Array Changing Technologies – North America

In the fast moving world of solar, each year brings new innovation across the supply chain. Since 2015, **pv magazine** has been recognizing excellence in innovation for solar components and PV power plant development and operation in the Array Changing Technologies feature and award.

In 2017, the award itself has continued to evolve. Now separated across the June, July, and September editions of the magazine, the award highlights 20 innovations in two feature articles, the first focused on European innovations and companies in the June edition of **pv magazine**, and the second on North American products and companies.

From each shortlist, three finalists rose to the top, from which winners of the Array Changing Technologies Award 2017 will be selected by the six person jury. The winner will be announced in the September edition of **pv magazine**, which will be distributed at the key Solar Power International trade show.

Hanwha Q Cells, with its new steel-framed module (Q.PEAK RSF L-G4.2); SolarEdge with its Smart Energy Management solution and S-series optimizer; and Wavelabs with its Sinus-2100 Outdoor LED flasher, were the three finalists of the European edition of the feature in June.

It is with great pleasure that **pv magazine** recognizes the finalists from the North America edition of the Array Changing feature. Congratulations to Amber Kinetics for its new take on flywheel technology, the M32; Enphase for its IQ 6+ microinverter; and Trina Solar, with its DUOMAX Twin module.

While winners are grinners, there is also plenty to be cheerful about the finalists from the North America Array Changing feature. Representing considerable innovation from power electronics through to mounting structures, a range of storage approaches through to a module cleaning robot, the jury set three finalists clearly ahead of the other shortlisted entries. To review both the full shortlist, visit *www.pv-magazine.com*. **pv magazine** and the Array Changing Technologies jury panel are pleased to announce the 2017 North America finalists:

Amber Kinetics
M32 Flywheel

Enphase Energy
IQ 6+ microinverter

Trina Solar
DUOMAX Twin

pv magazine thanks all entrants to the 2017 Array Changing Technologies award as well as the jurists, for providing their invaluable input.

Award Jury

Paula Mints
Chief Analyst, SPV Market Research

"I love supporting anything that fosters innovation," is how Paula Mints answered the request to be a jury member in this year's award. Paula is the Founder and Chief Analyst of global solar market research firm SPV Market Research. She began her career in the solar industry in 1997 with Strategies Unlimited. In 2005 she joined Navigant, where she continued as a director in energy practice until October 2012.

Tor "Solar Fred" Valenza
CMO Solar, Kiterocket

Tor "Solar Fred" Valenza is a solar marketing thought leader and the Chief Marketing Officer of Solar at Kiterocket (formerly Impress Labs), where he develops solar marketing, social media, and brand strategies for B2B and B2C solar and related energy companies. Before joining Kiterocket, he consulted for major solar brands such as SunPower, SolarCity, and Panasonic and wrote a weekly solar marketing and advocacy blog for Renewable Energy World. With his @SolarFred Twitter alter-ego, Tor engages with more than 15,000 solar industry followers and organizes annual "Tweetups" at SPI and Intersolar.

Rebecca Hott
Technical Adviser, Sunshot Initiative

Rebecca Hott is a Science and Engineering Technical Advisor with the U.S. Department of Energy's SunShot Initiative. In this role, Rebecca works on the Systems Integration (SI) team and serves as the main contact for the Sustainable and Holistic Integration of Solar Energy Storage and Solar PV (SHINES) portfolio. Projects within the SHINES portfolio aim to enable the development and demonstration of integrated, scalable, and cost-effective solar technologies.

Prior to this position, Rebecca was an Engineer/Environmental Planner for a consulting engineering firm in Washington, D.C. where her primary focus was electric transmission line planning and design. Miss Hott received her Master's degree in Energy and Mineral Engineering, focusing on solar energy, from Pennsylvania State University.

1 Amber Kinetics

M32 Flywheel

The need for storage to be coupled with renewables is well known, and for many, lithium-ion batteries are the preferred solution. Flywheel, however, is an alternative technology which can offer several advantages over chemical-based storage.

The M32 flywheel, developed by Amber Kinetics, targets commercial and utility-scale storage markets, particularly in regions with high PV penetration. The flywheel has a four hour duration, which the company points out is well suited to meet utilities' evening peak demand, typically from 5 p.m. to 9 p.m.

