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pv magazine corporate

Leading the grid-forming movement

Active safety from cell to grid

Growing storage, growing capabilities

SPECIAL EDITION DEVELOPED IN PARTNERSHIP WITH HUAWEI

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Smart String Grid-Forming ESS, An Epochal Shift to Carbon Neutrality

Huawei: Smart solutions for a smarter energy transition

Photo: pv magazine/Thomas Beetz

This is the eighth special corporate edition **pv magazine** is producing in partnership with Huawei, the Shenzhen-based multinational that has been a key player in the adoption of clean energy around the world. As the solar industry has evolved to meet the changing needs of the energy transition, Huawei too has developed new technology and brought out new solutions to not only meet these new needs, but to also help customers of all sizes – from homeowners to grid operators – overcome challenges to the burgeoning market for renewables.

This edition focuses on the grid-forming potential of energy storage – particularly large-scale energy storage systems (ESS) connected to the electricity grid. Huawei recognizes that the expanded use of renewable energy technologies like solar and wind can only happen when their intermittent nature is taken into consideration. When supply is high and demand is low, excess energy needs to be stored somewhere in order to balance the grid. In regions like the Middle East, where solar power is plentiful, exciting projects like the Red Sea destination are showing exactly how this kind of grid-forming ESS is working to prove the promise of renewables to provide 100% of a community's power needs.

Huawei's Smart String Grid-Forming ESS platform is not only winning over its partners in real-world applications, it's also achieving high marks when it comes to technology appraisals, and you'll see in these pages the strong results of the manufacturer's technologies in testing and demonstration for a wide variety of scenarios. Larger energy storage systems bring with them greater safety issues, and this edition also features an article focused on the active safety features that have been designed into Huawei's ESS offerings.

The pages that follow include a wealth of interviews with Huawei's partners, who offer a look behind the curtain at some of the world's most exciting use cases for renewable and energy storage technologies – whether it's providing an environmentally friendly home to pandas in Malaysia, stabilizing the grid in Mexico, or supporting the rise of microgrids and fast-charging of EVs in Morocco. In this edition we also shine a spotlight on Huawei's activities in the residential sector, enabling consumers to effectively achieve both energy independence and zero-carbon status for their homes.

In the wake of a summer of record-breaking high temperatures across the globe, the need for expanded efforts to reduce global warming is overwhelmingly apparent, driving the push for a speedier transition away from polluting fossil fuels. Every continent is suffering from the negative effects of climate change, but the challenge of switching to solar and wind sources has necessitated an attention shift toward the use of energy storage technologies to balance supply and demand. Switching to cleaner sources of energy does not mean sacrificing grid reliability. With Huawei's technological advances in its grid-forming ESS platform, the goal of clean, reliable, and stable power is in our sight.

Eckhart K. Gouras, publisher, pv magazine

Energy communities in Europe
Energy sharing is trending in Europe with the rise of PPAs, VPPs, and VPPAs. What does this mean for consumers?

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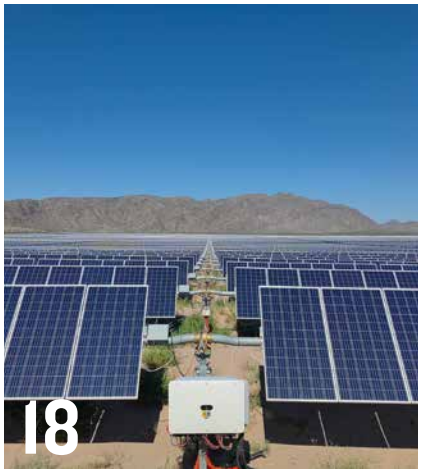


The switch to string in Mexico
Moving from central to string inverters is a trending method for improving PV plant reliability.

Power for the pandas
Ditrolic Energy and Huawei are powering a giant panda conservation center in Malaysia with sustainable energy.

Active safety from cell to grid
ESS safety is about more than just cell safety. It covers end-to-end protection, all the way to the grid.

applications & installations ▸

technology ▸

Shifting to carbon neutrality via grid-forming ESS

Grid-forming ESS technology is already demonstrating its benefits and meeting with success in a variety of scenarios. There are steps the industry can take to pave a smooth path forward.

In recent years, the PV and wind power industries have developed at a tremendous rate, with even more potential for future growth. COP28 proposes to triple renewable installations from 2022 to 2030 to exceed 11,000 GW. However, renewable energy requires flexible resources that help to regulate power systems. The randomness, fluctuation, and intermittence issues inherent in renewable technologies aggravate the power system balance and safety problems. The grid-forming technology concept is a key to improving the active support capabilities of renewable energy. As such, many countries are doubling down on the development and application of grid-forming solutions in commercial projects by releasing technical standards and policies.

Hou Jinlong, Director of the Board of Huawei and President of Huawei Digital Power, hast pointed out that with the rapid development of renewable energy, global power systems are faced with a high penetration rate of renewable energy. This hinders the stable operation of power grids and becomes a roadblock for the global development of renewables. As one of the key solutions to enable the transition to new power systems, grid-forming technology is at the forefront of power system innovations in various countries. Huawei

Hou Jinlong, Director of the Board of Huawei and President of Huawei Digital Power

Huawei's Smart String Grid-Forming ESS Solution supports the solar PV microgrid for The Red Sea destination.

Digital Power continuously accumulates experience in the connection of renewables and grid-friendly technologies to energy grids and promotes the transition from grid-following and grid-supporting to grid-forming. In addition, Huawei also has a role in contributing to the construction of new power systems.

Investing in research

Since 2011, Huawei has been investing heavily in research into the safety and stability of grid-connected renewable systems to drive the sustainable development of the industry. Huawei has applied its innovations in a wide range of scenarios and projects worldwide.

In the Middle East, the 400 MW PV plant and 1.3 GWh energy storage system (ESS) in the first phase of The Red Sea destination in Saudi Arabia use Huawei's Smart String Grid-Forming ESS platform. Since being put into operation in September 2023, the project has provided more than 1 billion kWh of green electricity. It is the world's first city microgrid powered by 100% renewable energy. The project has been running safely and stably for one year. Key grid-forming performance indicators have been fully verified, including the synchronous grid-forming activities of 1,000 power conversion systems (PCSs), minute-level power recovery, resistance to the impact of 100% of the transformers switching on/off, and zero-voltage fault ride-through in an off-grid scenario. The grid-forming technology deployed in The Red Sea destination is also being applied to microgrid scenarios such as mines and islands.

For example, when this technology is used to build microgrids for mines, the solution drastically improves power supply reliability and reduces energy consumption costs by more than 50%. To date, Huawei has completed more than 10 microgrid projects for mines and islands in Africa and Latin America. In the future, the grid-forming microgrid technology will be applied in more places around the world to help bridge the power divide.

Performance testing

In Qinghai and other provinces of China, Huawei has worked with power grid companies and power generation enterprises

Grid-forming technology reduces energy consumption costs by more than

50%

to promote and carry out the grid-forming ESS performance tests in five projects. These comprehensive and large-scale tests have successfully verified the ESS performance indicators in various working conditions and scenarios, including unit-level, plant-level, regional power grid simulation, and off-grid scenarios. More than 2,300 test items have been completed for the key indicators for grid-forming technologies.

"The industry needs to establish a first-class system of standards for grid-forming ESS solutions"

In Hami, a prefecture-level city in western China, comprehensive and systematic grid-forming technology tests have been carried out on the CR Power wind power plant, which is located at the supply end of the DC ultra-high-voltage (UHV) line and is equipped with Huawei's 100 MWh grid-forming ESS. In Golmud, Qinghai, the China Green Development Investment Group's (CGDG's) 100 MWh grid-forming ESS project for its multi-energy renewable power plant passed the 35 kV and 110 kV short-circuit tests on the first attempt. The test results show that not a single one of the 600 PCSs were disconnected from the power grid, and they generated three times the apparent current and 2.8 times the asymmetric current within 10 milliseconds, supporting the power grid voltage.

In Ngari Prefecture, the 24 MWh grid-forming ESS project managed by ZDI is located at a high altitude and in a weak power grid environment. The plant passed the 35 kV short-circuit test on the first attempt, with no PCSs disconnected from the grid. The PCSs rapidly generated three times the apparent current within 10 milliseconds, leveling out the power supply with no fluctuations and no overvoltage. Huawei's Smart String Grid-Forming ESS platform has been systematically tested in the following four aspects: multi-site self-synchronized amplitude and frequency regulation technology, wideband self-stabilizing and stabilizing control technology, new two-stage conversion architecture of the smart string ESS, and grid-forming ESS power modules. The tests verified that the technology can provide support for power systems in multiple scenarios with a high proportion of renewable energy.

In July 2024, Huawei's Smart String Grid-Forming ESS underwent a rigorous technical appraisal meeting organized by the Chinese Society for Electrical Engineering. The committee comprises experts from research institutions and companies, including members of the Chinese Academy of Sciences and the Chinese Academy of Engineering, along with experts from State Grid Corporation of China (SGCC). The appraisal meeting aimed to evaluate the key technologies and applications of the Smart String Grid-Forming ESS designed for various scenarios with a high proportion of renewables. The committee unanimously agreed that the applied projects have achieved world-leading capabilities in terms of improving new power system stability and renewable energy integration.

Next steps

Promoting the high-quality development of the grid-forming energy storage industry and enabling innovations to play a greater role in propelling the industry requires three serious next steps. First, it is important to gradually expand the scale of the application of grid-forming ESS as the technology matures. Second, the industry needs to establish a first-class system of standards for grid-forming ESS solutions. Finally, it is vital to form a market mechanism that is conducive to the development of grid-forming ESS technology.

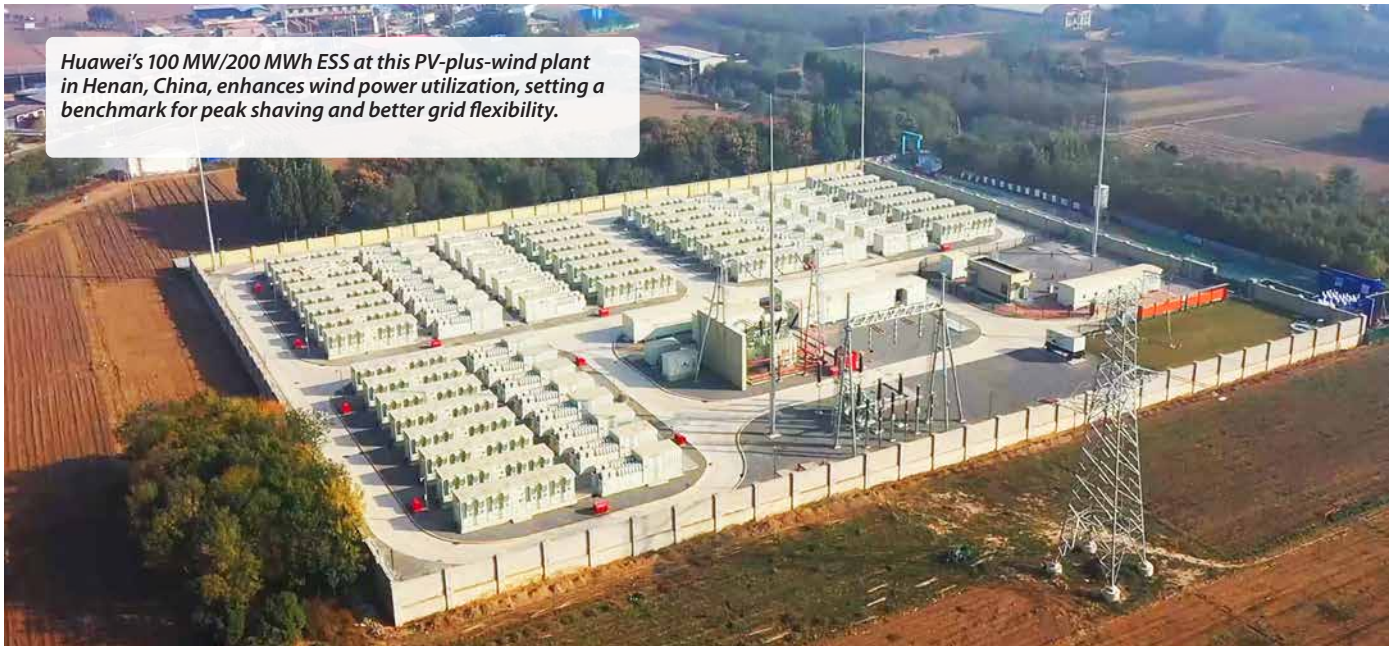
Looking ahead, Huawei Digital Power will continue to integrate what it refers to as the "4T" technologies – biT (digital technology), watT (power electronics technology), heaT (thermal management technology), and baTtery (energy storage management technology) – to provide high-quality, safe, and reliable equipment. The manufacturer will work with customers and partners not only to promote the development of the grid-forming energy storage industry, but to also contribute to the construction and development of new power and energy systems. pv

Grid-forming scenarios

Innovative grid-forming technology is based on power electronics and digitalization. It can effectively improve the stability of new power systems and can be promoted in various scenarios.

