costs for string inverters have continued to fall. Now, most plant owners will not bat an eyelid at building a 10 MW solar farm using string, and even far-larger solar plants have already been built in this way. Especially in China, Huawei string inverters are widely applied in large-scale PV plants that exceed 100 MW.

This is the clear trend heading into 2017, and it is one that will increasingly favor companies able to offer a compelling combination of quality, service, and price – something that Chinese companies are increasingly able to do. GTM Research data from 2015 reveal that 40% of utility-scale solar installations that year were made with three-phase string inverters, and this trend is now hitting the U.S. and Japanese markets as attitudes have begun to liberalize towards decentralization.

Cornering just 5% of the utility-scale market share in the U.S. in 2015, three-phase string inverter controlled solar installations are expected to account for 15% of the market in 2017 according to GTM Research projections, rising to close to 30% by 2020. Based on these forecasts, there are vast opportunities for companies that specialize in string inverters to grab a larger share of the strong U.S. solar market. ◆

1 GW PV Plant, Yanchi, China
Largest single-site PV plant in the world, utilizes SUN2000 Series

Inverters in action

Huawei is active in many of the world's most important PV markets. These projects already in operation demonstrate the strength and ability to operate successfully at any scale and in a range of challenging conditions.

2 MW floating Smart PV plant, Miyako-Jima, Japan
Water surface PV plant, utilizes SUN2000-28KTL

300 MW Rooftop Smart PV Plant, Haining, China
Largest rooftop project in the world, utilizes SUN2000 Series

66 MW Smart PV Plant, Monte Plata, Dominican Republic
50% grid-connected PV plant, utilizes specially customized SUN2000-30KTL-A

50 MW Smart PV Plant, Luhuo, China
The world's highest altitude ground-mounted PV plant, 4,300 m above sea level, utilizes SUN2000 Series

20 MW Smart PV Plant, Trowbridge, U.K.
Ground-mounted PV plant, utilizes SUN2000-28KTL

Photos: Huawei

Photos: Anesco

"I could buy cheaper inverters currently than I get from Huawei, but what we look at is the whole lifetime cost."

"What we look at is the whole lifetime cost"

U.K. market: Anesco has gone through a period of very rapid growth in recent years. Its solar business spans the commercial and utility-scale market segments. Anesco CEO Kevin Mouatt spoke to **pv magazine** about the importance of partnering with component suppliers, and how it will allow the company to make the next step in the evolving U.K. PV marketplace.

pv magazine: Anesco and Huawei have been close partners in the U.K. market. How would you describe the relationship?

At Anesco, we look for like-minded companies to partner with. I think historically if you look at the U.K.'s relationship with supply chain, its only been seen as a supply chain with a master/servant basis. Contracts in the U.K. are very adversarial and what we're building with Huawei is for the long term.

What we're looking for from Huawei is this flexibility that we're getting now. It's all about the working relationship, how we can carry on developing our product, rather that sitting down saying 'can you take two pence off this, can you take three pence off this.' It's better for me that I've got a partner I can use for future works, rather than just today.

I think that's a good message for the industry in many parts of the world.

I will keep going back to Huawei, because it's something I believe in. Even in the U.K. If you're really partners with someone you shouldn't need to have a contract in place.

What we're looking for is we want the simplest arrangement – somebody who's going to be there when it's raining as well as in the sunshine. What you normally find is people want to work with you when the sun shines, but the minute the rain comes down, they hide. That is what really attracted us to Huawei.

Well, talking of rain, after a period in which the utility-scale market in the U.K. has been a very good one, Anesco must now look to a post-Renewable Obligation solar market. How are you facing that challenge?

We've had to overcome some fairly challenging times in terms of the product, of what we have to do with each individual component. But not once has Huawei turned around and said "no" to one of our requests. They've worked with us and they understood what we want to get out of the design of the product and they've made changes to that product to suit where we want to go with our business.

Can you give me an example of that?

Just as an example, the U.K. has built [PV arrays] so far with 1,000 V inverters – 1,000 V for us is not good enough [going forward], which provides a bit of an insight into some of the changes we're going to be making.

Huawei's string inverter for utility-scale has made a significant impact on the power plant market in many parts of the world. How did it change the way Anesco does business?

We chose string inverters – not micro or central inverters – the reason for that is it gives better predictability for our investors. When we've gone out to build we've taken into account what our investors look for, what they see as bankable. The string inverter suits our needs and our investors better.

In what ways? Monitoring, speed of installation, service repair? What are the key points?

It allows us to monitor by string rather than the whole park. That allows me then to look at optimizing the performance of panels. In terms of predictability, I don't lose the park if there was to be an issue. So writing out contracts and guaranteeing performance, it's better to have the string than the central

inverter. The other side of that is the type of product that we're going forward with, we needed someone that could be more flexible with the way the inverter was to work, and we found that with Huawei.

Cost is always an important lever. What about the cost structure of the way you develop projects; what role has Huawei played there?

This is where we go back to partnering, when we look at cost within Anesco we don't look at the cost today or tomorrow – I could buy cheaper inverters currently than I get from Huawei, but what we look at is the whole lifetime cost. When I look at the cost of a product, it's the whole-of-life that I look towards. When I see some of the products and the guarantees that I can get, I've had more downtime with other inverters than I've had with Huawei.

Anesco does have some O&M contracts – sometimes for parks that Anesco hasn't developed itself. How do you go about developing an O&M regime?

Our maintenance is proactive, we'd rather go out and maintain it than have it break down. So we have a tight rule on that. What we can say from the 21,000 assets that we manage – which is just shy of 700 MW – of the string inverters that we look after: We have the least number of failures with Huawei.

And how does it compare with central? Do some of those parks have central inverters?

We don't have central inverters generally, it hasn't really been a big thing in the U.K. We've probably had two central inverters, and that really led to us moving to string inverters, because if one goes down you really lose the whole of the solar park.

Monitoring to spot faults is clearly important. What role does Huawei's monitoring solution play in your decision making?

I take it you mean the Huawei Fusion system. We're in close discussions at the moment because we're moving to the Fusion system for those reasons. It allows us to optimize the performance much better. It gives us transparency and real-time information.

How is your monitoring operating today, before Fusion is applied?

We have a system in place where we can compare to the Huawei Fusion system and see that it is much better. Fusion is more scalable as well. So going into the future – the next five years – the Fusion system will be better than our current one.

We've talked about ground-mounted systems, but the commercial rooftop segment in the U.K. has long been said to have good potential, in particular with other parts of Anesco's business, such as delivering energy efficiency measures to large corporate clients. What activity are you seeing there?

We see that as a growth market. It's perhaps been ignored because of the rush of everybody wanting to build solar parks before the end of March [the final RO grace period]. So everybody's been saying for the last five years, "we can build solar parks, and why should we go for the smaller rooftop one, when its easier to build on the ground." I see that as a huge opportunity. We are looking at asking Huawei for rooftop inverters. We are working with a very good rooftop inverter at the moment, but I'm sure that when Huawei comes out with its rooftop inverter in the U.K. it will be just as good, if not better.

Could you give a bit of background in volumes you've done with Huawei?

Perhaps 85% of our business is Huawei. Just to let you know how seriously we take partnering, two long-term supply chain partners we've had to move away from, because they didn't demonstrate the views we've just talked about. ◆

Anesco's Drayton Park project, in the U.K.

The initial benefits of installing string inverters at scale tended to be seen among EPCs, who were offered more scope for flexible plant design using string. Today, as the technology has improved, so have the possibilities.

A string of success

String inverters at scale: In the past few years the global solar industry has seen how string inverters are increasingly displacing central inverters in multi-megawatt PV power plants. **pv magazine** examines the benefits of this shift, and what the future may hold.

In 2011 the first multi-megawatt PV power plants equipped with string inverters were commissioned in Germany, proving that all grid-code requirements for large-scale solar systems could be met with a distributed inverter topology and not only by central inverters.

Megawatt-system layouts

Since then, three-phase string inverters have seen a growing adoption rate in large-scale PV power systems. Initially the key driver for the increased adoption of string inverters in utility-scale systems was the fact that switching to string inverters gave the EPCs a much higher degree of freedom in the plant layout. In instances where the plot of land was not simply flat, where (partial) shading was an issue, where modules with different power ratings had to be integrated in one PV system, or simply where the access roads would not support the heavy load trailer trucks required for bringing the central inverters on-site, the switch to string inverters was required to make the PV project viable at all. In such instances, the higher investment costs associated with string inverters could, even 2 – 3 years ago, be justified.

In the meantime, the price differential on a euro/kWp basis between central inverters with a power rating in the megawatt-range and three-phase string inverters with a power rating in the 30 – 60 kW range has diminished strongly.

As a consequence, more and more developers and system engineers of solar power plants are deciding in favor of the

Photos: Huawei

decentralized inverter layout even in the absence of specific incidents that would necessitate the use of string inverters for an efficient layout of a multi-megawatt solar power plant.

Taking only the investment and construction costs into account, equipping a 20 MW power plant with string inverters is no longer necessarily more expensive than doing so with central inverters. For the string inverter layout, the added cost for the transformer cabin and AC-combiner boxes have to be taken into account. On the other hand, no DC string monitors are required for the string inverter layout and significant savings can be realized at the DC cabling level.

Yet the budgeted costs laid down in spreadsheets don't necessarily reflect real life challenges involved in the construction of PV power plants. Stefan Koeberlein, MD at German EPC firm sun-factory Deutschland GmbH opines, "We usually have very tight schedules for the construction of the PV power plants. Often enough, regulatory frameworks impose deadlines that under all circumstances have to be met. Since the installation of a central inverter requires renting expensive equipment and coordinating specialists, this can cause quite a headache and extra costs if the weather conditions force the rescheduling of the originally planned installation date. Going instead with string inverters provides us with the option to react much more flexibly at the construction site to any external factors that force adjustments to the original time schedule."

Servicing faulty string inverters in the field remains much simpler than servicing a central inverter: Local electricians only need to know how to dismount and disconnect an inverter, and replace it.

Flexible service concepts

Today, the most frequently cited reason for operators and owners of PV power plants to opt for a string inverter configuration instead of a central inverter is the flexibility in the service concept.

With a central inverter architecture the operator is bound to this specific manufacturer for service and spare parts for the entire lifespan of the PV power plant. Furthermore, certain parameters of a central inverter can only be accessed and modified by authorized service technicians. If a problem with a central inverter cannot be solved remotely a qualified service technician of the inverter manufacturer has to travel to the site to perform the repair. In case the cause of the inverter problem could not be diagnosed remotely, two trips to the power plant are required: the first to identify the cause of the malfunction and the second for the actual repair. Depending on the location of the power plant and the availability of the given spare part, significant additional costs can arise from delivering the required replacement part to the site.

The whole time before the repair of the central inverter can ultimately be performed, the thousands of modules attached to the central inverter are affected by its underperformance, thus leading to substantial energy yield losses.

In contrast, the service concept for string inverter configurations has always been that local electricians simply replace the faulty inverter in the field and send the defective device back to the service center of the manufacturer where the fault analysis (and possibly the repair) is being performed. The local electricians only have to be qualified in mounting, dismounting, connecting, and disconnecting a string inverter, which for modern string inverter designs is fairly simple. This allows for much lower servicing costs and much faster reaction times. Even if the servicing time for the central inverter and the string inverter were the same, the effective loss in power generation would be 20 to 50 times lower per inverter failure.