Amber Kinetics states that its flywheels have a lifetime of 15,000 cycles, and 30 years, requiring minimal O&M – units are sold with a 10 year warranty. The technology allows for unlimited daily cycling, requires only passive, water free cooling, and can operate in remote locations and extreme weather conditions, including temperatures from -40 to 50°C.

The company shipped its first flywheel units in 2016, and while focused on the U.S., it has also provided flywheels for locations including Nigeria and the Philippines. Amber Kinetics states that its flywheels have collectively accumulated more than 15,000 hours of continuous run time.

A modular design allows for full scalability, the company currently has a 20 MW/80 MWh facility in development in Fresno, California. The four hour duration and unlimited daily cycling allow for easy flexibility, and the nature of the technology means that material degradation, fire risk, or hazardous chemicals will not become an issue – the flywheel is 98% steel, 100% of which can be recycled at the end of a project's life.

In its own analysis, Amber Kinetics finds that its flywheels will be more cost effective than lithium-ion storage, based on pricing assumptions for 2025. An independent report from the San Diego Gas & Electric Emerging Technologies Group also projected a payback period of between 2 and 3 years, as a part of California's Self Generation Incentive Program.

The array changer

Flywheel storage is certainly not a new idea, but with its simple, chemical free structure and extended duration, Amber Kinetics's latest take on the technology could prove a viable alternative to lithium storage at utility scale.

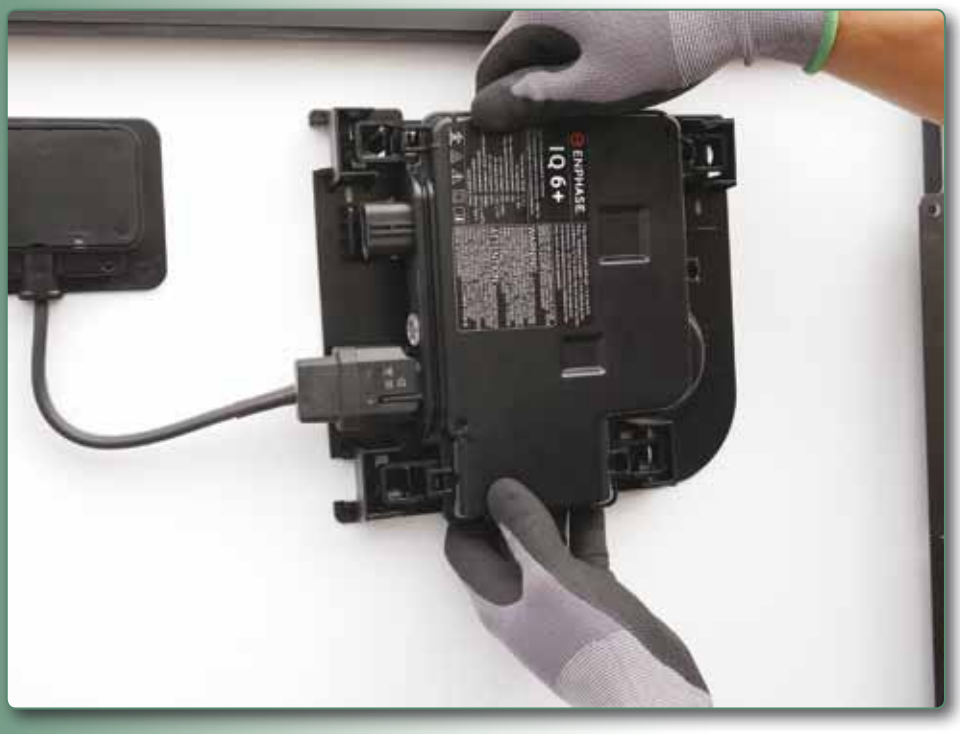
2 Enphase Energy
IQ 6+ Microinverter

The solar industry's lexicon is broadening with each passing day, learning to incorporate terminology such as Internet of Things (IoT) and other futuristic-sounding sound bites into daily usage. But U.S.-based microinverter specialist Enphase Energy looks to be heading back to basics with its newest addition to its portfolio – the IQ 6+ Microinverter.

Offering what the company claims is a "truly future-proof system," the sales literature associated with the IQ Microinverter range is encouragingly simple, yet describes a technology that appears to be something of a boundary-breaker. In short, this new microinverter is 30% lighter than previous iterations, and has a 50% lighter trunk cable. Aiding this ease-of-installation innovation are the new Enphase Energized AC Modules, which are solar panels built with the IQ 6+ Microinverter embedded, thus streamlining shipping, storage, and installation. The company has partnered with LG Solar, SolarWorld, and Jinko Solar to supply its microinverters in this manner.