- Power generation: In utility-scale renewable energy scenarios with weak power grids, the grid-forming technology will significantly improve the active support capability of renewable power plants, achieving the connection of a higher proportion of renewables to the grid.
- Power grid: This technology will enhance the flexible regulation and reliable operation capabilities of the power system in various scenarios, such as at the receiving end of ultra-high-voltage (UHV) lines, where the load center lacks conventional power supplies.
- Energy consumption: 100% renewable energy and on-grid/off-grid power supply can be implemented for the end power grid, microgrid, plateau, mine, and island scenarios.

This project in Spain, featuring 50 MW of solar paired with a 2 MW/4 MWh energy storage system (ESS), enhances grid integration and combines solar power with agriculture to maximize system benefits.



Huawei's 100 MW/200 MWh ESS at this PV-plus-wind plant in Henan, China, enhances wind power utilization, setting a benchmark for peak shaving and better grid flexibility.

The Kubuqi Desert, rich in land and solar resources, is ideal for combining solar power with sand control for desert restoration. A 1 GW "PV Great Wall" in the region creates a striking landscape of blue solar panels and lush green forests.

Growing storage, growing capabilities

Which factors are driving the trend of large-scale energy storage as it relates to the rising integration of renewables into the grid?

The global energy storage sector, closely tied to the growth of renewable energy and grid integration, is already expanding rapidly, with projections indicating steady 10% annual growth in installations through 2033. China leads the buildout, accounting for 53% of global deployments in 2024 with an estimated 68 GW/161 GWh, but the growth story spans all major market regions, according to analysts Wood Mackenzie. Its view of compound annual growth rates (CAGR) across regions such as China, North America, and Europe shows ongoing robust expansion, ranging from 24% to 37% in major markets and underscoring the worldwide embrace of energy storage solutions.

Looking ahead, a recent study by the International Energy Agency predicts that global installed battery storage will increase from 200 GW in 2023 to more than 1 TW by 2030 and nearly 5 TW by 2050. This will help achieve the once-unthinkable goal of 100% renewable energy penetration, driven in part by solar's ongoing status as the cheapest form of energy generation.

More than storage

Supporting intermittent renewables with storage in 2024 and beyond is more complex than simply shifting energy away from peak generation to demand peaks. As synchronous generators are gradually phased out due to uncompetitiveness or efforts to increase renewable generation, voltage regulation faces challenges. Large spinning turbines naturally provide physical resistance to frequency changes, known as inertia, and their controls enable quick responses to power imbalances.

On the other hand, renewables lack inherent frequency and voltage control, meaning an imbalance as grid operators are tasked with more and more solar and wind being connected to the grid, while stability from synchronous generators is being lost.

This is where batteries combined with more advanced power electronics and controls can provide support, including a suite of active and reactive power services. Grid-forming inverters aim to match key features of synchronous generators, but further enhance capabilities as well. This approach moved beyond the concept of "virtual" synchronous machines to go further, while maintaining stability.

Safety standards

At the same time, although grid-scale battery energy storage systems are proving incredibly versatile and valuable, the nature of battery cells packed within dense storage products has been shown to have some potential negatives when safety standards are not met.

In large-scale grid storage, battery chemistries and manufacturing largely favor dense, lithium-based cells, and there have unfortunately been a rising number of energy storage accidents, with over 120 fires reported globally, sometimes stretching across days and weeks, and often close to population centers.

Industry awareness and collaboration are actively supporting the best approaches to safety. Energy storage safety is an important cornerstone of the development of the new energy sector. But to build trust, the industry needs to show that incidents are trending down, even as the storage market continues to grow.

Best in class

With regards to power electronics hardware and software, the solar industry is wide awake to the needs of the grid. Efforts on safety, testing, and going beyond standards continue to progress. In the last decade, national standards from China to Europe and Australia have more closely dictated what new generation capacity must provide to the network in terms of grid-management services.

Early core requirements include passing tests such as zero-voltage and low-voltage

Grid-scale battery energy storage systems are proving incredibly versatile and valuable.

ride-through, while frequency disturbance and power quality remain. However, grid codes have hardened further. Germany, for example, was first to adopt the Network Code on Requirements for Generators (RfG), and went further than mandated, being the first country in the world in 2019 to require certified reactive power control on new solar installations.

Quality manufacturers have been passing these tests for years, and with the current opportunity to go further, we are seeing additional developments in grid-forming and active safety.

In terms of grid-forming efforts, best-in-class solutions can provide reactive or active power to ensure stable voltage, frequency, and power angle of the power grid. High-end hardware designed with extra capacity for short-term overload can temporarily handle higher loads and provide additional support through improved short-circuit level (SCL) contributions – an area where synchronous condensers typically excel.

In terms of safety, hardware and software are also improving. Regarding hardware products, containerized batteries are adopting more fire suppression systems and thermal runaway prevention as key features.

On the software front, advanced fault-finding systems now leverage machine learning and AI from large datasets from real-world operations to predict faults before they occur.

Learning by doing

The industry continues to develop grid-forming standards, with major off-grid projects like in the Red Sea region. Huawei delivered 400 MW/1.3 GWh of BESS, offering a modular, pre-integrated microgrid energy solution. This demonstrates the value of grid-forming technology and provides critical data for future projects, as preparation, planning, simulation, implementation, and field testing can now be compared to final operational results and real-world data. It also creates new modes of thinking for grid operators and for those projects where off-grid operation makes sense, such as islands, rapid response environments, remote mining operations, and rural communities. pv

Ten years of grid-forming development

Huawei has invested in the development of its grid-friendly technologies for a decade, accelerating the transition to a new energy system.

Renewable energy technologies, such as PV and wind power, are rapidly replacing traditional energy sources, and a clean, low-carbon, safe, and efficient new energy system is gradually developing amid a new round of energy transformation. The International Energy Agency (IEA) estimates that renewables will surpass coal to become the largest source of global electricity generation by early 2025. Traditional power systems using synchronous generators will be replaced by new power systems featuring a higher penetration rate of renewable energy and more power electronics equipment.

> *"It takes the collective efforts of the entire industry to address grid connection challenges"*

Grid integration of intermittent renewable energy on a large scale will impact the stability of power grids. Some of the typical problems currently include wideband oscillation, transient overvoltage, power quality deterioration, and power supply instability for islanded PV and energy storage systems (ESS). In many countries and regions, the key to the sustainable development of renewables is to improve the performance of grid-integrated wind, PV, ESS, and other power systems that use power electronics equipment.

Huawei Digital Power has long been committed to enhancing the safety and stability of renewable integration. Through the combination of digital and power electronics technologies – and cooperation with global power companies, grid enterprises, and electricity providers – Huawei Digital Power has continuously promoted the development of grid connection technologies.

The new power system, with renewable energy as the main source, is crucial to achieving the goal of carbon neutrality. Compared with synchronous generators, renewable energy features low controllability and low inertia. Nevertheless, as the renewable penetration rate increases, a conventional renewable energy system cannot proactively support the voltage and frequency like synchronous generators when a fault occurs. And as a result, such systems fail to meet the requirements of large-scale application of renewables, bringing risks in safety and stability.

To cope with the preceding challenges, Huawei has launched its innovative Smart String Grid-Forming ESS platform by leveraging its own expertise in PV, energy storage, and particularly, grid-forming technologies. This platform changes renewable energy control from current source to voltage source, actively mitigating frequency and voltage fluctuation and enabling PV power generation to transition from grid following to grid forming. With these grid-friendly technologies, Huawei helps customers achieve optimal ROI, intelligent O&M, safety, and reliability.

It takes the collective efforts of the entire industry to address the grid connection challenges. Huawei Digital Power adheres to the concept of "triple convergence": the convergence of power electronics and digital technologies, the convergence of PV and energy storage, and the convergence of energy flow and information flow. Huawei Digital Power will continue to increase investment in R&D and collaborate with global customers and partners to accelerate the development of the PV industry through technological innovation, enabling green PV as a major energy source for every home and business and building a better, greener future.

Grid following

2014 Huawei cooperated with the China Electric Power Research Institute (CEPRI) and the Qinghai Electric Power Research Institute in carrying out a series of tests on its smart string inverters, which passed the zero-voltage ride-through test, low-voltage ride-through test, frequency disturbance test, and power quality test in a MW-level plant. This made Huawei the world's first inverter brand to pass the zero-voltage ride-through certification.

2015 Huawei applied the low short-circuit ratio (SCR) adaptation algorithm for the first time in the industry in a 100 MW PV plant project in Inner Mongolia, China.

Grid supporting

2018 The AI BOOST active harmonic suppression algorithm was developed to eliminate the risk of harmonics exceeding the threshold in weak power grids.

2019 Australia released a new power grid standard, which was said to be the strictest grid connection standard in the world. Huawei obtained the admission license, making it the world's first and the only Chinese PV inverter brand with an active license.

2020 Huawei was awarded the first GB/T 37408-2019 certificate by CEPRI, and Huawei inverters became the first product that passed the new national standard in the industry. In the same year, Huawei worked with CEPRI to launch the weak power grid (SCR = 1.5) adaptability feature of PV inverters to ensure plant stability under transient and steady-state impact in extremely weak power grids, avoiding chain faults and improving renewable integration capability.

2021 Huawei received the first series compensation adaptability algorithm certification from CEPRI (Short Circuit Current Rating = 0.7, SCR = 1.2), improving the stability and capability of long-distance renewable power distribution.

Grid forming

2022 Huawei participated in the construction of the world's first GW-level microgrid project using grid-forming technologies in the Red Sea Project, Saudi Arabia.

2023 Huawei cooperated with CEPRI, Qinghai Electric Power Research Institute, and China Resources Power to complete the world's first onsite test of the grid-forming PV+ESS solution in Qinghai, China, which proved that grid-forming systems can play a key role in strengthening the operation of the power grid and achieving large-scale renewable integration.