With failure rates of Huawei's string inverters at below 0.5% per year, statistically there will be no more than one inverter service incident per year for a 10 MW PV power plant unit equipped with 200 string inverters. The larger the size the solar power plant gets, the more remote typically their location, clearly favoring the decentralized inverter concept – in particular for the largest solar power plants. Indeed, the largest PV power plant to date is a 1 GW system in China equipped with Huawei string inverters. More details of this landmark project can be found on page 9 of this issue.

Even more problematic than the servicing costs for central inverters is the complete dependence on the supplier. What happens if a manufacturer discontinues its inverter activities within the next 10 or 20 years? If today a power plant operator requires any kind of support for a Satcon central inverter, for instance, they must be prepared to pay exorbitant service fees, since Satcon went out of business a couple of years ago.

In contrast, if a solar power plant is equipped with 400 volt AC string inverters today and the original supplier is no longer active 10 years from now, there will always be a choice of 400 volt AC string inverters from alternative suppliers that can be used at that time to replace any faulty devices of the original supplier.

And consider an alternative service scenario: Suppose for whatever reason 10 years from now multiple solar modules have to be exchanged at the power plant. It is obvious that today's power ratings of the modules will no longer be available. With a central inverter architecture there is no chance to take advantage of the higher power ratings of the modules available by then. With more than 2,000 modules per maximum power point tracker (MPPT), Huawei has made great progress in the cost optimization of string inverters, resulting in negligible price differences.

Smart fault detection

All of the above cited arguments that have already led to string inverters capturing an ever growing share of the utility-scale solar system market can be summarized with the terms 'flexibility' and 'vendor independence.'

For an asset that has to operate for 20 years or more in order to earn the

intended investment yield, flexibility and vendor independence are good arguments by themselves to opt for this architecture. Yet Huawei is now introducing an argument that is unique to its architecture and cannot be replicated in a central inverter power plant layout.

All Huawei string inverters with power ratings above 36 kW launched since last summer are capable of performing a smart fault detection and diagnosis. How does that compare to the current state of the art?

As of today, the monitoring of a solar power plant is limited to monitoring the output power and comparing it to the expected power yield based on the irradiation level measured in parallel. In a central inverter topology, even when using smart DC combiner boxes the inherent measurement uncertainty of around 2% – 3% limits the ability to detect all relevant faults in a solar installation as long as they only affect single strings or modules.

With a conventional string inverter topology, underperforming strings can be identified yet without giving any further insight into the cause of the underperformance.

Compared to the central inverter architecture, this has the advantage of being able to better localize the affected areas within the solar park.

If the observed energy yield loss is severe enough to trigger a further analysis, in both scenarios it is required that a service team is dispatched to the site of the power plant and that it performs time intensive and costly measurements on-site, be it I-V curve measurements, electroluminescence measurements, or thermal imaging.

Often enough the detailed analysis of the field measurements is then performed back in the office, requiring a second service incident on-site to perform the actual repair. Consequently, the time that elapses between detecting underperformance in the field and its repair can easily exceed one week.

Given the high costs associated with each diagnostic test performed on-site, operators have to set significant thresholds before an on-site visit of a service technician can be justified. Therefore, a key economic requirement in day-to-day solar power plant operation is limiting false alarms.

All these issues can be solved with the use of Huawei's FusionSolar Smart PV Management System. From the remote moni-

Table 1: Fault causes that Huawei's FusionSolar can identify

Open circuit of string
Current mismatch in string
Panel shadowing
Glass breakage of panel
Hidden cracks in panel
Panel shading
Cell damage in panel
Diode short circuit
Bracing breakage in panel
Low string voltage
Risk of PID
String with minor current mismatch
String with high resistance
Low string short circuit current
High decay speed of string
Incorrect string configuration

The Huawei FusionSolar Smart PV Management System offers remote monitoring capabilities whereby the customers can identify and detect faults accurately in a very rapid manner.

toring center an operator can initiate the I-V curve scan of individual strings with a simple click. Intelligent diagnosis algorithms can not only identify faulty strings but can also distinguish between more than 16 different causes for the underperformance listed in table 1 (see p. 15). In order to perform the fault diagnosis, Huawei's software identifies typical I-V curve signatures associated with the specific faults.

From an operator's and an owner's perspective, such a remote fault analysis bears a number of important advantages:

1. No service technician has to be dispatched to perform the error localization and error identification on-site.
2. The fault diagnosis can be performed any time, independent of weather conditions.
3. The actual measurement is performed within a few seconds so that the time between error identification and repair can be drastically shortened.
4. No modules have to be disconnected

All Huawei string inverters rated above 36 kW and launched since last summer are capable of performing a smart fault detection and diagnosis. This capability is proving extremely beneficial for plant owners concerned about their ROI.

for the failure diagnosis, and so no energy production has to be sacrificed in order to perform the failure diagnosis.

5. The thresholds in the monitoring system that trigger an error analysis can be set much tighter, as no additional costs are associated with the failure diagnosis. Thus, underperformance can be identified at a much earlier stage, further improving the overall energy yield of the solar power plant.

This feature is a clear differentiator and has the potential to significantly increase the adoption rate of Huawei string inverters in utility-scale solar parks around the world.

Looking at today's success of Huawei in a stagnating European solar market – increasing its shipments from 400 MW in 2014 to some 800 MW in 2015 and more than 1.5 GW in 2016 – the intelligent failure diagnostic feature is bound to spur further growth in the next few years.

So far one can distinguish quite different adoption rates of string inverters in the utility-scale market segment globally. It is estimated that in 2016 roughly 50% of the newly installed PV power plants in China were equipped with string inverters. In Europe, anywhere from 15% to 25% of the megawatt-scale PV installations last year used string inverters while in the U.S. string inverters still made up less than 10% of the utility-scale market.

Huawei's introduction of the intelligent failure diagnostic feature at the inverter level will significantly impact what will be expected in future in the operations and maintenance (O&M) of solar parks. On the back of Huawei's success, string inverter-equipped large-scale solar parks could become as common around the world as they already are today in China. ◆

Huawei's string inverters can be rooftop mounted as pictured to offer even greater design flexibility for installers.

Photos: Strata

Mike Belikoff is the COO of Strata Solar.

Building it right the first time

Interview: Strata Solar has grown with the fast-moving solar market in North Carolina to become not only one of the largest solar developers, EPCs, and O&M providers in the state, but a national player. Recently, the company entered into an agreement to exclusively use Huawei string inverters for its business, and **pv magazine** caught up with Strata Solar COO Mike Belikoff in the company's North Carolina offices to talk about that decision, what got Strata to where it is today, and what the company sees for its future.

pv magazine: Strata obviously has a big presence in North Carolina's solar market. As you have been active here in your home state since 2008, can you describe what you have seen over time?

Mike Belikoff: Strata started out doing a couple of utility projects in 2011 and then geometrically grew the pipeline over the next few years to get to a steady state of 30-something odd projects a year, and that has taken us through to last year. And now the amount of work for projects that have been put on to distribution has gotten to the point where Duke is looking to reset the way the market is going to go forward, so there are now significant negotiations between the solar industry, Duke and politicians to figure out what solar 2.0 looks like in North Carolina.

Clearly Strata has not confined itself to North Carolina. You have projects in Massachusetts, the South, and other regions. Can you tell me what Strata is doing nationally?

Our CEO, Markus Wilhelm, likes to say that your success can be your failure. And so eating at the QF (PURPA Qualifying Facility) salad bar and not eating anywhere else gives them a concentration risk that is unacceptable.

So as part of Strata 2.0, the strategy is to have a national development organization, looking at different markets throughout the country, figuring out where what we do well that fits in with what those markets require, and to have our development team stretch its tent pegs.

So if you looked at our pipeline today versus two years ago, our pipeline two years ago would be heavily concentrated in North Carolina, with dabbling in Virginia, Mississippi, and Georgia. Today, it is somewhere between 10 and 15 states. We are stretched from Massachusetts to Florida, with projects as far west as Oregon, and as far south as Texas, Ohio, Mississippi, Alabama, Georgia, Louisiana, Arizona, and Virginia. It's fair to say that we have a strategy that is diversifying Strata, and that the pipeline we will execute on in 2019 will be extremely diverse from a region/state perspective, and we will have different mechanics of PPAs based on the markets we are playing in.

Are you finding that these are PURPA markets – RPS-driven markets – or is it really a mix?

It's a mix. One of the things that I think bears noting is that the market has grown significantly, based on the pricing of modules taking a significant drop over the past year-plus. So if you take $0.20 per watt on a cost stack that was already pretty aggressive, it makes a big impact on the PPA price we can offer.

You see PPAs being offered now in the sub-$40/MWh range. Strictly speaking, it is either at or near the lowest price of a PPA for the new generation that you can get. So the market has gotten bigger. The market is extremely competitive, so on a per-watt basis everyone makes less money, but because the market is bigger there are more dollars to be made with all the opportunities that just couldn't exist without the pricing coming down.

Strata is obviously a developer and an EPC, and you are moving into new states where you won't have the same workforce. Can you talk about how Strata maintains quality in new states where you have a new workforce?

That is a real challenge. You said Strata is a developer and an EPC, but you can't leave out our O&M and asset management capabilities. That vertical integration is essential for us to be

competitive. We build for us to own and operate. We may not own and operate every asset, but that focus on being the lifetime asset owner makes us focus on quality.

Now to answer your specific question, what we have done is a combination of self-perform and subcontract work. We have a program called First Time Right. The First Time Right program is essentially for construction: a training program that rationalizes the specifics of a technology. So if you wanted to compare, say, string inverter versus central inverter, what would construction have to know before they go build it – let's design the training program such that the workforce is going to be trained with a relentless commitment to quality, whether it is our workforce, or the subcontractor's workforce – everyone needs to go through the training program. And First Time Right isn't just for the labor force. It's a corporate mind set that goes into the design and engineering of everything we do.

Recently Strata made the choice to move from central inverters to Huawei string inverters. Can you talk about why?

If we had this conversation three or four years ago, string inverters were too expensive to be considered. If you went to SMA and requested a string inverter price, you would have said, "I can't make a utility-scale project work." We have struggled as an industry in utility inverters. The string inverter is more of a commodity product, and it has a lot of de-risking qualities that we like a lot. We made a connection with Huawei about two years ago, that we liked.

Strata has a unique mode of vendor relations. The lowest price vendor is not necessarily the right vendor for us. Our CEO and those of us on the leadership team need to feel that there is a partnership. Even if we are not making a formal joint venture type of partnership, there needs to be a philosophical or values-driven alignment. As big as Huawei is, it gave us a warm, fuzzy feeling about their customer-centricity, caring about what the customer thinks about, and then add to that the size of Huawei as an entity and an interest – It made us feel comfortable that we had value alignment with the people that we are working with – we have a substantial parent standing behind the product, which, you know, it is kind of a rare commodity.

If you look at some of the consolidations taking place in the central inverters space, like Power-One being bought by ABB, or fill-in-the-blank being bought by whoever else, the outcome has not been great. GE has probably been about the best, and that is not without the growing pains of integration.