But there's more. The new microinverters can also utilize Enphase's cloud infrastructure to enable tighter power data analytics, while also conforming with NEC 2014 and NEC 2017 rapid shutdown capabilities. The IQ 6+ can be remotely upgraded too, and is the first microinverter to be truly "no ground required" – Enphase has eliminated the Grounding Electrode Conductor, which means fewer electrical connections and components are required on the roof, further simplifying the install.

Deployment of the Enphase Q-Aggregator in the IQ 6+ ensures a consistent demarcation point between work done by installers and electricians, eliminating cable glands and wire nuts, and removing completely the most common source of call-outs for faulty installs. This also means installations can be simplified, thus vastly improving install time and reliability, and offering a tangible reduction in labor costs of up to $0.026/W.



The array changer

Safety, ease of install, increased performance: Enphase took aim at this holy trinity with the IQ 6+ Microinverter and, by the looks of it, appears to have hit the target. If this new model can do what the company claims and do so at an attractive price point, it could breathe life into Enphase's sales figures.

3 Trina Solar

DUOMAX Twin

High-powered and highly durable modules can deliver compelling BoS reductions for developers when produced at the right price. Coupled with 1500 V architecture, such module solutions can result in significant LCOE savings.

Trina's new DUOMAX Twin takes aim at exactly this, bringing together high efficiency bifacial cells, in a glass-glass module format. Trina says that the DUOMAX twin can deliver an LCOE reduction of at least 4.63% in applications with limited albedo, such as over grass, and up to 12.37% when albedo is ideal, a white C&I rooftop or fresh snow.

The Trina DUOMAX Twin is available in a 60 cell configuration and has a power output of 285-300 W. It utilizes monocrystalline cells and achieves a module efficiency of 18%. With 10% back side gain, the module can deliver between 314 and 330 W, with that increasing to 356-375 W output.

Importantly, Trina reports that it can produce the DUOMAX Twin modules at a cost structure that is only "slightly higher" when compared to its standard lines.

The DUOMAX Twin deploys slim-profile, split junction boxes mounted close to the module edge, preventing shading of the back side. The frameless modules have slim mounting clamps on the long edge, again preventing rear shading and optimizing the bifacial boost.

The dual-glass encapsulation delivers high performance and long life in harsh environments, Trina claims. The glass is 2.5 mm in thickness, reducing module weight, and is heat-strengthened. The Chinese producer reports that the modules are less prone to cracks, module warping, UV aging, and corrosion from sand, acid, alkali, and salt mist.

The module comes with a 30 year linear warranty. Trina believes the DUOMAX Twin is ideal for both power plant and commercial rooftop applications.

The array changer

Cost effective dual-glass modules can deliver long lifetime and reliability to developers. High efficiency monocrystalline cells, mean that this 1500 V compatible product can deliver reduced LCOE, making it an attractive proposition.

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4 Swimsol SolarSea

Swimsol GmbH's SolarSea was selected this year for its incredibly simple yet downright ingenious open-water solar solution. The product from this startup represents "the world's first solar system that can float in the ocean," the company claims. The system was designed for coastal areas, including bays and tropical lagoons, with power transferred to land via an armored submarine cable.

Setting up the system has been compared to Ikea furniture — although it may be easier. The knock-down package consisting of sealed corrosion-proof solar panels and a patent-pending floating framework. Three people can build the array in a day's time, at the beach, in flip-flops. When it's done, the oceanic solar array can power up to 25 homes.

The 14 by 14 meter framework, with panels safely elevated above the water level, allows waves and wind to pass through, barely moving the array or straining the anchoring system.

The array can withstand two meter waves, 120 km/h winds, and is built to last over 30 years. It does not serve as a diving platform unfortunately.

The specially-sealed solar panels are combined with platform components and made from corrosion-proof material, and the system can resist extreme UV rays and intense humidity. The concept for Solar Sea emerged from the crystal-clear waters of the Maldives, a nation of some 1,200 tropical islands spread out across the Indian Ocean.

Globally famous for its natural beauty and abundance of sunshine hours, the Maldives has not sought to use much solar energy – until today.