2024 Huawei's Smart String Grid-Forming ESS solution has been verified through performance tests to have excellent grid-forming capabilities, compatibility with various types of power supplies, and parallel operation capabilities for multiple devices at a 50 MW/100 MWh project in Qinghai, China. These tests included a world-first 35 kV and 110 kV short-circuit test, during which 600 power conversion systems (PCS) were running stably and provided quick reactive power support for the system under fault conditions.

Energy communities in Europe

Energy sharing is trending in Europe with the rise of power purchase agreements (PPAs), virtual power purchase agreements (VPPAs), and virtual power plants (VPPs). What do these technical terms mean for consumers?

The PPA market began to take off in Europe in 2020, when the Covid-19 pandemic prompted companies to opt for a fixed price for the supply of electricity, which in turn served as a way for developers to secure financing for their projects. The market is now in full swing, and Swiss consulting firm Pexapark recorded 214 new European PPAs, totaling 10,345 MW, from January through August 2024.

VPPs, as networks of decentralized energy sources that are connected to function as a single entity, have also been helping to stabilize the grid and to support the integration of renewable energy sources. BCC Research projects that the global VPP market will reach €5.6 billion by 2028, and the company highlights Germany and Austria as pioneers in this sector in Europe.

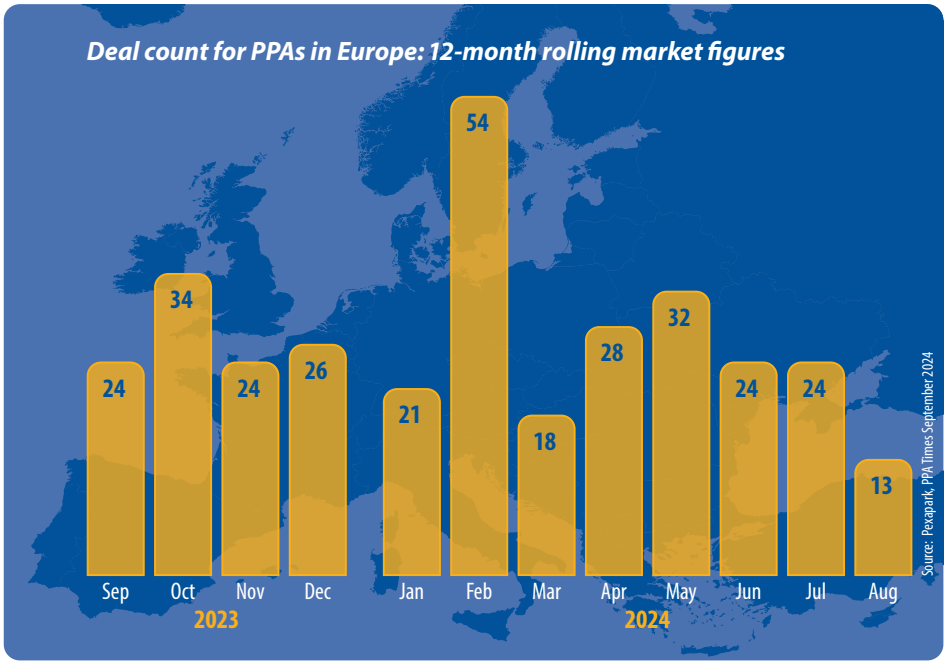
Energy sharing enables consumers, through an energy community or another organizational form, to self-consume locally produced renewable energy close to real time. An interesting model in Spain is offered by Spock, a startup that carries out collective energy purchases thanks to the union of small consumers. In March, it closed a collective PPA of 68.3 GWh for 23,269 individuals.

There is also the possibility of individuals joining together to create an energy community. The European Commission first set up rules for energy-sharing communities in 2018 and 2019, with Portugal rolling out its own legislation soon after. Nevertheless, five years on, there are only three energy-sharing communities legally operating in Portugal, with hundreds more stuck in a year-long regulatory backlog, and another 200 awaiting legal authorization in Portugal's "time-demanding" regulatory backlog, according to Humberto Queiroz, a researcher at Portugal's Nova School of Science and Technology.

Some companies offer a VPPA model to hedge the offtaker against unpredictable electricity prices, in case on-site space is not available, or as a way to generate energy in countries where project development is easier and probably cheaper. At the end of 2021, German energy producer BayWa r.e. announced a virtual PPA with Finnish packaging giant Huhtamaki. The 10-year deal ensured the construction of two solar farms in southern Spain with an aggregate generation capacity of around 135 MWp.

According to Pexapark, France boasted the largest decentralized solar PPA in Europe in July 2024: a 20-year partnership between French developer GreenYellow and Carrefour. The partnership aims for a 350 MW installation of PV systems covering nearly 180,000 parking spaces across 90 hypermarkets and 260 supermarkets. Just one month earlier, German renewables integrator Enpal and AI-innovator Entix had announced the formation of Flexa, a startup that says it intends to build Europe's largest VPP.

Germany's government offers a number of subsidies and financial incentives to help homeowners and businesses – including solar communities – install solar panels. Greece also aims to support the development of new, locally operated



From Pexapark, PPA Times September 2024

renewable energy communities – using net metering or virtual net metering – with about €42 million ($45.9 million) of new funds.

In December 2023, the Danish Energy Agency said it had allocated approximately €566,000 in grant funding to nine local energy communities and projects supporting renewable energy. Projects include an energy community startup guide for rural environmentalists, as well as an energy community feasibility study.

In Spain, Iberdrola created a self-consumption solar community in the village of Cedillo, a project that is managed by the citizens themselves. The largest "solar neighborhood" in Spain – according to its promoters – is located in the municipality of Rivas Vaciamadrid (Madrid). Forty-three collective self-consumption installations totaling almost 1,900 photovoltaic panels and a nominal power of 775 kW (864.9 kWp) supply electricity to 512 homes (more than 1,500 people). The community claims that it has managed to start up only 47.61% of the installations due to delays from the electricity marketers, according to a spokesperson at LaPabloRenovable.

Another current model in Spain is to allocate Next Generation funds to create energy communities, and some municipalities are tendering contracts for their creation. For example, the Industrial Energy Community Association of Jinámar, in Gran Canaria (Canary Islands), obtained €1.5 million to promote a total of eight PV installations with an overall power of 1.63 MW to supply energy to companies located in the industrial area of Telde.

Spain's Sivortex is promoting a project that would combine 100 MW of photovoltaic generation with 200 MWh of liquid CO_2 storage. The company plans to invest €120 million to build the plant, which will occupy 274 hectares in the La Paz business park and offer "shared self-consumption at a stable price to companies in the territory," according to Sivortex CEO Carlos Badía. Once developed, the company says the project will boast the largest PPA in the European Union.

Recently, the EU implemented a second generation of legislation recognizing the role of energy communities in various activities, including the development of large projects. Belgium stands out as an example. In 2019, a Royal Decree on new offshore zones included citizen participation as one of the tender criteria. A minimum of 1% of the capital raised for the entire project should be opened to citizens by law. The tender criteria will allocate 10% of the points to citizen participation, and the renewable energy communities are entitled to contract 25% of the energy through a citizen PPA.

Photo: Dimitris Vetsikas / Pixabay

In 2019, Belgium's Royal Decree on new offshore zones included citizen participation as one of the tender criteria.

Gnesta, a small town in Sweden, is building a sustainable green community by deploying solar systems powered by Huawei's FusionSolar Residential Smart PV solution. The systems maximize the self-consumption rate of electricity while reducing electricity costs and protecting the local ecological environment. The project has equipped 500 homes with solar systems since 2023, and there are plans to equip an additional 1,500 homes.

To provide more legal clarity and make energy sharing more accessible to citizens, the EU created the Citizen-led renovation (CLR) initiative. The European Commission's Energy Community Repository has been supporting energy communities the past two years through a range of technical assistance activities. A total of 23 communities from 11 countries have benefitted from direct technical assistance from national experts.

> *"The EU has put in place a second generation of legislation recognizing the role energy communities play in ... the development of large projects"*

A green miracle in the desert

Upon completion, The Red Sea destination will be a role model tourist development with 50 hotels and other amenities powered by 100% renewable energy, thanks to a 400 MW PV power plant supported by a 1.3 GWh battery energy storage system from Huawei.

Red Sea Global Executive Director – Projects, Grant Suckling

Along the western coast of Saudi Arabia, an ecosystem is blooming that is set to become a role model of sustainable development in the tourism sector. Spanning 28,000 km², The Red Sea destination is a key component of the country's Vision 2030, which aims to not only establish Saudi Arabia as a global leader and improve the lives of its citizens, but also to diversify the economy away from dependence on oil.

The primary goal of The Red Sea is to spearhead a new model of development that prioritizes people and planet, according to the developer, Red Sea Global (RSG). Leveraging innovative concepts and technologies, RSG has committed to developing a destination that will be powered by 100% renewable energy upon completion, thanks to 760,000 solar PV panels supported by one of the world's largest off-grid battery energy storage system (BESS) facilities.

Grant Suckling, Executive Director – Projects at RSG, says that "Huawei was the optimum supplier of the BESS for the development" and was "selected by the public-private partnership (PPP) consortium and awarded the PPP utilities infrastructure of The Red Sea destination (Marafiq Red Sea for Energy) through a competitive bid process." The 1.3 GWh energy storage system uses Huawei's Smart String Grid-Forming ESS, making it the world's first GWh-level standalone microgrid project for 100% renewable power supply.

Huawei's ESS technology features IP55-level dust and water protection, C5 anti-corrosion capability, and a distributed cooling design, which are vitally important, given the region's challenges with high temperatures, humidity, and salt fog, as well as sandstorms. The highest summer temperature in the Red Sea region exceeds 50 C, and the project is only 100 meters away from the sea.

Grant says "the role of the BESS is to receive and store electricity from the PV solar farms during the daytime and then release the stored energy back into the microgrids during the non-daylight hours to meet consumer demand." He adds that the BESS is an integral part of the energy mix that "forms and stabilizes the voltage and frequency of the grid and provides for a continuous, stable supply of electricity from renewable sources while reducing greenhouse gas emissions and the carbon footprint."

Development of The Red Sea destination has been scheduled for two phases. According to Grant, "Phase One is progressing, with our first three resorts now open and our dedicated airport welcoming domestic and international flights." The first resort, Six Senses Southern Dunes, has a dedicated microgrid consisting of eight BESS containers totaling 14.45 MWh of energy storage capacity and a solar farm with 11,312 PV panels, featuring 6 MWp/5 MWac generation capacity. An additional 14 hotels are set to open throughout 2024 and 2025, marking the end of Phase One.

According to Huawei, the project uses biodiesel generators only for emergency backup, which means the PV+ESS system must be able to operate stably under various steady-state and transient fault conditions. Faced with complex grid conditions, The Red Sea uses Huawei's Grid-Forming Smart Renewable Energy Generator Solution to make the PV+ESS system a reliable voltage source. The stable microgrid can implement continuous off-grid fault ride-through and support GWh-level black starts, enabling minute-level power recovery and avoiding loss caused by power outages.

Other challenges faced by the PV+ESS system include the inrush current caused by frequent connection/disconnection of

The Red Sea destination has a goal of a

30%

net conservation benefit by 2040

The 1.3 GWh energy storage system uses Huawei's Smart String Grid-Forming ESS.

transformers, as well as startup/shutdown of motor-type loads – both of which risk collapsing the microgrid.