There is a level of trust that we have been able to achieve with Huawei. And then you get to "trust but verify." Our experience so far has been good. The Huawei service people have stepped up and done a pretty good job, and validated our hypothesis.

We still think there are opportunities to make an integrated string inverter – and really, let's stop calling them string inverters – to make a small inverter on a less-cost basis, but I would say generally we are pleased in our first go-around. And really the best part was that on startup and anti-islanding, no hiccups whatsoever. Whereas with every central inverter we have had some measure of difficulty along the way.

Can you talk a little bit more about quality issues? What makes a quality inverter product?

Why would you want to buy an inverter from a company that may or may not be there to honor its warranty? That, to me, is a big deal. I don't know what the real length life of an inverter would be.

The 20 MW Butler solar farm, built by Strata Solar using Huawei string inverters.

If you are an asset owner, you want to pay the least amount, to get the most value out of it. So the way that someone rightly should think about it is you should look at the life-cycle cost of the inverter, the serviceability of the inverter, the parts availability. I don't think there is any rocket science here.

Strata has 600 volt central inverters, where you already see spare parts concerns, and there are no off-the-shelf, go buy something to fix.

If we did do some sort of replacement, we would have to reformat the form in order to include a different inverter. The string inverter makes that problem easy to deal with. The output voltage of a string inverter at 40 volts seems to be coming to a theater near you in volume.

Can you talk about Strata's plans for the future, which markets you are looking at and what direction you see for your business?

String inverters will be a big part of our future pipeline. I had questions from several utility companies about what is the maximum size of a power plant that should use string inverters. My answer was: What is the maximum size of a power plant that should have a 350 watt module in it? It doesn't matter. It is the same thing.

As the string inverters become more widely adopted and as people are more focused on life-cycle costs, you will see more and more string inverter projects. One of the biggest constraints of inverter adoption is what the interconnection agreement is written around, for the risk of having a restudy required. The secret for any inverter vendor is to work with developers, to support interconnection agreement applications, and those constraints become a little different as you work on down the pipe. ◆

Smart I-V Curve Diagnosis

1 Large number of PV strings in large-scale plants, make it difficult for fault location and string performance analysis.

Energy Yield

Why

100MW PV plant: around **400,000** modules, **20,000** PV strings and **2.5** km² land area.

Central Solution: difficult fault location on PV strings

Normal DC combiner box
No PV string monitoring function.

Smart DC combiner box
Only **3%** accuracy on string monitoring, unable to fully detect string faults on time.

String Solution: no precise analysis on string faults.

Traditional string solutions can monitor PV strings but lack of accuracy, lack of fault cause analysis, and no diagnostics.

2 The present PV string inspection method is high-cost and low-efficiency, and not possible to be done for all strings.

Spot checking on PV strings via the I-V Curve tracer?

1 Go onsite with the I-V Curve tracer.

2 Remove the PV string to be inspected.

3 Connect the I-V Curve to PV string and start inspection.

4 Analyse the string faults afterwards by a team of experts.

High cost, low efficiency, no full inspection of all PV strings.

Huge inspection workload, not all PV strings inspected
Since there are numerous PV strings in a PV plant, it is impossible to inspect all PV strings one by one to identify faults.

Low inspection efficiency, high inspection cost
Using an I-V Curve tracer to inspect PV strings in a PV plant is labor-consuming, low-efficiency, and costly.

Long inspection period, high power loss
For a 100 MW PV plant, it takes five to seven days to spot-check 1% to 5% PV strings, which brings over 1000 kWh power loss.

3 Complex scenarios in PV plants make on-site inspection difficult, labor intensive, and time consuming.

Ground-mounted PV plant

Large-scale PV plant, wide footprint, heavy inspection workload

Mountain-mounted

Rugged and steep terrain, scattered fields

Rooftop PV plant

Scattered rooftops, working at heights, hard to carry detectors

Solar-agricultural and solar-fishery PV plant

Complicated terrain, inconvenient transportation, difficult to get onsite

4 FusionSolar Smart PV Solution Innovative Smart I-V Curve Diagnosis.

FusionSolar Smart PV Management System

- Starts smart I-V curve by one click
- Identifies faulty PV strings with the help of the intelligent diagnosis algorithm.
- Provides diagnosis report on PV strings.

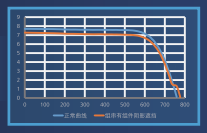
Smart PV Inverter

- Built-in CT scanner for I-V Curve diagnostics.
- On-line scan all PV strings
- Up to 0.5% inspection accuracy.

5 Smart I-V Curve Diagnosis locates problematic PV string, and analyzes root causes, using Huawei big data technologies – data mining and pattern recognition.

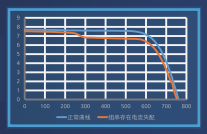
- Abnormal I-V behavior spots problematic PV string(s)
- The pattern recognition algorithms identify fault types and provide fault handling suggestions.

Shadowing on PV modules



Note: The symptom is prone to happen in the morning and evening.

PV string current mismatch



Note: PV string current mismatch may be caused by dust, attenuation inconsistency, material deterioration inconsistency, and mix of high and low-quality PV modules.

6 Full inspection of all PV strings enables a comprehensive understanding of the whole PV plant.

Inspection Mode	I-V detector	Huawei Smart I-V Curve Diagnosis
Inspection Volume	1%–5% PV strings	All PV strings
Time	One week (for a 100 MW PV plant)	Online scanning in 1 second. Report issuing for one subarray in 7 minutes
Personnel	Two to three persons	One-click mode
Energy Yield Loss	＞1000kWh	≈ 0 kWh
Data Analysis	Manual data analysis with low efficiency.	Automatic I-V Curve analysis,fault identification and report issuing.

7 The inspection accuracy and diagnosis effectiveness are certified by TÜV.

Smart I-V Curve Diagnosis

Efficient O&M tool for PV plants

Valid credential for transactions

Precise presentation for valuation of PV plants

Always Available for Highest Yields

Higher Yields

Smart O&M

Safe & Reliable

Photos: Phanes Group

Martin Haupts, Founder of the Phanes Group: "One of the advantages that we bring to the table is that we follow an integrated approach, where we have a commercial and technical team who work hand-in-hand."

"We are extremely bullish about sub-Saharan Africa"

Africa and the Middle East: Growth solar markets in the MENA region and sub-Saharan Africa are rich in PV potential. However, they have been slow to emerge at scale. Martin Haupts founded Phanes Group to deliver utility-scale, off-grid and distributed PV solar projects to the region, and speaks to **pv magazine** about the challenges these markets face, and how to overcome them.

Could you give me an update on Phanes Group's operations in solar. What are the highlights and what's in the pipeline?

Martin Haupts: Phanes Group is an end-to-end solar energy developer, investor, and asset manager with a strategic focus on MENA and sub-Saharan Africa. From an organizational perspective, we are headquartered out of Dubai and in 2016 we opened two offices in Africa – one in Abuja and one in Johannesburg, illustrating our commitment to our target markets. I would say our regional emphasis is about 80% sub-Saharan Africa, 20% MENA.

What project highlights – particularly recent ones – can you share with us?

We are executing the Middle East's largest distributed solar project – the solar rollout for DP World in Dubai. That's in phase 1, a project in excess of 20 MW across 60 rooftops with around 7 GWh of energy output. That is a project that we won by way of a competitive tender, against some much larger companies, which underscores the fact that we are seen as one of the leading developers in the region and possess a distributed and utility-scale skill set. In sub-Saharan Africa, a lot of energy is currently going into a project that we are on the path to closing in Nigeria's Sokoto region. This is one of the 14 projects backed by one of the Nigerian government's PPAs. That's a project in the northwest, that is 60 MW in size and that we are looking to [reach financial] close in 2017.

We have seen a pretty uneven pathway to project development and realization in these promising markets. Would you say that's an accurate description?

Very much so. I think the commonality between both markets is that in the past 12 – 18 months there has been more activity in both areas than in the five preceding years. We see a development focus in GCC or MENA on large utility-scale, government-arranged tender programs in Morocco, or news from Algeria of the 4 GW program.

Sub-Saharan Africa is more fragmented. The emphasis is more on bilateral agreements and small-scale systems, between 10 and 50 MW, whereas in MENA we have seen these mega tenders, like Sweihan. This can be explained through different infrastructure conditions. Africa is a little behind in terms of grid infrastructure, electrification and the ability to digest [the electricity produced by] these large-scale programs.

You mention the 1 GW Sweihan project, which has captured headlines with impressive LCOE figures, and is an interesting project in terms of peak demand and a variable PPA structure. What do you make of these very low bid prices?

We'll see some further low price points, which is also being facilitated by decreasing component prices and consolidation on the manufacturing side. However, I think there will be a bifurcation in the market with some programs heading towards these price points where solar is a race to the cheapest in the market, like we've seen with the Abu Dhabi program. Some say we might even see a similar development in Saudi Arabia. On the other hand, there are much higher price points in some sub-Saharan countries, where it's not about the lowest price available, but about deploying infrastructure in a robust, sustainable manner.

What would you say is the potential of the distributed market in the Gulf States?

The potential is being indicated in the UAE at the moment. The Government has basically formulated the objective of having

solar on every rooftop by 2030. In an environment like the UAE it just makes sense: You have abundant sunlight, you have very large surface areas in the residential space, and you have high energy costs and a reduction of previous subsidies.
If you see what's happening in Dubai it marks the way, but it's also interesting that markets like Saudi Arabia, where under the current changes being implemented all the subsidies are being cut because they are being viewed as uncompetitive. There will be a lot of interest in distributed solutions [for consumers] to hedge against an energy price that increases by a double-digit figure every year.

What are the major regulatory hurdles that need to be overcome in unlocking this potential?
I believe that distributed solar is only possible if driven from a private sector perspective. To do that there needs to be an attractive framework for the private sector to deploy investments. That means that deploying distributed solar requires predictability of revenue, which is already partially implemented through the regulations in Dubai.

Turning to sub-Saharan Africa, you said there have been some positive signs; what's your outlook for the next two years?
We are extremely bullish about sub-Saharan Africa. We are active with development in various stages in 14 African countries, focused on West Africa but also selected markets in southern and East Africa. The trend that we see is over the past couple of years a lot of homework has been done, especially in aligning local regulatory frameworks to facilitate private power investments, and also allowing for renewable energy generally to be deployed. This was lacking in many markets outside of South Africa even two, three, or four years ago.

You have a relationship with Huawei on a number of projects, how did that come about?
We selected Huawei for a project two years ago. It was the result of a process where we gave Huawei a stringent price/quality matrix. So it was a competitive selection. We generally choose technology according to [technology] agnostic criteria.
Both from the quality and service perspective, we were very happy with what Huawei brought to the table. They are strong in after sales [service], they're very strong as far as innovations are concerned, and when it comes to O&M solutions and assisting with technical requirements from a design perspective.
On top of that, if you consider that of the three main components in a power plant – inverters, mounting gear, and panels – inverters are the component subject to the earliest and most regular replacement cycles. What's important for us is a strong balance sheet, where from a bankability perspective you have faith that this company will be your partner for the next 20 years. We're certain that Huawei stands out as a financially sound company within the arena.