"The project's advanced grid-forming energy storage algorithm supports 100% of unplanned transformer connections without the need for additional power conversion systems," says Grant.

By 2030, when The Red Sea destination reaches full completion, it will be home to 50 hotels across island and inland sites, with the goal of being completely carbon neutral and aspirations to become carbon negative. The destination will also include luxury marinas, golf courses, entertainment, food and beverage services, and leisure facilities.

RSG has a steadfast commitment to enhancing – not just sustaining – the natural environment throughout its portfolio, as well as delivering world-leading luxury experiences for guests.

"The Red Sea goes beyond sustainability to have a regenerative impact on the environment, aiming for a 30% net conservation benefit to local ecosystems by 2040," Grant emphasizes. "This will be achieved by enhancing biologically diverse habitats including mangroves, seagrass, corals, and land vegetation." pv

Performance tests completed for energy storage plant

Huawei has completed performance tests for CGDG's 100 MWh multi-energy grid-forming energy storage plant in Golmud, Qinghai, China.

As a greater number of power systems shift toward low-carbon sources, the high penetration of renewable energy and power electronics equipment will impact the stability of power grids worldwide. In order to achieve sustainable development of renewables, many countries and regions must improve the grid integration performance of PV, wind, energy storage systems (ESS), and other power systems that utilize power electronics equipment, enabling these technologies to have the same characteristics as traditional synchronous generators.

The Qinghai Branch of China Green Development Investment Group Co., Ltd. (CGDG) is one of the pioneers in promoting the large-scale application of grid-forming energy storage technologies. CGDG's multi-energy project is in Golmud, in the Chinese province of Qinghai, with a total installed capacity of 700,000 kW. The project includes 200,000 kW of PV power, 400,000 kW of wind, 50,000 kW of solar thermal power, and 50,000 kW of ESS capacity. Currently, the energy storage plant in this project has achieved 160 million kWh of charged energy and 140 million kWh of discharged energy, saving 49,000 tons of standard coal.

Huawei Digital Power is dedicated to enhancing the safety and stability of renewable integration by combining digital and power electronics technologies, leveraging technical experience, and col-

CGDG's multi-energy project in Golmud, Qinghai, has a total installed capacity of 700,000 kW.

Huawei's 50 MW/100 MWh Smart String Grid-Forming ESS passed the grid-connection performance test in May 2024.

laborating with global power companies and electricity providers. The company is working closely with CGDG on the multi-energy project.

As renewable energy penetration increases, the local grid shows clear signs of weakness. The CGDG project includes various power supplies, such as PV capacity, wind, solar thermal, and a conventional energy storage component featuring Huawei's 50 MW/100 MWh Smart String Grid-Forming ESS. On May 31, 2024, this grid-forming energy storage plant was successfully put into operation and passed the grid-connection performance test.

On June 15, the 35 kV three-phase short-circuit test was completed under two types of working conditions: (1) charging status in grid-forming control mode; (2) discharging status in grid-forming control mode and charging status in grid-following control mode. This test has verified the frequency and voltage regulation capabilities of the ESS and the plant in response to different voltage levels and asymmetric fault events.

On June 30, the 110 kV single-phase short-circuit test was completed. During the short-circuit fault period, more than 600 power conversion systems (PCS) were running reliably and stably to provide fast reactive power support for the system.

These short-circuit tests simulate real-world fault conditions by creating artificial short circuits in an operating power grid to observe and record how the system or equipment responds. The short-circuit tests are included in the grid-connection performance tests of the grid-forming ESS because they can verify the regulation characteristics of the ESS and the plant in response to power grid events. The performance tests have successfully verified Huawei's Smart String Grid-Forming ESS in terms of compatibility with various types of power supplies, parallel operation capabilities of multiple devices, and support for large-scale renewable integration and distribution, demonstrating its successful large-scale application.

These tests generated valuable data and experience for mitigating safety and stability risks associated with integrating a high proportion of renewables into power systems. Huawei's Smart String Grid-Forming ESS has advanced from "grid-following" to "grid-forming," representing a significant breakthrough in power electronic grid-forming technology. This is seen as a crucial step toward building new power systems with renewables as main sources, and a major technical milestone toward carbon neutrality. pv

"The energy storage plant in this project has achieved … 140 million kWh of discharged energy, saving 49,000 tons of standard coal"

The switch to string in Mexico

Kino Energia COO Rodolfo Garcia De La Cruz discusses the company's measures to improve PV plant reliability by switching from central to string inverter technology.

How has the switch to string inverters helped Kino Energia to grow or overcome any challenges?

We have three solar plants, and as with most solar plants, 80% of the problems came from the inverters. Central inverter technology historically has had a greater failure ratio than string inverters. Solar technology is still developing very fast, and new products are released regularly. This means that products frequently are replaced every couple of years by a new design. This sometimes brings about that some products are developed very fast, and there is limited operation data during the product lifetime. Some products end up being unreliable, and massive failures and/or low efficiencies appear. In some cases, manufacturers may even face problems in continuing their activity, which causes a very serious problem for solar plants to obtain spare parts that allow them to continue operating with high availability.

This challenge has also affected Kino with some central inverters that we had on the original PV plant design. So we have to replace the old inverters that we cannot repair, and substitute them with string inverters, which have been a very flexible and reliable solution in the last several months. The switch to string inverters has helped us a lot.

Huawei's string inverter technology is used at Kino Energia's Villanueva project.

What specifically attracted you to Huawei's technologies and services for your photovoltaic projects?

We chose Huawei because it has one of the best string inverter technologies on the market, with great capabilities and a very low failure ratio. That is what we expect as owners of a PV plant. Also, the ease of the replacement of any inverter. You can do the corrective maintenance in almost 24 hours. You can substitute one inverter for another very quickly, without sacrificing a lot of availability in the plant. Also, Huawei's aftercare service is great, so we are very happy to have chosen their string inverter technology.

What types of things affect the return on investment of your solar plants, and how have you worked to improve the return on investment?

We have been clearly affected by failures on the main equipment, especially on inverters. This causes an increase in the operational cost and a decrease in energy revenues. In trying to solve this, we are implementing a plan with different measures to try to reduce the current failure ratio. We also must repair all the equipment that is viable for repairing. Equipment that we cannot repair is being replaced with Huawei technology. Recently, Kino has created a technical office that plays a key role in understanding these points and tries to manage these issues in the most efficient way possible.

Can you talk about your experiences with your 820 MW solar plant?

With a plant as big as this numbers are huge. When you look at the annual gigawatt-hours, the number of people we have operating the plant, or the operational cost, the numbers are gigantic. So it's a very demanding experience, and it also allows us to do things that we usually cannot do in smaller plants, like investing in tests, or having staff 24 hours a day, 365 days per year, which reduces response time significantly.

It's a great responsibility and a great learning opportunity to have a plant like this in your portfolio. A large plant like this also means greater troubles when things don't go as expected. With the measures we have been instituting to address these problems, including the use of Huawei string inverters to replace inverter capacity that we cannot repair, we expect to recover the availability of the plant to 99% in the first quarter of 2025.

What kind of challenges have large-scale solar plants faced in Mexico?

Uncertainty in the market is clearly the largest challenge that Mexico faces. However, if we look at the current situation, it's actually promising. Mexico is a growing country that is currently deficient on electrical capacity. We also now have the additional impulse caused by the "nearshoring" that will require a further increase in the electrical capacity. The solar panel pricing is lower than ever. Finally, there is a consensus that new increases in electrical capacity must involve renewable energy technologies. So, if we consider these points all together, we should expect a huge growth in the solar market in the next few years.

Of course, there are other issues. For example, development of battery systems in Mexico is very behind compared to other countries, and the transmission network also needs to be improved to allow this increase in electrical capacity.

And there are also the same challenges in other countries, like energy storage, and making solar plants compatible with agriculture and the surrounding environment. But mainly, it is the current uncertainty that needs to be solved to allow the market in Mexico to grow again.

What suggestions would you give to investors of future PV plants in Mexico?

I have been involved for almost 20 years on the development, construction, and operation of renewable plants. With the development and construction of projects, we always tend to focus on the levelized cost of energy (LCOE). We tend to focus more on choosing lower cost equipment to implement the design with the lower cost impact. However, after being involved in operations for so many years, I highly recommend investors try to foresee how the plant operation is going to be in the following 30 to 35 years. Even if many things cannot be foreseen, a deeper and expert analysis, and an experienced decision-making on the design, choosing the right technology can critically affect the operation and the financial model over the next 30 to 35 years.

Rodolfo Garcia De La Cruz, COO, Kino Energia

> *"Equipment that we cannot repair is being replaced with Huawei technology"*

Improving grid reliability

Alexander Gomes, COO of Matrix Energia, discusses grid reliability issues in Brazil and the important role energy storage systems are playing for energy providers and customers.

What factors led Matrix Energia to launch the energy-as-a-service (EaaS) business?

Our goal is to allow clients to focus on their core business, leaving Matrix responsible for the electrical infrastructure. We believe this approach brings more efficiency, as clients can allocate their resources to their main activities while we handle the energy supply, either through the free energy market or with flexible solutions such as energy storage systems.

Can you describe grid reliability issues faced in Brazil and how this affects consumers at all levels?

Both in Brazil and globally, we have seen an increase in extreme weather events, which often compromise energy availability. Recently, for example, in São Paulo, neighborhoods like the East Zone and part of the North Zone experienced difficulties with energy distribution during severe weather events. Our role is to provide secure and stable infrastructure, ensuring that our clients, who are connected to the grid, are not affected by such disruptions.

How important is energy storage to the growth of renewable energy technologies in Brazil?

Energy storage is crucial for complementing renewable energy sources, which are intermittent and not always available. For instance, there is no solar energy generation at night. With storage systems, we can ensure that renewable energy is accessible at any time, making it dispatchable and continuously available, which strengthens the presence of these technologies in the market.

Matrix Energia's projects incorporate Huawei's battery energy storage systems.

in Brazil

Photo: Matrix Energia

Do you have any projects that you would like to highlight?

The project installed at Frigorífico Cofril represents a significant milestone for Matrix. It is a battery energy storage system (BESS), provided by Huawei, with a capacity of 2 MW of power and 4 MWh of storage, implemented at the Atílio Vivácqua unit in Espírito Santo. This installation is part of our strategy to offer cutting-edge technological solutions that provide not only cost savings for the client, but also greater security and flexibility in energy management.

The storage system helped Frigorífico Cofril reduce its energy costs, especially during peak hours when tariffs are higher. In addition, it provided greater stability and reliability in the energy supply, protecting the client from grid interruptions and ensuring continuous operation, even during adverse weather conditions. The inclusion of the storage system further strengthened our partnership with Cofril. Since the client joined the Free Energy Market with us in 2020, this new phase with the BESS was a natural evolution to optimize operations and bring even more benefits. Cofril was extremely satisfied with the system's performance, both in terms of cost savings and operational security.

What has been your experience partnering with Huawei, and how have the company's technologies supported your PV projects in the country?

Our partnership with Huawei has been very positive. The quality of their products and the level of service we've received have exceeded our expectations. The equipment already in operation has shown complete reliability and performance beyond what was initially projected. Huawei's energy storage solution is fully aligned with the principles of sustainability and innovation that we uphold at Matrix. Huawei provides us with both technical and commercial support, making this collaboration extremely beneficial. The BESS complements renewable energy sources, allowing our clients to have continuous access to clean and dispatchable energy, even outside solar generation periods, for example. This not only ensures a more eco-friendly operation, but also contributes to the decarbonization of the Brazilian electricity sector, promoting a more sustainable future for all.

How are BESS technologies helping to achieve cost savings not only for energy providers but also for end consumers?

The BESS is a new innovation that entered the Brazilian market at the beginning of 2024, the year in which Matrix Energia also celebrates its 10th anniversary. The launch of this system, in partnership with Huawei Digital Power, promises to transform the Brazilian energy landscape. Focused on offering the best electrical energy solutions to our clients, we are investing in this innovative system and offering its installation at no cost to our clients. Storage systems help reduce not only the cost of energy itself but also related costs, such as demand, wire availability, and capacity. These systems also help balance the grid, providing more stable energy for our clients.

Matrix Energia offers the system to clients free of charge, reinforcing our commitment to accessibility and quality. We manage the entire BESS system, which is enhanced by a Huawei digital platform that provides real-time visibility of energy performance. Our initiative, in partnership with Huawei, not only meets current demands for renewable energy but also sets new standards for efficiency and sustainability, revolutionizing the energy market and proving that innovative solutions are essential for the future.

Is there anything specific you would like to add regarding the use of Huawei's technologies for Matrix Energia projects?

I would like to highlight Huawei's commitment to innovation. Recently, our board visited the manufacturer's headquarters to learn about the product roadmap and the technological innovations planned for the coming years. We were impressed with the level of investment in the development of high-tech equipment. We are confident that we have chosen the right partner to drive this new sector in Brazil, offering our clients the most advanced and reliable energy storage systems available.

> *"The storage system helped Frigorífico Cofril reduce its energy costs, especially during peak hours when tariffs are higher"*
>
> **Alexander Gomes, COO of Matrix Energia**

Bringing power to the people

Dr. Hicham Bouzekri, Director of R&D and industry, the Moroccan Agency for Sustainable Energy (MASEN)

Dr. Hicham Bouzekri, Director of R&D and Industry for the Moroccan Agency for Sustainable Energy (MASEN), explains how battery energy storage is helping the country to empower all of its people through renewable energy microgrids.

What are some of the needs specific to the Moroccan electricity grid when it comes to integrating power generation and energy storage systems?

Morocco has close to 99.9% electricity access, and over 98% of our population is grid connected, but we import over 90% of our energy needs. Morocco has very high-quality wind and solar resources, but it still does not provide us with the base-load needed for a developing country where the electricity demand increases by 4% to 5% every year. This means we have to double the installed capacity approximately every 10 years.

Back in 2009, Morocco made a decision that no new fossil fuel generation capacity would be added to the grid, so all of our new generation capacity is coming mostly from solar and wind, but also hydro, which is limited here given the droughts. We have an ambitious program to increase the installed generation capacity of renewable energy sources to about 52% by 2030. However, because solar and wind are intermittent, you need storage for grid stabilization. MASEN sees storage as being a key to increasing the penetration of renewable energy into the electricity mix.

Another really interesting application for battery energy storage is in cities that are adopting electric vehicles. Being able to deploy batteries in gas stations will allow us to have more fast-charging capacity, which will alleviate the range anxiety that people have in the adoption of EVs.

Why are microgrids an attractive option in Morocco?

While most of Morocco's population is connected to the grid, about 2% are not. So, through a national rural electrification program, we initially offered individual solar kits, which included a couple of panels with lead batteries along with a few LED lamps for electricity inside the house.

But what we are seeing is that this barely meets the minimum vital requirement for these populations and does not provide electricity for economic development. You cannot power a facility to preserve fresh produce. You cannot do preprocessing for agricultural products locally. You cannot meet heating needs.

So you basically have two alternatives for getting electricity to non-electrified areas. The first is the traditional way, which means building a grid infrastructure that would take decades and billions of dollars and will take years before electricity reaches these populations. The second is decentralized electricity generation through microgrids using solar and batteries, and we believe strongly that this is the most effective and efficient way to bring electricity to these populations.

Back in 2019, we started working with microgrids in smaller villages, and the goal there was to have a capacity building program so we could better understand microgrids and the dynamics they involve. The goal was for Morocco to act as a leader in adoption of renewable energy regionally and continentally. For Northwest Africa and French-speaking Africa, MASEN is really leading the way. When you look at these regions, this is the last frontier of electrification that we see in the world. So Morocco has been hosting many of the decision-makers within these countries, trying to help them through our experience.

MASEN uses Huawei's LUNA2000 energy storage solution in its microgrid projects.

What was the impetus behind the Morocco Rural Microgrid C&I Energy Storage Project and what stage is it at currently?

We wanted a system that was as self-reliant as possible. We couldn't deploy technicians to be there 24/7, so we chose integrated solutions that had the battery system, the battery management system (BMS), and the energy conversion system that would stabilize the grid down the line.

We decided there was an urgent need for approximately 2 MWh of storage total and started with a temporary housing project the government had put up to host populations displaced by the AL Haouz earthquake, and that was the most advanced in terms of construction. We deployed a 600 kWh system there, which was tested and is now operational, and we have started work on the rest of the systems.

We still have 1.4 MWh of storage and generation to be deployed. A few of the villages have already been identified, and others are undergoing discussion.

Why did MASEN select Huawei to partner with, and what value is the company providing?

We wanted an integrated solution, meaning we did not want to handle all of the intricacies between the battery storage, the power generation, and the grid management. So we issued an open call for proposals, and we ended up selecting the Huawei energy storage solution – the LUNA2000.

A specific reason is that it checked all of these boxes with an integrated, all-in-one battery storage system with a BMS and energy management system. Having a company that had technology solutions that were interoperable between multiple subsystems is absolutely key to a smooth deployment.

Another reason that was absolutely key was having boots on the ground. Huawei has a strong local team with technical expertise, and we felt comfortable going into an earthquake-stricken area with them to deploy a relatively new technology for Morocco. We needed to make sure that if something went wrong, we had the know-how and support with local expertise.

We felt quite confident with the solution, because we had a counterpart that we could go back to in terms of technical questions. Even though we ended up buying the system, we did not feel like it was just a regular customer-supplier relationship, where as soon as you pay for something then you have to go figure it out yourself. It was more of a partnership.

Given that the first commissioning of the microgrids went according to plans, there is absolutely no reason for us not to continue with that cooperation.

> *"We have an ambitious program to increase the installed generation capacity of renewable energy sources to about 52% by 2030"*

Solving grid issues with ESS

The high amounts of solar and wind power being fed into the Dutch electrical grid cause issues that affect the ability of businesses to expand, according to ELIX CTO Pieter Hofstede, who discusses the growth of energy storage solutions in the Netherlands.

What types of PV or solar-plus-storage projects does ELIX focus on?

ELIX is one of the largest EPC companies in the Netherlands, and we've been in business since 2016. We started with smaller PV projects, and scaled up to C&I and to utility-scale PV projects. Our biggest project, which will be 30 MWp, is currently in development this year. From the start, we've been building with Huawei products.

What we see in general is that the market is transitioning from mono-asset projects to multi-asset projects. So in addition to PV, we've also added ESS into our energy solutions for clients, and those are fully based on the Huawei product. We started with 0.2 MWh up to around 20 MWh, which is our biggest project. We are also starting to work on EV projects as well, so we can offer a complete energy solution for our customers.

Additionally, we saw that our clients also needed an energy trading solution, so we are an energy trader as well, and we are registered to buy and sell kilowatt hours on the on the Dutch energy trading markets.

With this transition from providing PV to providing complete energy solutions, we responded by expanding our engineering team. In the last three years, we went from two engineers to, currently, 11 engineers. We understand that when we have the knowledge inside our team, we can come up with a solution for the technical demands of our clients.

ELIX CTO Pieter Hofstede

Can you talk a bit about the development of your current energy storage projects for the C&I segment?

At ELIX, we start with a full technical design based on the request of the customer and after reviewing their business case. Then we come up with a technical design that meets their energy requirements. We also do a commercial review to figure out the best solution, so we know our customers are spending money in the right manner. Then we come up with a final design and begin the general layout. We take full responsibility to get the necessary approvals from the authorities, including the Dutch Fire Department and the Dutch local government.

For the 6 MW/12 MWh distribution center project in Veghel, our customer wanted an energy system to provide power for the center, and they wanted to use the battery for energy trading. The ESS system has already been ordered, and there will be six containers total. Once the equipment is ready, it will take approximately six weeks for us to build it. Then we have the final commissioning and design acceptance tests of two weeks. So, by the end of 2024, we will have a system running for the customer.

We also have a large C&I project in Dordrecht, where we installed 1 MWh of ESS using 15 of Huawei's SUN2000-100KTL-M2 inverters on top of the roof of a distribution center. This system can provide energy for the company and directly back to the grid, depending on how much the client is using. Whatever surplus the client isn't using gets stored temporarily in the battery.

We are also doing energy trading with this battery system. So when the time is financially beneficial to put energy into the grid, we fully deliver the energy stored in the battery. And when the energy prices are low, we buy energy, we store it in our battery, and then supply the energy to the distribution center or back to the grid at certain times.

Doing this also helps to keep the Dutch grid stable. We have one of the most stable grids in the world, but due to the high PV and wind production, there are times when we have far too much energy, and then that surplus must be pushed somewhere. Batteries are the perfect place to store the excess energy.

How do you see the PV-plus-ESS market developing in the Netherlands and how will this affect the growth of electric vehicles?

Photos: ELIX

This rooftop installation in Dordrecht features 15 Huawei SUN2000-100KTL devices supporting a 2.7 MWp PV system.

In 2023, more than 50% of the total electrical energy going into the grid in the Netherlands was from sustainable sources. Because our grids cannot match the high ramp-up and ramp-down rates when supply and demand are out of balance, we have quite a lot of grid congestion issues. So ESS solutions help to keep the energy system in balance, and that's what's driving growth of that market in the Netherlands.

The grid congestion issues also affect the growth of the Dutch EV market. Companies with electric trucks, for example, have problems charging their fleets due to grid issues. So DC chargers are sometimes used next to ESS and PV to make sure EVs can still recharge. 2025 and 2026 will be years for scaling up BESS and EV DC charging solutions massively.

On top of that, the grid issues lead to expansion problems for companies. Our customers want to expand, but they cannot, because the grid operator is trying to keep the system in balance and will not provide a new connection or additional capacity for free. That's where we come in – to cover that lack of capacity by adding an energy solution on top of the already existing grid connection.

Can you talk about your partnership with Huawei and why their products were selected for your projects?

We chose Huawei first of all because they have the best product range. Huawei provides the power electronics that are critical to the system, as well as the battery cells, inverters, and transformer stations. On the EV side, they provide the super-fast DC chargers. Additionally, Huawei has very reliable, high quality products, along with outstanding support. They have engineers based in the Netherlands, for instance. They have very good product documentation. And in the end, of course, a good price. For ELIX, Huawei is more than the product we get. It's also the support and the knowledge that helps us come up with a good solution.

In 2023, more than

50%

of the total electrical energy going into the grid in the Netherlands was from sustainable sources

Power for the pandas

Mr. Tham Chee Aun, Group CEO of Ditrolic Energy, talks about the market for solar in Southeast Asia and the company's collaboration with Huawei on a remarkable project to power the Giant Panda Conservation Centre in Malaysia with sustainable energy.

How has the solar market developed over the past few years in Southeast Asia?