On the technology front, what attracted you to Huawei?
A lot of the markets in which we are active are emerging markets where there is not an abundance of highly technical staff, which is why we like string inverter solutions as opposed to central. String inverters do not require such highly skilled staff, and they can be maintained by staff that were not involved in the construction process of the plant. The second thing is that Huawei is a closed box system. So in very dusty environments like Dubai, or the area where we are building in northwestern Nigeria, which is very arid and dusty, we think that inverters that have the closed box have a longer shelf life.

On the investor side, what are the challenges in raising debt and equity capital in emerging PV markets?
The key directive is making the project bankable from day one. It's much more important to emphasize small details when it comes to bankability in emerging markets because the lending requirements are much more stringent. The bulk of the [emerging] countries are basically supported only by development finance institutions or multilaterals, which have much more stringent lending requirements than, for example, commercial banks in Europe. While a company like Phanes Group is in the project development process, we basically have to apply much more stringent, much higher standards in terms of putting the project together.

The second phase of this 67.7 MW project in Monte Plata, Dominican Republic, was completed this year, making it the largest PV power plant in the Caribbean at the time of grid connection.

From an equity perspective, growing competitiveness is certainly a challenge. There is a compression of margins in the PPA space. On the one hand there are lower margins from the sale of electricity, however in many ways equity still has the same cost as two or three years ago. In some ways, we can offset that with the lower cost of technology.
Looking at growing competition on the component side, this brings certain cost expectations. Let's look at the price erosion in the panel market. We are observing that in some sub-Saharan markets like Kenya and South Africa, it becomes increasingly difficult to balance between the market's expectations from an equity/cost perspective. The local regulators have their own ideas about what a competitive energy price is, but not how to translate that into reality.

And how do you do that?
By squaring the circle [laughs]! One of the advantages that we bring to the table is that we follow an integrated approach, where we have a commercial and technical team who work hand-in-hand. We observe that we can facilitate a very competitive plant design through this approach, which we have seen in almost all the projects we have been involved in. ◆

FusionSolar: a forerunner in China's energy evolution

This 100 MW solar PV plant in Datong, Shanxi, was constructed using Huawei's FusionSolar Smart PV solution.

Datong, in Shanxi, China, is an important coal-producing region. Unfortunately, the water and soil in some areas of the city have been irreparably damaged by coal mining, and the land is no longer suitable for farming. What this land does have is huge potential for solar energy, with annual irradiance of 5,432.8 million joules per square meter. Within China, this is second only to the Tibetan Plateau, making Datong an excellent location for the construction of PV plants.

In April 2015, the Shanxi government sent an official report to China's National Energy Administration (NEA), proposing the construction of PV power generation bases at mine subsidence areas in Datong. In June that year, following approval by the NEA, China's PV Top Runner program was launched in Datong. This competitive bidding program seeks to promote the deployment of advanced solar technologies, and provide certain minimum requirements for core PV components. For example, module conversion efficiency rates of 16.5% for mono-cSi, and 17% for poly.

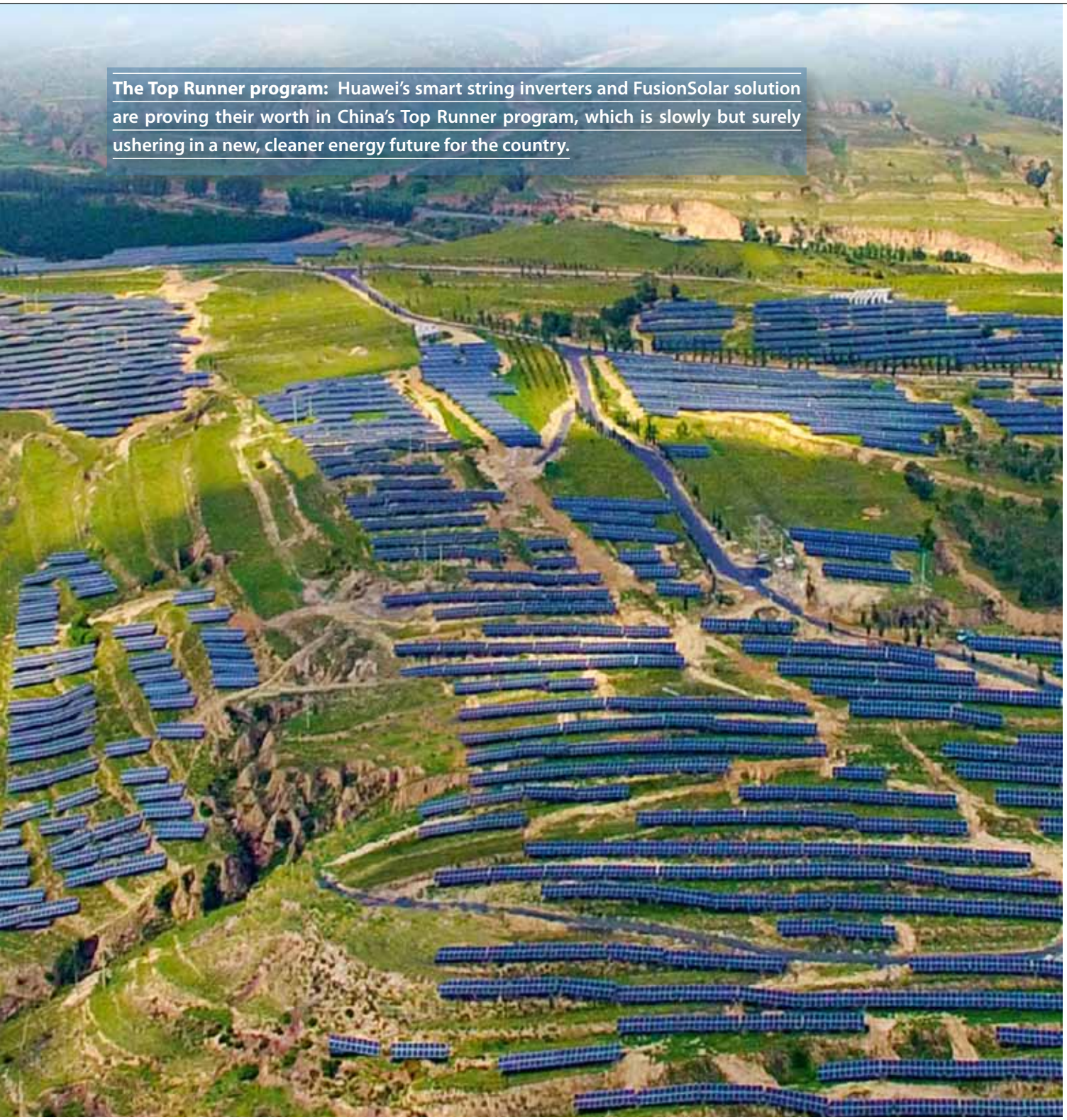


Photo: Huawei

The Top Runner program: Huawei's smart string inverters and FusionSolar solution are proving their worth in China's Top Runner program, which is slowly but surely ushering in a new, cleaner energy future for the country.

On June 29, 2016, the first phase was finished on time, with 1 GW capacity being completed, installed, and then grid-connected. The incredible construction speed demonstrated by this project shows its leading place within the future of solar energy.

Intelligent, cost-efficient power generation was a critical factor for the investors that won the bidding in the first phase, because they directly correlate to ROI for the shareholders. In the contest of cutting-edge technologies in PV, the enterprise that focuses on technologies that will improve energy efficiency, drive down cost, and has strong brand appeal is almost certain to emerge the winner among rivals.

Seven enterprises including CHD Energy, China General Nuclear Power Group (CGN), United New Energy, and CTG New Energy each won bids to develop a 100 MW PV plant in the Top Runner demonstration program. Another five, including Jinko Power, each won a bid to develop a 50 MW PV plant. Following the application of the

Photo: XXXXX

Huawei string inverters installed at a 200 MW ground-mounted array, in Tongxin, Ningxia, China.

Huawei FusionSolar Smart PV solution at mine subsidence areas, 10 mainstream developers chose to partner with Huawei. These developers made use of Huawei's smart string inverters and FusionSolar Solution, and all were successful in achieving grid connections without any faults. In total, Huawei has supplied 500 MW inverters to the Top Runner demonstration base in Datong, accounting for 50% of its total capacity.

Smart string inverter

Only high efficiency components can be short-listed for use at the Datong base. An inverter must have conversion efficiency of more than 99%, (or a Chinese efficiency standard of not less than 98%), and the capability of zero voltage ride through (ZVRT). Considering the challenging terrain and difficulties with O&M in mine subsidence areas, investors favor string inverters and intelligent O&M systems. Wang Yanguo, a senior engineer of Shanxi Electric Power Engineering Co. conducted a site survey on the geological environment of the mine subsidence areas in Datong. The engineer concluded that the challenging terrain can cause inconsistencies with PV module orientation, decreasing energy yields. Other factors such as continuous and uneven subsidence and airborne ash can also increase the chance of a module power mismatch. Fan Xiushan, General Manager of the North China Region of CTG New Energy, a company that has cooperated with Huawei several times, said: "String inverters succeed in reducing the energy yield loss caused by the shade that PV modules can be under when deployed on mountainous terrain, compared with central inverters under the same conditions. This ensures an improvement to more than 81% of plant PR [performance ratio] and an increase of 4.62% of energy yield." Of the 10 developers that use smart string inverters, CGN and United PV use only Huawei smart string inverters; 95% of the inverters used by CTG New Energy are Huawei smart string inverters; and 80% of the inverters used by Jinko Power are Huawei smart string inverters.

Meng Yaqi, Vice General Manager of the Inner Mongolia region of solar developer CMN, praises the terrain-based PV array deployment supported by the string inverter solution. String inverters are ideal for outdoor use because the IP65 rating and natural cooling design can completely protect string inverters from ash. This eliminates the need for some maintenance tasks such as the removal of dust. Coincidentally, fellow developer CHEC has also chosen to use string inverters, which improve efficiency using precise maximum power point tracking (MPPT) technology and increase energy yields using a solar tracker. Li Yanhong, Chief Design Engineer of CHEC, said: "Dust accumulation greatly reduces energy yields. Due to the location within

an area previously used for coal mining, the time taken to clean a PV plant is twice that of a normal array. Thanks to Huawei's smart PV O&M platform, which works in unattended mode and requires only a few maintenance personnel, the O&M cost is reduced while the efficiency is greatly increased. This leads to 'lower investment and higher return,' making it an economic project."

Intelligent O&M

To withstand tough terrain and harsh demand, Top Runner program shareholders and EPC units spare no effort to ensure that they have high quality components. This is particularly true when selecting PV modules, inverters, combiner boxes, and box-type transformers.

Furthermore, many shareholders have higher requirements regarding intelligent O&M than they do regarding energy yield increase. A convenient and efficient O&M system can function as the "brain" of a PV plant. Many shareholders are now collaborating with Huawei to construct intelligent O&M networks across regions, countries, and even the world.

Jinko Power was one of the developers involved in the first phase of the Top Runner program. Jinko Power undertook a 50 MW project in Dianwan, Zuoyun. Gong Chuanhe, President of Jinko Power Design Institute, tells us that a medium-sized (for example 50 MW) PV plant requires a far more complicated management unit than a small-sized PV plant. The O&M system must be intelligent, efficient, and reliable, and must support systematic and centralized management. When selecting such an O&M system, shareholders will consider the pros and cons for devices, intelligent inspection, and power generation efficiency.