The solar market in Southeast Asia has experienced significant growth over the past few years, driven by increasing energy demand, supportive government policies, and a growing awareness of the need for sustainable energy solutions. Countries like Malaysia, Indonesia, Philippines, and others have implemented progressive policies to encourage the adoption of solar energy, leading to a surge in both utility-scale and rooftop installations. This regional development is part of the larger global shift toward renewable energy, as nations recognize the urgent need to transition from fossil fuels to more sustainable energy sources.

However, the market in Southeast Asia is still maturing, with challenges related to grid integration, regulatory frameworks, and financing. Despite these hurdles, the trend and commitment are clear. We have seen the introduction of new key policies, such as third-party access for renewable energy, offsite PPA programs, renewable energy portfolio schemes, and the removal of restrictions on solar self-consumption in some markets.

What challenges has Ditrolic Energy faced with its solar projects and how did you overcome them?

Our journey has been marked by challenges typical of a rapidly growing market. One of the key challenges has been navigating the regulatory landscape across different countries in Southeast Asia, where policies can be inconsistent and sometimes unpredictable. We have been working closely with local stakeholders and industry players, as well as advocating for clearer and more supportive regulations.

Which of the many projects you've partnered on with Huawei has impressed you the most?

The project that stands out the most is the solar project at the Giant Panda Conservation Centre in Zoo Negara Malaysia. This project was remarkable because of its symbolic importance and emphasis on our determination and efforts to protect endangered species. Integrating sustainable energy into such a facility underscores the broader impact solar energy can have beyond just power generation. Huawei's technology played a crucial role in ensuring that the system was efficient, reliable, and seamlessly integrated

Huawei and Ditrolic Energy partnered on a solar project at the Giant Panda Conservation Centre in Zoo Negara Malaysia.

into the existing infrastructure, making it a showcase for what can be achieved when advanced technology meets environmental stewardship.

The collaboration between Ditrolic Energy and Huawei on the Giant Panda Conservation Centre's rooftop solar system was an exceptional partnership that demonstrated our commitment in supporting the local conservation and enabling sustainability. This Corporate Social Responsibility initiative is led by Ditrolic Energy, which donated the solar PV system to the zoo, including designing and installing a 100 kWp solar system that could meet the energy needs of the conservation center while minimizing its environmental footprint. Huawei's smart inverter was a key element in ensuring the system operated at peak efficiency. This project is a prime example of how renewable energy can be integrated into conservation efforts, providing both environmental and educational benefits.

What benefits has this collaboration brought to the zoo?

This collaboration has profoundly impacted Zoo Negara Malaysia by transforming its approach to energy use and conservation. The solar system has provided substantial savings on electricity bills, and it also enhanced Zoo Negara's operational sustainability. The reduction in the zoo's carbon footprint directly supports its mission to safeguard endangered species by mitigating the environmental impacts of its operations.

The successful implementation of the solar system has generated public, media, and industry interest, reinforcing Zoo Negara's image as a forward-thinking organization in environmental stewardship. This increased visibility will turn the project into an educational showcase, illustrating to visitors and the wider community how renewable energy can be effectively utilized beyond commercial purposes, directly contributing to the preservation of the natural environment and bolstering conservation initiatives.

What drew you to partner with Huawei on the project?

Huawei's track record in delivering cutting-edge solar technology was a major factor in our decision to partner with them. Their commitment to innovation in the solar industry, particularly in developing smart PV solutions that enhance system performance and reduce operational costs, aligns perfectly with our goals. Furthermore, Huawei's global reach and strong presence in the region provided us with the confidence that they could support our projects not just technically but also in terms of supply chain management and after-sales service.

Are you currently working on any other projects with Huawei?

Ditrolic Energy is currently executing and exploring various projects in the region with Huawei, including one of the largest behind-the-meter solar plus battery energy storage systems (BESS) for a world-renowned furniture retailer in Singapore. The project enables the building owner to significantly increase their green energy self-consumption to achieve their net zero goals. Additionally, Ditrolic Energy is also exploring utilizing Huawei's technology for an upcoming utility-scale project combining solar plus tracking and colocation of a BESS system in northern Malaysia, which is slated to commence construction by end of 2024.

What is your strategy for the solar market in the Asia-Pacific region?

Our strategy is to be a leader in the transition to sustainable energy by offering a comprehensive integrated clean energy solution. We aim to empower businesses to achieve their 100% renewable energy targets through a holistic approach that encompasses every aspect of clean energy implementation, including advanced energy storage, management systems, and energy efficiency solutions.

By leveraging the latest technologies and innovations, we reduce costs and enhance the efficiency of solar installations, making renewable energy more accessible and affordable for a diverse range of customers. Also, we prioritize strategic partnerships with industry leaders like Huawei to ensure that our solutions are at the forefront of technological advancement and reliability. Through this integrated approach, we will create a robust infrastructure that supports our customers in their journey toward full renewable energy adoption, contributes to carbon emission reductions, and promotes overall energy independence in the region.

Top to bottom: Mr. Tham Chee Aun, Group CEO of Ditrolic Energy; Panda House at Zoo Negara; and Huawei's inverter at the Panda House

Impressing the appraisers

Huawei's Smart String Grid-Forming Energy Storage System (ESS) has passed a rigorous technology appraisal by the Chinese Society for Electrical Engineering.

On July 28, 2024, Huawei's Smart String Grid-Forming ESS platform underwent a rigorous technology appraisal meeting in Beijing, China, organized by the Chinese Society for Electrical Engineering. The appraisal meeting aimed to evaluate the key technologies and applications of the ESS solution, which is designed to cater to various scenarios with a high proportion of renewables.

The appraisal committee comprised 13 experts from research institutions and companies, including the Chinese Academy of Sciences, Chinese Academy of Engineering, State Grid Corp. of China (SGCC), SGCC Dispatch Center, China Renewable Energy Engineering Institute, China Electric Power Planning & Engineering Institute, China International Engineering Consulting Corp., China Huaneng Group, and CHN Energy.

"Huawei's solution demonstrates capabilities similar to synchronous generators"

This appraisal was applied for by Huawei Digital Power and nine other companies. After rigorous review, the committee unanimously agreed that the projects developed by the applicant companies have achieved world-leading capabilities in terms of improving new power system stability and renewable energy integration. The committee also agreed that the companies have developed and adopted the smart string grid-forming ESS through research in multi-site, self-synchronized amplitude and frequency regulation technology, wideband self-stabilizing and stabilizing control technology, smart string two-stage conversion architecture, and power modules with high overload capability and high reliability.

Key innovations

Huawei's Smart String Grid-Forming ESS solution features four key innovations. First is the multi-site self-synchronized amplitude and frequency regulation technology, which implements self-synchronized parallel grid-forming, significantly enhancing fast active reactive power response, active power support, fault ride-through, impact load support, and synchronous black start with loads. This technology enables grid-forming in various scenarios and under all working conditions, providing proactive power grid support, effective suppression of circulating current, and large-scale self-synchronized stable operation of multiple sites.

The second key innovation is the wideband self-stabilizing and stabilizing control technology, which ensures stable grid connection and wideband oscillation damping under different power grid conditions with varying scales and strengths. This enables the ESS to operate stably in parallel with multiple types of power supplies, including PV systems, wind power systems, and synchronous generators, expanding the application scenarios of the grid-forming ESS.

With Huawei's third key innovation, the pioneering smart string two-stage conversion architecture, the voltage and active power decoupling control technology supports power grid stability. It ensures the safety of the ESS and improves its availability, scalability, and upgradability. The manufacturer says its intelligent battery management technologies include digital features to improve the constant power output capability in the full state of charge (SOC) range, eliminating the need for manual SOC calibration and providing warnings for various faults.

Finally, the grid-forming storage system's high overload capability and highly reliable power modules provide fast active and reactive power support. The packaging with new anti-humidity materials improves long-term operational reliability in complex and harsh environments. The appraisal showed that Huawei has developed a reliable system for the design and production of fundamental core components.

The Golmud project supplies 1 MW/2 MWh of energy storage for the grid in Qinghai, China.

Performance in applications

Huawei's technical achievements have been applied to projects in western China and the Red Sea destination in Saudi Arabia, among others. The functions and performance of the grid-forming ESS have been tested at the equipment, single-site, and multi-site levels, including the 35 kV and 110 kV short-circuit tests.

The onsite test and operation results demonstrate that Huawei's Smart String Grid-Forming ESS significantly improves the grid integration of renewable energy and applies to various scenarios, including strong and weak power grids and off-grid conditions. In on-grid scenarios, the appraisal found that Huawei's platform demonstrates capabilities similar to synchronous generators (including synchronous condensers) in supporting the stability of voltage, frequency, and power angle. In off-grid scenarios, the solution has been put into commercial use and operates reliably for a 100% PV+ESS microgrid at the gigawatt-hour level. The tested performance for the project reaches or exceeds the current performance in the industry.

At the appraisal meeting, the committee pointed out that the smart string grid-forming ESS developed by Huawei Digital Power features a unique architecture and has been tested and verified in multiple projects and scenarios. These tests have proven the technology's ability to support power systems, which is a significant and innovative contribution to the development of grid-forming technologies. The tests are also important references for formulating grid-forming energy storage standards.

Hou Jinlong, director of the board of Huawei and president of Huawei Digital Power, said that the grid-forming ESS is a key technology for the new energy industry and can be widely applied to various sectors. Huawei will continue to increase R&D investment in core areas such as grid-forming technologies, energy storage safety, digitalization, and work with industry partners to promote standardization of the grid-forming technology.

Looking ahead, Huawei expects its grid-forming ESS to be widely used in various scenarios, including renewables integration, weak power grids, and microgrids. It will help the high-quality development of the global new energy industry and lead the energy storage industry into a new era of grid-forming.

A renewable future is fraught with hurdles.
Are you ready with explosive power, agility, and endurance?

Integrating high levels of renewables and power electronics can challenge grid stability. So, how do we seamlessly blend renewable energy into our power grids?

NEARING OUR CARBON NEUTRALITY GOAL

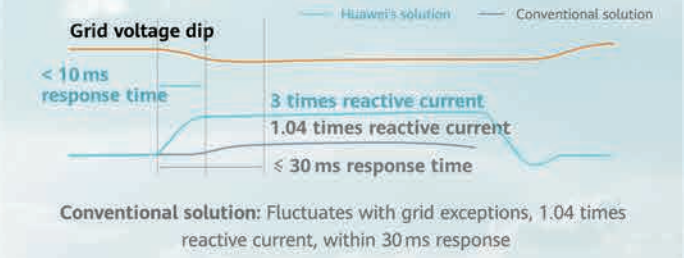
JOURNEY BEGINS

More renewables connected to the grid
Tougher Journey

High renewable feed-in reduces the grid short-circuit ratio (SCR), weakening rotational inertia, voltage support, and system resilience.

No Tricks
Just Triple the Capability

Huawei's Smart String Grid-Forming ESS delivers 3x reactive current in **10 ms**, stabilizing grid voltage.



Conventional solution: Fluctuates with grid exceptions, 1.04 times reactive current, within 30 ms response

This visual created by Huawei Digital Power

Smart String Grid-Forming ESS Adopts String Two-stage Conversion Architecture

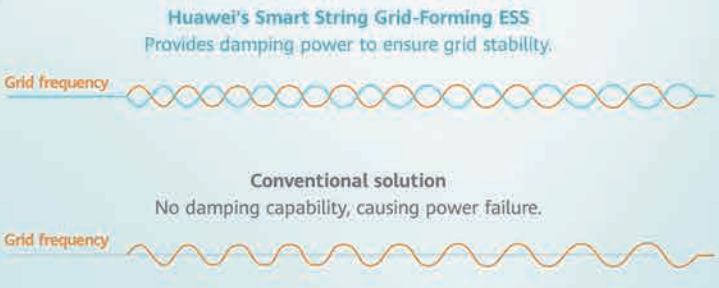
High availability and strong resistance to high voltage

Smart String Grid-Forming ESS Stabilizes Grid Frequency Against Disturbances.

Smart String Grid-Forming ESS Ensures Power Angle Stability.

Smart String Grid-Forming ESS delivers rotational inertia and **5 ms** response for rapid grid frequency recovery and wideband **(0.1–100 Hz)** oscillation damping, enhancing stability.

Conventional solution: Response time is ineffective for adjusting active power based on the frequency change, which may result in grid disconnection.



This visual created by Huawei Digital Power

Active safety from cell to grid

Energy storage system (ESS) safety is not only about cell safety, but covers end-to-end protection from battery cells and battery packs to racks, the system, and the power grid. Huawei Digital Power has designed its Smart String Grid-Forming ESS with active safety features to prevent thermal runaway from spreading at the pack level.

With the increasing penetration of renewable energy, power grids are significantly impacted by the high proportions of renewables and power electronics equipment. The grid-forming ESS is a key solution to this challenge. As the era of energy storage begins, more large-scale energy storage projects are being launched. However, these large-scale energy storage projects incur higher safety risks. ESS safety is becoming a growing concern in the industry as competition intensifies, causing a bottleneck and a pain point to its development.

Once a major safety issue occurs, its negative impact can last for several years and even influence the trajectory of the entire industry. As a part of the energy infrastructure, an ESS usually has a service life of 10 to over 20 years. It must ensure long-term, safe, stable, and high-quality operations under various complex, application-focused conditions. Therefore, ensuring ESS safety while meeting market demands is a critical challenge that the entire industry must address.

Huawei Digital Power is leveraging its extensive experience in power electronics and digital technologies to develop its industry-leading Smart String Grid-Forming ESS. This ESS resolves the inconsistencies and uncertainties of lithium batteries through the controllability of power electronics. By adhering to the principle

The Huawei Smart String Grid-Forming ESS

of comprehensive ESS safety from cell to grid, Huawei's safety design minimizes the risk of thermal runaway in the ESS and enhances the active safety capabilities through the end-to-end, multi-dimensional intelligent diagnosis by the battery management system (BMS).

Cell specifications

Huawei Digital Power collaborates with battery cell vendors to define cell design specifications for all scenarios, jointly developing and verifying the specifications. They simulate failure scenarios, including common applications and physical impacts. Over 100 rigorous tests are conducted on battery cell performance, ensuring no fire, explosion, leakage, or thermal runaway when battery cells are dropped from a height of 2.5 m. Additionally, no thermal runaway occurs when battery cells are penetrated by nails, and no fire, leakage, smoke, or lithium plating occurs when battery cells are crushed by a force of 50 kN. These tests have verified that Huawei's ESS outperforms samples from other vendors and exceeds national standards.

The cell-level isolation design adopts a thermal insulation layer (patented materials with an ultra-high temperature resistance of over 400 C) between battery cells to stop heat transfer. Additionally, cycle tests are conducted to simulate the real situation of battery cells in a battery pack, outputting more accurate parameters.

Battery packs

Battery packs are the core of an ESS. Given the uncertainty of ESS safety, the smaller the safety protection unit of the ESS, the safer the ESS is. Therefore, three protective measures are provided for each battery pack to minimize risks, prevent pack-level thermal runaway, and ensure pack-level safety under test conditions such as battery pack overcharge and external short circuits.

Smart cooling algorithm for rapid cooling: When detecting an abnormal temperature for the battery pack, the smart liquid cooling system activates, reducing the temperature by 20 C per minute to prevent any abnormal temperature rise.

Positive pressure oxygen blocking and directional smoke exhaust: The battery pack enclosure is constructed from metal, ensuring high reliability and airtightness. It features a directional smoke relief valve and patented smoke exhaust duct. In the event of thermal runaway in a battery cell, the highly protected battery pack prevents oxygen from entering and vents the generated combustible gases through the directional smoke relief valve and smoke exhaust duct, achieving pack-level smoke exhaust and reducing fire risks. Additionally, the iron enclosure (tin plating) of the battery pack can withstand up to 1,538 C, higher than the thermal runaway temperature of the battery cells, preventing thermal runaway from spreading at the pack level.

Cross-linked polymer insulation: This patented insulation material can resist electrolyte corrosion for more than 1,000 hours, ensuring that an electrolyte leak does not spread to other battery packs.

> *"These tests have verified that Huawei's ESS outperforms samples from other vendors and exceeds national standards"*

Rack protection

Each battery rack features six protective measures to reduce the risk of battery overcurrent for electrical safety. Four-level active protection includes BMU overcurrent protection, contactor protection, a rapid disconnection switch on the DC side, and DC/AC overcurrent protection, while two-level passive protection includes circuit breakers and fuses.

System safety

At the system level, four protective measures – detection, exhaust, suppression, and relief – are interconnected to provide comprehensive protection.

Detection: Multiple sensors, such as smoke detectors, heat detectors, humidity sensors, water sensors, and CO sensors are deployed in the system to detect the internal environment in real time and trigger the release of gas extinguishant in case of exceptions.

Exhaust: Each cabin is equipped with a proactive smoke exhaust function. If combustible gases are detected in a battery cabin, the exhaust fan is activated.

Suppression: The perfluorohexanone gas extinguishant and water spray cool-

The system is designed for harsh environments, from the cold of Inner Mongolia and Northern Europe at -40 C to the heat of the Middle East at 55 C.

ing solutions are used to prevent heat from spreading.

Relief: The battery cabin door adopts a directional explosion relief design, with 3 m^2 large pressure relief panels that are positioned 2 meters above the ground, ensuring quick pressure relief after thermal runaway gas accumulates.

Grid fluctuations

In conventional energy storage solutions, the power conversion system (PCS) uses a single-stage architecture. During abnormal grid voltage fluctuations, current may flow back to the ESS, posing significant safety risks. Huawei's new PCS, however, employs a two-stage architecture design with integrated DCDC and DCAC circuits. This design ensures that the active power is not derated and that it maintains battery voltage stability during high voltage ride-through (HVRT), even when the state of charge (SoC) of the ESS is 10% or lower, thereby preventing energy backfeed from the grid to the ESS. Additionally, the PCS HVRT adaptive algorithm dynamically adjusts the bus voltage during HVRT to ensure a stable active power output.

Proactive O&M

As the capacity of the energy storage plant grows, the volume of information to be collected also increases. Conventional ESS monitoring systems lack a comprehensive evaluation mechanism and rely on information from limited sources, making it difficult to accurately assess the actual condition of devices. Typically, operations and maintenance (O&M) personnel respond only after receiving alarms, and the system does not support proactive maintenance. Huawei Digital Power offers an end-to-end, multidimensional intelligent diagnosis system. It collects data from battery cells, battery packs, battery racks, and the entire ESS to provide a comprehensive evaluation of the system's operating status across five dimensions: consistency, charge and discharge, health, O&M management, and troubleshooting management.

Moreover, Huawei has developed battery cell and module fault warning technologies, which have been implemented at multiple sites. Data from battery cells and modules is collected over 8,000 times daily. An intelligent algorithm analyzes this data to identify more than 10 types of safety risks, generating warnings one to seven days in advance. This feature mitigates risks associated with battery abuse, internal and external short circuits, and low consistency. In addition, Huawei provides systematic O&M instructions, including diagnosis reports and site visits by experts, to help customers reduce safety risks and ensure the healthy operation of ESS.

The energy storage industry is rapidly evolving, and safety is the cornerstone of its high-quality, continuous development. Huawei's commitment to providing comprehensive and multidimensional ESS safety protection drives the healthy and sustainable growth of the energy storage industry and contributes to the construction of clean, low-carbon, safe, and efficient new power systems. pv

Linking safety and yield for C&I

The C&I solar segment continues to rally as part of a global effort to install more solar. As the cost of PV modules continues to fall while efficiencies and outputs rise, the return on investment (ROI) for businesses adopting solar energy is improving.

On the inverter side of the equation, Huawei has a new offering for the C&I segment via its FusionSolar C&I Smart PV Solution SUN5000 Series, featuring the SUN5000-150K inverter and MERC optimizers at two different power ratings: 1,100 W and 1,300 W.

One key difference for the new solution – designed by Huawei to address the unique demands of C&I solar projects – is integrating power optimizers with inverters. Optimizers are well-known at the residential level, but applying them to C&I uses is less well known, although optimizers offer clear benefits in certain scenarios to maximize yield and ROI. In addition, Huawei brings together key features for safety and to streamline operations and maintenance (O&M).

Latest model

The latest string inverter from Huawei, which has been ranked among the top three inverters by companies like Wood Mackenzie and S&P Global for almost a decade, is combined with the company's optimizers for C&I installations. This targets the growth in applications that mix rooftops with more complex installations in unconventional locations, such as on carports, building-integrated photovoltaics (BIPV), and ground-mounted and rooftop systems on sprawling industrial campuses. While "the more solar the better" is often the right approach, diversity can lead to challenges, mainly when panel orientations are inconsistent, or installations are in difficult environments.

Some highlights of the new SUN5000 solution include a maximum AC output power of 165 kVA, a nominal power of 150 kW, and a maximum power point tracking (MPPT) range of 200 V to 1,000 V. The MERC optimizers are applied to each module to increase performance, and each string of up to 12 can have a maximum input power of 20 kW, with 1,100 V maximum input voltage and maximum short circuit current of 66 A. The concept of full optimization applies.

The overall package of inverters and optimizers from Huawei has three key features: ProfiLink, SafeLink, and SmartLink. These features focus on key concerns and targets for business, starting with safety.

Ensuring safety with SafeLink

Safety is a critical concern in the PV industry, particularly in large-scale C&I installations. The SUN5000 Series integrates advanced safety features through its SafeLink system, which connects Rapid Shut Down (RSD) and arc-fault circuit interrupter (AFCI) technologies to enhance both property and personnel safety.

One key challenge in ensuring safety is managing the interaction between AFCI, which requires precise detection of high-frequency signals on DC cables, and power optimizers, which can introduce noise on these cables. Huawei's solution to this challenge is a systematic design that includes intelligent frequency selection to minimize interference, thereby reducing the risk of false arc detection. The result is a reliable AFCI and RSD system that lowers rooftop voltage from 1,100 V to under 30 V within 30 seconds, significantly enhancing safety during both operation and maintenance.

Maximizing energy yield with ProfiLink

Despite PV modules falling in price, a typical installation will see them as the most expensive component, often accounting for around half of the system's total cost. Conventional systems typically lack real-time monitoring of individual module performance. This makes the actual details of energy generation, par-

Huawei's new SUN5000 Series integrates its smart string inverter with power optimizers to meet the complex needs of a growing commercial and industrial (C&I) market segment.

ProfiLink can increase energy yield by up to

30%

in specific scenarios

The SUN5000-150K and MERC-1100/1300W-P solution

ticularly in shaded or complex environments or with unusual soiling, a matter of guesswork.