CGN has also chosen Huawei FusionSolar Smart PV Solution for its 100 MW PV project in Datong, Shanxi. A technical engineer from CGN said: "The 100 MW PV plant covers an area twice as large as that of a normal PV plant, which makes manual inspection an impossibility. The FusionSolar Smart PV solution can precisely monitor the running status of each PV string and accurately locate any faults, greatly reducing the time required for checks. Therefore, we decided to team up with Huawei to set up a remote centralized control platform. We will build provincial monitoring systems to implement hierarchical control and reduce site O&M personnel." CMN is also optimistic about the future of the smart PV strategy. The head of the Top Runner program team of CMN announced that "when designing the intelligent O&M, the starting point for each PV plant is high reliability, high intelligence, high automation, high efficiency, a simple system, easy maintenance, and internet-based design. The Huawei FusionSolar Smart PV solution meets all of our requirements." CMN has been involved in constructing an intelligent global PV plant O&M center together with Huawei. This center will manage 46 PV plants that are either owned by CMN or with which CMN has agreements. CMN has successfully introduced Huawei FusionSolar Smart PV Solution into the first Top Runner base in Datong. Huawei intelligent O&M cloud center makes "centralized resources, managed by few people" a possibility.

Wireless communication

An intelligent PV plant requires information communication technology that can keep pace with the fast-developing world around it. The mine subsidence areas sink 3 – 5 cm every 20 years, which could break the RS485 communications cables that are buried underground. Changing a broken cable in mountainous terrain is difficult, as people have to dig a ditch and then route a new cable.

Developers such as CHEC, CGN, Jinko Power, and CMN share a similar view to Wang Yanguo, the engineer at Shanxi Electric Power Engineering Co. Wang Yanguo says: "In a mountain-mounted PV project, cable routing is never what you planned. However, Huawei's industrial-level power line communication (PLC) can replace RS485 cables. This reduces the costs involved in purchasing and routing RS485 cables, reduces information loss caused by unstable RS485 signals, and reduces the risk to cables that will inevitably break when the ground sinks."

A construction company has also praised PLC, saying: "The application of PLC and wireless technologies not only reduces communication cables and engineering expenses, but also makes construction quicker and easier."

Efficient and reliable service team

Huawei is a fully customer-centric company, and wanted to ensure that the trailblazing Top Runner program was successfully connected to the grid before June 30, 2016. To achieve this, Huawei invested in service personnel and assigned a service team to provide site support. From the beginning to the end of this project, Huawei recruited more than 30 people to deal with solution delivery, ensuring that it was fully supported.

During the delivery process, Huawei overcame the challenging site environment and proactively helped customers with site problems. This approach meant that the Top Runner program was successfully connected to the power grid one week in advance of deadline.

To help customers quickly locate faults, the Huawei service management team maintained contact with, and trained the O&M personnel, of all customers after grid-connection and accelerated the monitoring system commissioning. Customers were satisfied with the quick fault location for devices and PV modules during troubleshooting. To minimize the risk during operation, Huawei sets up a dedicated spare part and technical support team in Datong for the Top Runner program, ensuring future worry-free operation.

Huawei's efficient and reliable service team has been acknowledged and applauded by all the shareholders and EPC companies of the Top Runner program. All services provided by Huawei have received high praise from CGN, CTG New Energy, CMN, and other customers on the satisfaction survey. One customer said: "Huawei is highly skilled, provides professional services, and resolves issues in a timely manner."

Smart PV industry chain

Within the project, Huawei FusionSolar Smart PV Solution won acclaim from customers for technological advancement, solution rationality, and low electricity prices. This was made possible thanks to the core benefits of efficient power generation, intelligent O&M, and security and reliability.

In the future, Huawei will continue to collaborate with numerous EPC companies, component manufacturers, institutes, and shareholders to construct an open, collaborative, and a progressive smart PV industry platform. This will cement the leading place of the Top Runner program and promote the mature development of PV. ◆

Photo: Sunseap

Rooftop arrays in Jurong, southwestern Singapore. In April 2017 Sunseap signed a deal to provide Tampines Town Council with power from an 11 MW aggregated PV system.

A unique approach to solar

Singapore and Southeast Asia: Each region of the world brings different challenges in terms of logistics, culture, and financing. Sunseap is an expert in Singapore's unique solar landscape, and boasts a wealth of experience in understanding how best to bolster PV in this space-constrained country. The firm's Founder and Director, Frank Phuan spoke to **pv magazine** about its history, its approach, and its preference for Huawei technology.

Sunseap started as a family business, and we are one of the first solar companies in Singapore. At that time, Singapore was a contract manufacturing hub and we were a contract manufacturer. In the early days, we were largely involved in manufacturing OEM for Siemens Solar; and that is how we got our first break and experience in the industry.

During this time, we also did a fair bit of export, particularly to the United States. These were small-scale systems targeted at the off-grid market. Back then, there was no grid-connected solar, and solar was a niche product. Around the 1990s and at the turn of the millennium, we began manufacturing solar panels, primarily for export to Germany.

During this transition, we also waited for the feed-in tariffs (FITs) to be launched throughout Southeast Asia, but that never happened.

In order to create a competitive environment, the Singapore government has taken a stance that there will not be any grants or incentives to introduce a way to stimulate competition and the development of the cleantech sector. Renewables such as solar will have to compete on a level playing field with conventional sources such as oil and gas.

Seeking a sustainable solution, we have come up with the Solar Power Purchase Agreement (PPA) model. While the rest of our neighbors in Southeast Asia, Europe, and other parts of the world relied heavily on incentives and grants, we had to devise a solution to work around the policy laid out in Singapore. We are currently operating at grid parity, which allows us to offer competitive prices against conventional electricity. As a result of this phenomenon, solar is not only cleaner, but also cheaper in Singapore. That manufacturing and system integration business that formed the foundation of Sunseap's beginning has transformed into a service and energy business.

We lease our solar system under the Solar PPA model to our customers. Customers do not need to incur any up-front investment costs, unlike with a typical purchase of a solar system. We build, finance, and operate the solar systems so there is no risk to the customer. All that they incur is a monthly tariff that is charged for the energy that is consumed.

What we are doing is shifting the paradigm in people's minds. There is a misconception that solar is more expensive, and that renewables would not be possible without incentives. We are communicating the message to people that, not only are we clean and green, but we are making solar energy more affordable as well.

In 2016, we installed a total of almost 50 MWp of solar capacity. In recent years, we have posted 100% growth year-on-year. This year we are intending to double our installation capacity to more than 100 MWp. We source our solar panels for all of our projects from the various tier-1 module manufacturers such as Jinko Solar, JA Solar, Trina Solar, and Canadian Solar.

We are also looking into energy storage. Pairing our solar systems with storage technology (for example lithium batteries) in urban environments will allow us to create a virtual power bank. This will also enable us to assess how solar intermittency and storage can better manage peak demand.

In terms of inverters, we are very enthusiastic about Huawei, and we also work with ABB and SolarEdge.

Huawei has a really interesting portfolio. It has an inverter with a natural cooling feature and a unique DC fuse-free design. Inverters are at the heart of every solar system, and it is critical that the failure rate on faulty fans and fuses is kept at the lowest level possible. Huawei reduces this failure rate by removing the fan and fuse. This also allows us to reduce our capital expenses, improve energy yields, and lower our O&M costs.

In terms of the solar industry, Huawei is still a relatively young entrant, the company is very well positioned in the telecoms sector and they are now bringing their experience and unique perspective as a leading player to the PV sector. This is serving them, and the industry, very well so far.

Huawei is gaining good market share and traction in China. In Singapore, we have embraced their products as a major player in the country. Huawei currently has a great deal of market share, both in terms of solar and power line communication (PLC) technology and LTE wireless technology, which allow the transmission of inverter data to the monitoring system, so you can read the data without going physically to check on the inverters.

This feature greatly helps us with our monitoring and maintenance of the solar systems. Usually, you have to go to the physical site of the solar plant, but with Huawei inverters it gives us the convenience of checking the data remotely. The company utilizes its network capabilities to transmit its data. We are pretty big on data analytics – data collection is vital to us. We perform analysis on this data, which includes carrying out pre-failure analysis so that we can do a forecast for any potential issues.

As a result of land scarcity, projects are usually carried out in tight spaces in Singapore, which can make installation more challenging. In order to address this challenge, we advocate the use of string inverters. We use this for our project at Jurong Port, which is a 9.5 MWp solar PV system (the largest solar system in the world that is installed at a port). String inverters allow us to identify and replace any underperforming or faulty unit easily.

Photo: Sunseap

Frank Phuan is Founder and Director of Singapore-based Sunseap.

Outside of Singapore we also strive to achieve the same service standards via joint ventures (JVs). We set up our JVs with local partners as the majority partner, because we want to make sure that they have knowledge in the game. We believe that this also helps to preserve long-term targets of the JV to ensure that it can stand on its own two feet.

We use a centralized system in the way we handle our O&M. This means that all of our projects report back to Singapore – while monitoring is done centrally, maintenance is done by the local teams. We started using Huawei inverters in 2016, and it looks very promising. ◆

Photo: Huawei

Huawei heads home

Residential solar: Since entering the solar inverter space in 2013, China's Huawei has enjoyed rapid market share gains in all utility-scale and commercial markets in which it has competed. Now, as the many mature solar regions begin ramping up residential, Huawei is poised to introduce new technology solutions for this expanding market.

With its new products, Huawei aims to become a leader in the rooftop solar segment, both at residential and commercial scale.

The overarching theme from 2015's COP21 UN Summit in Paris was finding viable ways to limit CO_2 emissions to prevent the earth's temperature increasing past critical mass levels by 2050. Heads of state shook hands, signed documents, and posed for pictures before the world's media, emerging triumphant in their belief that their words, promises, and pledges could prove pivotal in this fight.

Strong, stable leadership has a huge role to play in keeping climate change at bay. But top-down actions always run the risk of alienating masses of people, and effecting behavior change en masse is not only fraught with contradictions, but is nigh on impossible to achieve in a functioning democracy.

The battle against rising CO_2 emissions has long been, and remains, economic. During the recent global downturn, Western nations actually saw their emissions flatten or fall in line with tumbling consumption, while the great worry among environmentalists is that, as nations with huge populations become more developed, their emissions are going to push past the point of no return.

So the question of how best to tackle climate change is not one of ideology, but of simple economics: If clean power sources can become cheaper, the whole world will benefit. And this is what has happened with solar in recent years. At the utility scale at least, solar PV plants have reached grid parity, and in some cases are even cheaper than gas or coal. Maturing solar markets are now bringing their innate ability to drive down costs to bear on the residential space. Where previously, home solar was supported by necessary subsidies in order to prove attractive to cash-conscious homeowners, now costs are so low in many leading markets that typical rooftop solar systems make economic sense on their own.

In the U.S., Japan, Australia, and much of Europe, residential solar installations are poised to be one of the chief drivers for PV growth over the next few years, and it is this opportunity that has piqued the interest of Huawei. The Chinese firm has already proven a disruptive presence in large-scale solar markets, and analysts are confident that its entrance into the residential space will prove telling in a number of ways – not least in driving costs down further and, in turn, increasing uptake of solar PV.

Huawei's offering

The string inverter portfolio offered by Huawei is evolving. At the 2017 PV Expo in Tokyo the company showcased its new 33 kW and 40 kW inverters that boast four maximum power point trackers (MPPTs), two DC switches, and eight strings each. These iterations have been designed for the commercial rooftop market and weigh 55 kg each, but the firm also unveiled its range of smaller inverters ranging in size from 4.12 kW and 4.95 kW, weighing 10 kg and easily groupable for installation on 50 kW small commercial rooftop and free field installations.

With such flexibility in size and scope, talk has obviously turned to Huawei's residential ambitions. "We have enjoyed a lot of success in the commercial rooftop markets of Europe, Japan, the U.S., China, and the APAC region," a Huawei spokesperson told **pv magazine**. "So as requested by our customers, and driven by the development strategy of Huawei itself, we will expand our product portfolio to residential markets. This will be an important year for us to have a global launch of residential products in Europe, Australia, China, and the U.S."

The new residential inverter from Huawei is a rather sleek, smooth-edged appliance that has evidently been designed with the style-conscious homeowner in mind. It is lightweight, so can be easily installed, and comes battery-ready for those homeowners who wish to add storage capacity. As with all Huawei inverters, it will also be compatible with the

FusionSolar APP, meaning homeowners can quickly and simply monitor their solar energy production.

"This new inverter has already won a Red Dot design award, having impressed the judges with its smart home design," said the Huawei spokesperson, who remarked on the importance of developing different applications and products for different scenarios and solutions. "How to manage solar PV, storage and self-consumption in the home is a different challenge for us. This is why the new inverter is presented as part of our new smart home energy management center.

"Second, it is challenging to create a partner sales network and pull-push power in the residential market. But the Huawei brand is becoming more and more well-known thanks to our smartphones." With this in mind, Huawei is aiming to become a leader in the residential solar PV industry in a similar way that companies such as Tesla have used their excellence in other fields to create hype and demand for their home energy solutions, namely the Powerwall battery.

However, Huawei is acutely aware that style requires substance. "Our brand pull power will be really helpful for entering into residential markets," said the spokesperson. "But quick and reliable service is a must in this market. We believe that it is premier quality and efficient services that ultimately win the trust of our clients, which is why we have a dedicated service channel in our portal system to support our customers intelligently and efficiently."

A numbers game

The growth in the uptake of module-level power electronics (MLPE) in recent years has been almost exclusively rooted in rooftop solar sectors. The slight efficiency gains proffered by the use of DC optimizers and microinverters make sense at this smaller scale, the additional 2 – 3% yield a viable trade-off against the costs associated with installing such technology. At utility-scale, the cost benefits are not quite there yet, however. Hence, with further opportunities for homeowners and businesses to increase their solar energy yield, one can expect growth in this sector to continue rising sharply – and again, Huawei is awake to the possibilities at hand.

"We are making investigations into the [MLPE] markets and assessing the best options," Huawei's spokesperson confirmed. "The new NEC2017 safety code in the U.S. mandates rapid shutdown of modules on rooftops, and this is making the argument for MLPE more compelling than ever. In other markets, we see similar trends of safety requirements and demand for module-level monitoring. The challenge now for Huawei is how to create value for our customers with balanced cost and long-term reliability. But we have confidence in our unique ability to overcome those challenges."

It is expected that Huawei will introduce DC power optimizers to the U.S. market in the second half of this year, with further markets to follow later on in 2017.

A key tenet of this growth will be identifying viable partnership networks that can ably support Huawei's expansion strategy and service standards. Residential solar markets tend to be less easy to regulate than utility-scale markets, which are often dominated by smaller clusters of suppliers and EPCs.

"As market opportunities in distributed generation emerge, along with the launch of our residential products, Huawei will continue to explore more partnerships and rapidly expand the number of trusted partners to reach more cities and towns and to be closer to our customers to offer them the best products and services," concluded the Huawei spokesperson. ◆

Photo: pv magazine/Ian Clover

Independent solar industry analyst Yoshi Murasawa believes that Huawei holds a strong position in the Japanese inverter market, having entered just two years ago.

"Huawei is now thriving in the tough Japanese market"

Interview: Yoshi Murasawa is an independent consultant on the solar industry. Speaking with **pv magazine** at the recent PV Expo in Japan, the former University of Tokyo professor explores the successes and challenges for Huawei in operating in the competitive Japanese inverter landscape.

In your view, how is Huawei positioned right now in the notoriously tough Japanese solar market?

Murasawa: Around four to five years ago when we studied the FIT, Japan was the highest cost country for PV. Germany was a leader, and Japan was maybe three times as expensive as Germany. I anticipated that the prices would come down sharply, first with solar panels, and then inverters would feel the pressure. That is happening now. Japan and many other global PV markets are now focusing more and more on the Levelized Cost of Energy (LCOE) throughout the life cycle of PV power plants than just the initial investment cost.

Therefore, how to reduce maintenance cost, increase power generation, and improve the overall ROI has become a major focus for many Japanese investors in PV power plants. Huawei's solution is quite competitive in the measure of LCOE, if you look at how it optimizes from system cost to maintenance efficiency to yields. And that's why Huawei has been gaining trust and popularity in the Japanese market in just two years. So I believe it is now well-positioned in the tough Japanese market.

You have said that you expect Japanese inverter suppliers to face difficulties in the future. Are their struggles a direct result of what Huawei is doing in the market?

Huawei is delivering a shock to the inverter landscape. Even traditional market leaders are having a difficult time because of Huawei's rise. In Japan, Tabuchi and TMEIC still hold the leading positions, but are losing share of the market very quickly. When the market is growing, if you are expensive that is OK. Three or four years ago the market in Japan was growing, and the leading Japanese players were happy because it was a seller's market. Now, the market is slowing down – Huawei is here, Delta is here, ABB is here, SMA is still here. There is no reason why Japanese inverter manufacturers will maintain their leadership, except for TMEIC.

What would you say is the main reason for Huawei's success so far in the Japanese market? Is it simply a matter of competitiveness on cost?

There are two major reasons for Huawei's success in Japan. One has been the drastic improvement of the image of Chinese companies in general. In Japan, there is still a mistrust of China; they tend to look down on Chinese companies, considering them to be producers of low price, low quality goods. But I see that attitude is changing. Some smarter Japanese people understand that.

In my view, Huawei inverter quality is one of the best, if not the best. It is the same with cost – Huawei is among the lowest-cost producers. So, low cost, high quality naturally sells. And as the FIT keeps coming down, the industry has to keep reducing costs too.

Another trend is towards distributed string inverters. Huawei has been a pioneer here. They tripled their sales in Japan last year, and I strongly believe they will continue to grow, building upon position three to become the number two supplier in Japan this year.

With Huawei offering lower cost, higher quality, and this distributed string approach, do you think this then tallies

Photo: Huawei

A 2 MW power plant utilizing Huawei's SUN2000 28KTL inverters in Miyako-jima, Japan. Yoshi Murasawa predicts that Japan's utility-scale segment will continue to see around 5 GW installed each year.

with how the Japanese like to build solar plants?

Exactly. Japan understands the advantage of distributed solar architecture, and the cost and performance benefits associated with that. Last fall, I introduced Huawei to a customer that had been buying inverters from a Japanese-based supplier. The company owner was wary of Chinese-built inverters, but after the introduction Huawei was able to explain the benefits of its system, and a 10 MW supply deal was duly signed. It has taken some time, but the perception is changing.

"High quality" can sometimes come across as a throwaway comment, so as an independent consultant, what is it about Huawei's inverter that is actually high quality?

When I buy home appliances and electronics from China, the feeling is that they are now almost as good as Japanese, German, or American products. Because of culture, because of history, people associate China with poor quality. The image of quality is changing, and people are now backing Chinese products. In Japan, our economy has been in trouble for many years, and there is a desire now for low cost, and people have to be smart enough to pick the right products. I cannot afford to buy a Tesla Model S for example. So instead I bought Tesla stock and enjoyed five times gain. It is highly overpriced, but why does the market buy Tesla stock? They are not buying Tesla, but Elon Musk. He is one of the best company figureheads in the world today. Tesla has a great image, and its acquisition of SolarCity promises a tremendous synergy. And when it comes to good image and good quality, Huawei does both very well. The company has high quality control, and reliable, advanced products. For example, its inverters have remote I-V curve diagnosis, which is something that many Japanese companies do not have. And, its presentation is good.

Given the changing landscape of the Japanese solar market, there is an expectation that the utility sector will contract. What is Huawei's position in the Japanese commercial landscape, and also – potentially – its residential sector?

At utility scale the market is shrinking. Two years ago annual installations in Japan were close to 10 GW, but this year it is probably going to be closer to 6 or 7 GW. I have been predicting 5 GW per year for the next 20 years, and by 2030 Japan is likely to be at 100 GW.

That is realistic. Huawei will still grow within this space, which means a big share gain at the cost of Japanese manufacturers. That is my prediction. In residential, JPEA is predicting that by 2020 the market will grow strongly for at least a decade, and so it makes sense for Huawei to look into the residential market. This year Huawei introduced a low-voltage inverter for the Japanese market, which received strong positive market reactions. The difficulty will be attaining the notoriously tough JET (Japan Electrical Safety & Environment Technology Laboratories) certificate. The certification body's objective is to ring-fence the sector for Japanese companies.

Do you believe that the intention is to stop foreign suppliers gaining market share?

It is one of the intentions of JET certification, yes. Though it would never state that explicitly. JET tried to make a barrier against foreign panels and modules, and were unsuccessful. It is a safety and security issue of course, but the hidden agenda is to create difficulty for foreign entrants.

After-sales service is also a vital part of the inverter package. We have established that you believe Huawei is very good at pre-sales, so what is your impression of the company's post-installation service?

It is yet to be fully seen, because Huawei is very new in the inverter space. What I am hearing is that Huawei's Japanese distributor Marubeni is doing well, and effectively meeting customer needs on behalf of Huawei. Although my data point is limited, some of the customers I know have said they are very satisfied with Huawei's after-sales service. ◆

Photo: Huawei

Paul Pan, Huawei's General Manager for the Smart PV Plant Business, Middle East & Africa, explains the FusionSolar Smart PV Solution at Huawei's booth at this year's World Future Energy Summit (WFES) in Abu Dhabi.

Huawei's roadmap to success

ICT beginnings: Huawei's ICT grounding has played a pivotal role in contributing to the firm's PV success. Not only in information communication technology expertise, but also in terms of logistics, business nous, and bankability. This is Huawei's story from humble beginnings to global leadership.

Huawei's track record in the global PV industry is truly startling. It was a late entrant to the inverter market in 2013, when it commenced with the production and sale of PV inverters. Just four years later in 2015 Huawei was ranked the number one inverter supplier by GTM Research and IHS Markit, on the basis of the amount of inverters shipped (in megawatts) in that year. How was Huawei able to catapult itself to first place in such a short period? Its success, experience, and expertise in the information and communication technology (ICT) industry offers perhaps the most compelling explanation.