Huawei addresses this with what it calls ProfiLink. This makes the most of the combined power optimizers and inverters to ensure each module operates at its maximum power point, independent of the performance of other modules in the array. This approach mitigates issues such as shading and module mismatch, enabling the installation of PV modules in previously unsuitable areas, including those with variable shading. According to Huawei, this optimization can increase energy yield by up to 30% in specific scenarios.

Streamlining O&M with SmartLink

O&M challenges multiply when PV applications become more diverse, especially when dealing with installations on different roof pitches or in varying environmental conditions. The new SUN5000 includes a SmartLink feature to address these challenges before installation.

During the design phase, SmartLink uses a 3D modeling tool that factors in geographic location and basic system information to identify shaded areas and optimize the placement of modules, inverters, and optimizers. Once commissioning is complete and the installation moves to the operation phase with maintenance as an ongoing requirement, SmartLink offers comprehensive management capabilities, with real-time monitoring at the module level, accessible via both computers and smartphones. Issues are covered with detailed alerts and diagnostic reports, for more helpful troubleshooting.

OASIS

With the rapid decline in the cost of PV power generation and the growing consensus on the development of renewable energy worldwide, the C&I PV market is expanding rapidly. C&I enterprises have high energy demand and large rooftop areas, which are key factors in promoting the application of PV power, plus they strive to achieve carbon neutrality goals.

As a key part of the energy transformation, PV systems can allow thousands of industries to realize flexible and diverse business goals and paths via an "energy oasis." Huawei envisions empowering thousands of industries with technological innovations, so that green energy can fully be used and electricity can fully be utilized. Therefore, Huawei has upgraded the C&I Smart PV Solution and has renamed it the Huawei FusionSolar C&I OASIS Solution, which is a one-stop solution for customers.

OASIS features optimizers, inverters, energy storage systems (ESSs), and chargers, focusing on four core values: system-level active safety, enhanced green power supply, enhanced power grid support, and lifecycle intelligence. Huawei believes that ubiquitous PV+ESS, ubiquitous safety, and ubiquitous intelligence will be the future trend for C&I.

This 400 kW PV and 800 kWh ESS plant at a chicken farm in the Netherlands provides new revenue streams and contributes to carbon neutrality.

All 15 MW of PV modules at this factory in Türkiye are equipped with optimizers, meeting the high safety standards of the paper mill. The PV system is helping the energy-intensive factory to transition to low-carbon operations.

A 4 MW PV project paired with an 8 MWh ESS supports peak shaving and provides emergency backup power during outages, pioneering low-carbon development in Peru's mining industry.

The home as an energy management hub

Huawei's FusionSolar PV and storage solutions reshape home electricity production and consumption for a zero-carbon lifestyle.

A recent report by EUPD Research predicts that residential solar installations in Europe will reach 462 GW by 2029. Moreover, analysts say an increasing percentage of these installations will incorporate battery-based energy storage systems (ESS).

The combination of behind-the-meter photovoltaic energy generation and battery storage opens the potential for homeowners to not only enjoy greater energy savings – even to the point of grid independence – but also to enable their homes to sustain a zero-carbon electricity footprint. The key to achieving these goals is a highly capable energy management system that incorporates all aspects of residential electricity generation, storage, and usage to ensure maximum productivity and up-to-the-minute responsiveness to utility pricing, as well as lifestyle benefits and safety.

Huawei is positioning its FusionSolar residential PV and ESS solution to enable homeowners to assume more intelligent management over their green power generation, grid usage, and power consumption. FusionSolar incorporates an array of technologies, including PV module optimizers, power inverters, ESS, chargers, and an intelligent energy management system. Huawei's integrated solution is part of a whole-home approach to designing and implementing a solar installation with a single vendor and one point of service contact.

Huawei's FusionSolar Residential Smart PV Solution is helping towns like Gnesta, Sweden, build a sustainable green community.

Rooftop productivity

Given that the vast majority of residential solar installations are roof mounts, installers will start with a thorough understanding of the rooftop surface, including all obstructions and shadows that may be cast by gables, vents, and neighboring structures and trees. Satellite imagery or drones may be used to map challenging rooftops for module layout design.

Solar energy productivity naturally changes over the course of the day and throughout the seasons. The height of the sun in the sky relative to a module's angle, cloud conditions, the movement of shadows cast by obstructions, and temperatures are all factors. Huawei's optimizer units communicate with the inverter to improve the output of modules on an individual basis as conditions change so that an output reduction in one module does not affect others in the same series. Moreover, individual optimizers enable installers to place and orient modules freely on the rooftop without the constraints imposed by strings – more installations lead to higher yields.

While more optimizers might suggest more maintenance, Huawei's approach is to use simpler units to manage module output while the inverter handles the boost. The company says this architecture is 5% to 30% more productive than modules alone and its optimizers have a failure rate one-third that of conventional buck-boost designs.

Liberating storage

Producing electricity is only half the battle. Using it more intelligently is where the real opportunities of residential solar are revealed. In the early stages of the industry, tax incentives and rules requiring utilities to purchase surplus power encour-

aged homeowners to go solar. However, tax rules change and feed-in-tariffs vary widely, so neither can be counted on in the long term.

The most significant change in this dynamic has been the advent of battery-based ESS that is affordable at the residential level. Huawei's residential S1 battery incorporates battery cells, active pressure release technology, a fire suppression kit, and temperature regulation systems that enable normal operation in temperatures as low as -20 C. The architecture enables the addition of supplemental battery cells in a plug-and-play process.

The residential S1 battery operates with Huawei's SmartGuard whole-home backup system, which enables the inverter to operate in grid-connected mode and in the absence of grid power. SmartGuard is equipped with the company's Energy Management System (EMMA) that integrates system communication and meter function – as well as the management of PV, ESS, chargers, and all connected devices – through a user interface.

FusionSolar's integration of PV generation, ESS, charger, and energy management at the residential level opens up opportunities for homeowners to pursue sophisticated strategies for how they use electricity.

In regions where electricity costs are high and feed-in tariffs are low or nonexistent, excess solar energy during peak production times is stored for later use – especially at night – reducing the need for purchase grid power. A variation on this approach is a time-of-use strategy that charges the ESS when the sun is productive and rates are lower, for use during peak hours when rates are higher. This can also charge the batteries with grid power when the rates make this desirable.

For homeowners that do have access to a feed-in-tariff or net-metering program, EMMA can be set to prioritize sending solar-generated electricity to the grid, using the ESS to minimize curtailment. Excess energy is stored when production exceeds what the inverter can output, and is released when most useful to be fed back.

Residential power plant

Huawei is working to make residential solar as productive as possible to enable homeowners to take control of their power usage. In one example in Spain, where the solar resource is high, a Fusion-Solar installation was able to achieve a nearly 100% solar self-consumption rate. The installed system includes a 6 kW PV array, fully integrated optimizers, a 10 kWh ESS, an EV charger, and the EMMA system.

Since 2023, 500 homes in Gnesta, Sweden, have been equipped with Huawei's residential systems.

According to Huawei, the optimizers enabled 60% more PV output by making full use of the available roof space, which was shaded by air conditioning units and walls. EMMA's energy scheduling capability adjusts the deployment of the generated solar power in response to fluctuations in local electricity prices, weather conditions, and consumption patterns. Additionally, the chargers operate in a "PV power preferred" mode, wherein solar energy is the first choice for charging purposes.

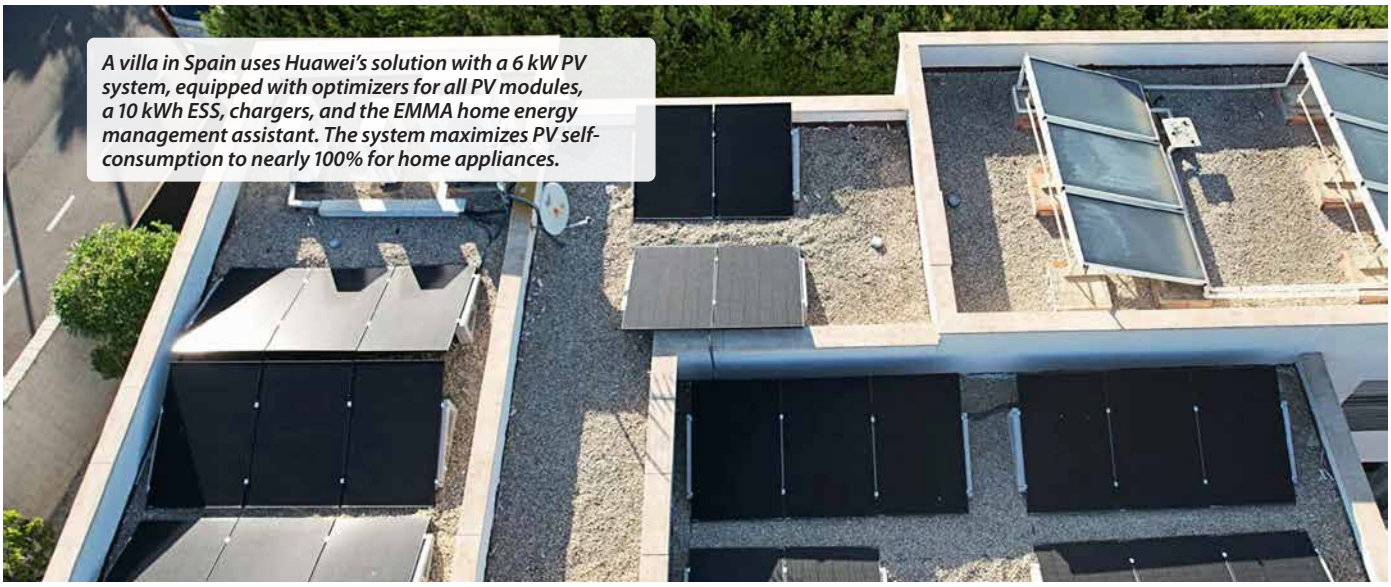
In Sweden, Huawei's FusionSolar Residential Smart PV Solution is helping the town of Gnesta build a sustainable green community. Since 2023, 500 homes have been equipped with Huawei's residential systems, and there are plans for an additional 1,500 homes as part of the project.

Energy demand is increasing due to increasing loads from data centers, electric vehicles, manufacturing, and other sources. This increase is causing utility costs to rise, leading to higher retail prices. These factors are making solar more attractive, particularly if paired with storage. Huawei's FusionSolar architecture is designed to make residential PV more productive, versatile, and economical at the residential level while bringing zero-carbon homes closer to realization. pv

Optimizers enabled

60%

more PV output by making full use of roof space



A villa in Spain uses Huawei's solution with a 6 kW PV system, equipped with optimizers for all PV modules, a 10 kWh ESS, chargers, and the EMMA home energy management assistant. The system maximizes PV self-consumption to nearly 100% for home appliances.

This 22.36 kW residential PV system, paired with a 10 kWh ESS, provides uninterrupted power supply for low-carbon living in Zhejiang, China.

This villa in Nanjing, China, is powered by a 20.24 kW solar system and a 15 kWh ESS.

HUAWEI

Fusionsolar

FusionSolar Residential Smart PV Solution

A Home that Always Shines

Shine on Active Safety I Shine on Full Journey Convenience I Shine on Energy-using Prospect

HUAWEI

Fusionsolar

Huawei FusionSolar C&I OASIS Solution

Active Safety, Integrate Innovation,
Accelerating PV+ESS+Charger to Become Ubiquitous

System-Level Active Safety | Enhanced Green Power Supply
Enhanced Power Grid Support | Lifecycle intelligence