Huawei was founded in 1988 and its first breakthrough came in 1993, when the company launched its own digital telecommunications switch, the C&C08, which was both reliable and much cheaper than other systems. In the early 1990s telecommunications was largely a "closed shop" around the world,

with state-owned monopolies running their own networks and dictating prices in most markets. The dominant applications were phone calls, either local, domestic, or international. And most of this traffic was over fixed-line networks with mobile networks just getting started in most markets.

All of this was about to change radically, and Huawei was set to emerge as one of the leaders in building these new telecommunications networks, both at home and in foreign markets. Again and again, Huawei would win contracts based on its cost leadership and its reliability and performance. Reliability is one of the core values in telecommunications and the overriding requirement in this industry is 99.999% availability. To get there is no easy task, and the team evidently worked very hard and for many years to achieve this critical milestone. Once it was reached, large foreign equipment providers such as Ericsson and Siemens, who had dominated the business of equipping government-owned telecoms operators around the world, found it hard to compete against this nimble and hard-working supplier, based in Shenzhen in southern China.

This applied especially to Huawei's home market in China, which was soon to become the world's largest telecommunications market, much as China has recently become the number one PV production and installation market globally. If we are staggered by the 35 GW of solar China installed in 2016, the ICT numbers for this market are even more remarkable: China's ICT industry had a volume of $465.6 billion in 2015, up 11.4% from 2014. With its 700 million web users and 1.3 billion mobile users, China has overtaken the U.S. to become the number one consumer electronics market.

In the ICT sector there is a fundamental distinction between carrier network equipment and end-user devices such as desktops, notebooks, tablets, and smartphones. Huawei's historic strength has been in supplying carrier network equipment, and not on the consumer electronics side. Its approach to the PV industry has taken a similar tack with the initial focus being on large-scale ground-mounted and rooftop deployments. Once a dominant presence in these markets is secured, it can leverage this presence to address end-users. On the ICT side that moment came in 2012, when Huawei decided to launch an Android-based smartphone internationally, the first time a Chinese ICT manufacturer had done so.

From ICT to solar PV

If we jump forward and look at the situation today, Huawei is not only a strong global brand in B2B ICT markets, but also increasingly among consumers looking for a compelling smartphone to handle a wide range of applications. Since these applications ultimately drive how telecommunications networks are put together, Huawei benefits from being closer to the end-user and the ICT devices being deployed at the network edge. Given the fact that distributed generation, especially when combined with affordable energy storage, represents the "holy grail" of the PV industry, Huawei's upcoming push into residential PV can be seen as a similar attempt to harness a critical piece of the value chain.

However, its push into residential PV will not only mirror the path it has taken in the ICT industry. It can actually apply much of the expertise it has gained in ICT to PV. Perhaps the most important bit is the 99.999% availability mantra mentioned already. Huawei has demonstrated time and again that it can build ICT networks that hardly ever have an interruption in service. That also matters for PV power plants and the electricity output investors are expecting from such plants over a very long lifetime. Furthermore, Huawei has demonstrated that it can maintain such uptime in very demanding environments.

For example, when **pv magazine** interviewed Paul Pan, Huawei's General Manager for the Smart PV Plant Business, Middle East & Africa, at this year's World Future Energy Summit (WFES) in Abu Dhabi, he pointed to the manufacturer's development of very robust remote radio units (RRUs) as helping Huawei build more durable inverters with fully enclosed units being able to withstand the harsh sandstorms encountered in many parts of the MENA region. Sand and dust can impact electrical performance and also trigger fires in PV power plants, according to Pan.

At its booth at this year's WFES, Huawei also showcased its innovative FusionSolar Smart PV Solution and FusionSolar Cloud Management Center. This technology is firmly rooted in Huawei's ICT know-how, where multiple devices at the ICT network edge deliver valuable real-time data to a central management location. In the telecommunications industry such a central location is called the "Network Operations Center" (NOC) and in Huawei's latest FusionSolar Smart PV Solution this NOC becomes the FusionSolar Cloud Management Center. "Cloud computing" is of course a key concept in today's tech world, and by delivering all these PV data to the "solar NOC" Huawei can readily apply cloud computing technology to optimize PV power plant O&M, and with it plant ROI.

Photo: Huawei

Paul Pan points to Huawei's track record of building very robust remote radio units (RRUs) as an example of the manufacturer's contribution of ICT know-how to the solar PV industry, in this case to develop even better inverters to withstand harsh environments like deserts.

Just like end-user smartphones at the network edge in the ICT world, smart devices and sensors installed within the PV power plant provide the granular data, which are fed back to the FusionSolar Cloud Management Center. The network architecture resembles that found in ICT networks and in combination provides the smarts behind Huawei's FusionSolar Smart PV Solution: A bottom layer provides hardware intelligence, including intelligence of PV components, inverters, and power distribution devices; an intermediate layer consists of produc-

Photo: Eckhart K. Gouras

Utility-scale PV power plants have dominated PV installations in China so far. Many are in remote locations, where Huawei's FusionSolar Smart PV Solution provides an ideal solution to remotely handle plant O&M.

tion monitoring, management, and optimal power generation control; and a top layer allows for comprehensive centralized O&M of a wide range of PV assets.

Sharing expertise

The power of Huawei's ICT expertise, as well as the capabilities of cloud computing, are most visible at the top layer. **pv magazine** had the opportunity to visit Huawei's own demonstration FusionSolar Cloud Management Center at its headquarters last December, and it provides a cockpit view of PV power plants in various locations, including one inside the company's Shenzhen headquarters. While providing a broad view of multiple PV assets, each asset is also sliced down to the string level, where the cloud computing approach really shines. Utilizing a smart I-V curve diagnosis, the real-time I-V curve of each PV string is compared to I-V curve data stored in the cloud and to I-V curve data coming from neighboring strings. This smart I-V curve diagnosis can automatically and in real time diagnose up to 17 panel faults, ranging from diode problems and shading issues to cracked module glass or soiling issues with the arrays.

Huawei pioneered this smart I-V curve diagnosis in its vast home market, where many of the utility-scale PV power plants are located far away from population centers in remote parts of the country, often in harsh desert environments. In these locations the benefits of this "best of both worlds" approach, where cutting-edge ICT technology is combined with PV technology, are immediately apparent. Problem cases can be addressed remotely to the extent that faults can be precisely identified, minimizing the deployment of experts to the actual plant location. Mobile and drone technology can further enhance the remote O&M by providing details and making use of the ICT network Huawei has set up at these PV power plants.

The advanced ICT network Huawei utilizes in its FusionSolar Smart PV Solution also reduces the cost of rolling out large PV power plants.

And they promise to do the same on the residential front once these solutions are rolled out in 2017. Huawei has done away with expensive cabling by deploying PLC technology in large-scale installations. PLC makes use of power cables to transmit information within the bottom layer of the three-layer network architecture discussed above.

When all is said and done, the incorporation of all this smart ICT provides for a system performance ratio of at least 83%. Compared with the traditional PV solution, the average electricity yield of the smart PV power plant is boosted by 2% or more and the internal rate of return of the project by 1.2% or more.

A discussion of the contribution of Huawei's ICT business to its PV business would not be complete if it did not also touch on Huawei's global footprint and bankability as a manufacturer. As mentioned above, Paul Pan manages the company's Smart PV Plant Business in Middle East & Africa.

In this capacity he oversees the PV business in over 70 countries, where Huawei is already present with offices serving its ICT customer base. Huawei's global footprint involves another 100 countries (so over 170 altogether) with many of these locations forming part of Huawei's Global Technology Support platform. GTS is a shared platform, meaning it can be utilized both for ICT after-sales support as well as PV after-sales support throughout the world.

Based largely on the success of Huawei's ICT business, the company is ranked number 129 among the world's Fortune 500 companies. With global revenues of $60.8 billion in 2015, the company is poised to boost revenues by a staggering one third in 2016 to $81.8 billion.

The fact that the company booked revenues of $36.8 billion already in the first half of 2016 shows that it is well on its way to meeting this ambitious goal. Its founder's devotion to innovation is still apparent in the large share devoted to research and development ($9.18 billion in 2015 or 15.1% of annual revenues). In 2015 it ranked first globally in patent applications (almost 4,000), a further sign that innovation forms a core value at this manufacturer.

Here as well, we see the favorable impact Huawei's ICT business has provided to its PV business. Its global footprint, ICT excellence, and Fortune 500 ranking equates to sound bankability for investors and other key participants in PV projects around the world. Huawei's entrance and embrace of PV technology is also an endorsement of the global PV industry's own bankability, as it seeks to convince energy stakeholders that solar PV technology has become a mature and dependable provider of low-cost clean electricity.

And perhaps there will be a day in the not-too-distant future when Huawei's track record in clean energy will be as historic and transformational as its track record in the ICT market. ◆

PV digs in against poverty

Agri-PV: Solar is increasingly being paired with agricultural applications in China. But while this market niche is contributing to the government's focus on the development of distributed generation solar, the connection to Beijing's DG goals is incidental.

"It is not really about using PV to drive the modernization of agriculture," says Macquarie analyst Patrick Dai. "It is to deploy PV plants in more applications in vast rural areas to relieve poverty."

Dai estimates that roughly 1 GW of PV was integrated into agricultural projects in 2016. While that is significant, given that 4.23 GW of distributed generation (DG) solar was connected to the grid last year, Dai says that China's National Energy Administration (NEA) views agricultural projects separately.

"It's not included in the DG target," he claims. "Their target doesn't include the 1 GW or more for poverty relief."

China announced the PV poverty alleviation program in 2014, with plans to implement it in more than 470 rural counties across 16 provinces by 2020. Projects vary from rooftop arrays to larger projects integrated into greenhouses, farms, and aquaculture businesses.

Several large installations have been completed over the past year, including a 200 MW solar-aquaculture project that developer Hangzhou Fengling connected in January in Cixi, Zhejiang province. Nationwide, PV+agriculture capacity, including installations at fish farms, now stands at roughly 2 GW, Dai says.

Under the 13th Five Year Plan, the government aims to lift 15 million people who earn less than CNY 2,300 ($333) per year out of poverty by 2020.

"It's mostly related to agriculture because poverty is in the farming areas," Dai explains.

Photo: Huawei

Huawei's FusionSolar Smart PV Solution has been applied to a range of agricultural projects under China's PV poverty alleviation scheme.

A localized approach

Local governments calculate the power needed to alleviate poverty in target communities. Proceeds from electricity sales are evenly distributed among residents.

In what Dai describes as a "top-down approach," local authorities target communities for poverty alleviation and identify plots of land on which solar can be installed. Then third parties are brought in to develop the projects, with the local authorities arranging financing.

"Project sizes vary from dozens of kilowatts right up to hundreds of megawatts," says a spokesperson for Shenzhen-based Huawei, which has supplied its FusionSolar Smart PV Solution and inverters to numerous such installations.

"Huawei's FusionSolar Smart PV solution has been applied in ground-mounted, roof-top, mountainous, agricultural, and fishery scenarios."

The opportunity is huge. Global Market Insights expects Chinese demand for solar microinverters to surpass 1.4 GW by 2024, partly due to the PV poverty alleviation program.

Huawei says its remote monitoring systems are ideal for agricultural and fishery installations, which can be difficult to access. The company also claims its products are suited to such projects because they take up little space, in part because there is no inverter house.

"In our solar agricultural projects, string inverters are mounted on the latest supports, which are directly anchored to the field. [They have] small footprints, do not cause damage to fields, and do not require permanent buildings," the company says.

However, problems remain. Although institutional lenders are participating in the poverty-relief effort, financing remains an issue.

Dai points to the "poor penetration of the grid" in rural China as a challenge to PV+agriculture projects. However, about CNY 522 billion ($77.5 billion) of grid extensions will be built in rural areas by 2020 to support the alleviation scheme.

Huawei's FusionSolar Smart PV Solution has also begun to make a difference in China's PV poverty alleviation program, bringing clean and affordable solar power to some of the nation's poorest regions, despite a lack of viable grid infrastructure in many parts of the country.

That underscores how many of the projects do not really contribute to Beijing's DG targets, which are about generating power near centers of demand, and feeding it into the grid.

"Otherwise you can only install PV for self-consumption," Dai says. "If you want to sell the power back to the grid, you need well-developed infrastructure in those areas." ◆

From steps to strides

Prior to 2013, Huawei was best known for its expertise in the ICT industry. Founded as a sales agency for Private Branch Exchange (PBX) switches in 1987, Huawei now operates in more than 170 countries, employs more than 180,000 people, and has sold more than 20 million of its highly rated smartphones globally. In 2015 the company posted revenues of $60 billion. During Huawei's rapid success, the company developed high green standards and even as early as 2009 had deployed more than 3,000 sites powered by alternative energies around the world. Building on that, the Chinese company entered the solar PV inverter market in 2011, and what follows is a series of notable Huawei milestones within the solar industry since that date.

2011

Huawei opens up the Energy Center of Competence in Nuremberg, Germany.

2014

April: Frankensolar sells Huawei inverters in Germany.
April: For an 11 MW rooftop Smart PV Plant in Jiaxing, Zhejiang, China, Huawei delivers 490 of its SUN2000-28KTL inverters.
May: Huawei installs 7,857 SUN2000-28KTL and a Smart PV wireless transmission system in Golmud, Qinghai, China for a 220 MW PV plant.

2015

January: Huawei installs 140 SUN2000-28KTL plus 652 SUN2000-28KTL inverters in phase 2 of an innovative 108 MW Solar-Fishery Smart PV plant in Yangzhou, China.
March: Huawei delivers 707 SUN2000-20KTL inverters to a 20 MW PV project in Trowbridge, U.K.
May: Huawei delivers 285 SUN2000-28KTL inverters to a 10 MW project in Krempendorf, Germany.
Huawei delivers 462 SUN2000-28KTL inverters to a 13.5 MW PV project in Melksham, U.K.
June: Huawei installs SUN2000-28KTL inverters and a Smart PV wireless transmission system at a 30 MW Mountain Smart PV Plant in Panzhihua, China.

Photos: Huawei

2016

June: Huawei inverters are installed on the world's first 1 GW solar PV plant at Yanchi, Ningxia, China.
September: Huawei integrates new manufacturing capabilities into its Eindhoven hub, Netherlands, where it can produce 7,000 inverter units per month.
October: Huawei forms a strategic partnership with Strata Solar after entering the North American market as an inverter manufacturer.

2017

April: Huawei enters the residential solar market with the launch of its residential string inverter and DC power optimizer.

Imprint

Special publication

A special publication produced by
pv magazine group GmbH & Co. KG in partnership with
Huawei Technologies Co., Ltd.

Publisher

pv magazine group GmbH & Co. KG
Kurfürstendamm 64, 10707 Berlin, Germany
Managing Director: Eckhart K. Gouras

Editors/Contributors

Jonathan Gifford
Editor in chief pv magazine global
Tel.: +49-30-213 00 50 37
gifford@pv-magazine.com

Ian Clover
clover@pv-magazine.com

Christian Roselund
roselund@pv-magazine.com

Mark Hutchins
mark.hutchins@pv-magazine.com

Authors: Tim Ferry, Götz Fischbeck, Eckhart K. Gouras, Brian Publicover.

Proofreader: Paul Zubrinich

Translators: Tim Hanes/ Veritas Traducción y Comunicación

Photo editor: Tom Baerwald

Graphics: Harald Schütt

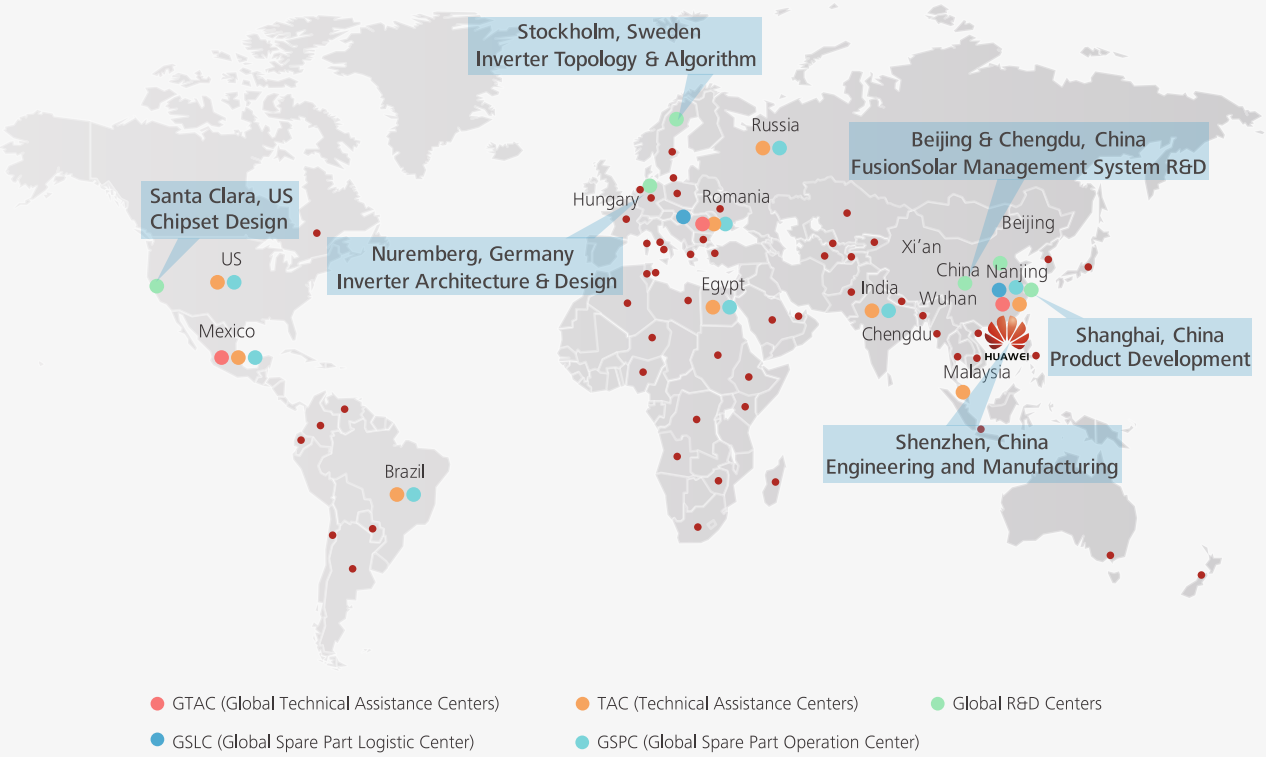
Layout and typesetting

Petra Plociennik

Printer

Sedai Druck GmbH & Co. KG, Böcklerstraße 13, 31789 Hameln/Wangelist

Where there is our product there is our service



Huawei FusionSolar

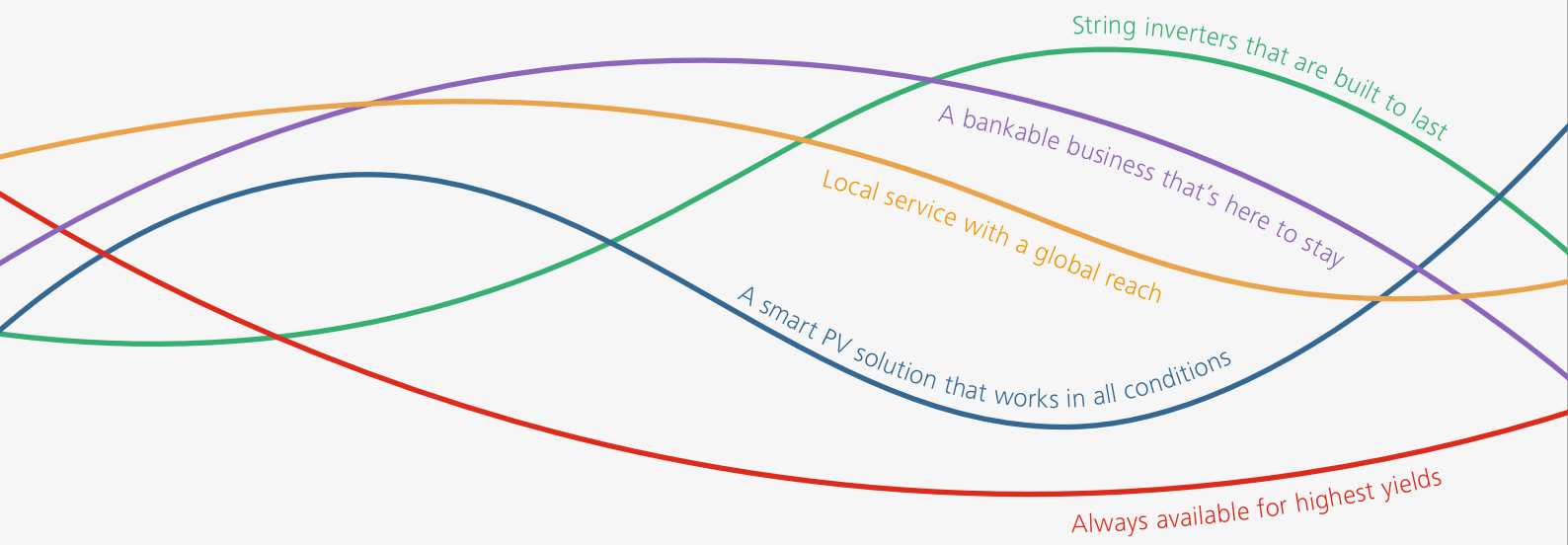
As a global leader of ICT solutions, with **over 27 years** of experience, HUAWEI has developed the **FusionSolar Smart PV Solution** that combines **PV technology** with **digital information** and **Internet technology**.
FusionSolar Smart PV Solution: A Simple, Fully Digital Solution with Automatic O&M

According to the reports released by global consultancies **IHS** and **GTM**, the shipment of Huawei inverters is ranked **No.1** worldwide.

Excellent Inverter Performance and Operation Verified by TÜV, **Availability - 99.996%**

HUAWEI

Solar intelligence, with strings attached.



Global #1 Inverter Shipment

Our SUN2000 string inverters use intelligent software that lets you monitor your solar system from your phone or tablet,so you're always in control of your yields.
And with no fuses,and no moving parts to replace, our inverters are built to last for 25 years or more.

We're stable, we're bankable, and we're here for the long haul.

@ Huawei FusionSolar

FusionSolar Smart PV Solution
www.huawei.com/solar