The product is an economic no-brainer, since island communities typically rely on imported fuel oil for generators, with corresponding costs for electricity estimated at up to seven times more than land-based consumers pay in the United States or Europe. This first generation of the SolarSea promises to reduce the cost of energy in adopting communities by as much as 50%.

The design of the SolarSea came about with four years of help from the Technical University of Vienna, where hundreds of designs were modeled in computer simulations, and 50 finally were built and tested in wave-channels. The first high-wave version was successfully ocean tested in 2016.

The array changer

While long thought a tiny niche, floating PV appears to be emerging at pace, and the natural extension is setting sights on the sea. Swimsol has delivered a new concept that may make the open ocean accessible for solar, at least where protected from the surf.

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5 Powin Energy

bp-OS

Providing and effectively managing data is rapidly becoming recognized as a vital way to optimize energy production and storage and to quickly spot any system issues. To that end, a broad variety of energy management software solutions is appearing on the market, covering all areas from home applications to megawatt-scale plant monitoring.

Powin energy's battery pack operating system (bp-OS) is designed to optimize and collect data on stationary storage systems. The company points out that while most storage installations utilize battery balancing software designed with electric vehicle use in mind, its system treats each battery cell individually, instructing it to draw or release energy to optimize to a pre-programmed level, rather than transferring power back and forth between battery packs to keep the whole system balanced.

The bp-OS is compatible with any form of lithium-ion storage, which allows Powin Energy to choose the best type of cell for a given project. The system continually measures charge/discharge rate, cell voltages and battery temperature, recording every few seconds and calculating battery usage.

The data provided by bp-OS could prove valuable to the growing utility-scale storage industry. Operators can spot a fault and identify its cause more quickly, and see how different configurations and use cases affect battery life. The system can also be used to compare the performance of different batteries and chemistries. This, says Powin Energy, could lead manufacturers to give better warranty and insurance coverage, ultimately making storage projects easier to finance.

Powin gives the example of a 2 MW/8 MWh system it installed in Southern California as an example. In this case, bp-OS cut the installation time for the project down to under six months, because the software could run diagnostics to find and replace problem cells or packs during construction, rather than waiting until the entire system had been completed and connected to perform tests.

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A software application specifically focused on monitoring battery installations could yield an endless amount of valuable data for manufacturers and project developers alike, supporting the growth of storage at utility scale.

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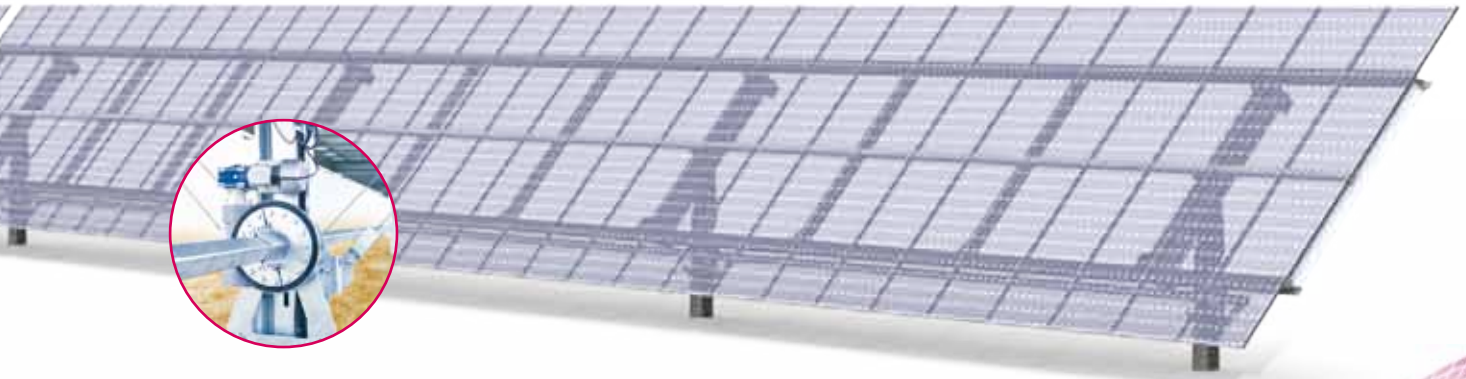

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6 Miraikikai Solar Cleaning Robot Type 1

The advantages of installing PV in arid regions and deserts are clear: lots of space, lots of sun. However, the dry and dusty conditions create several other problems for PV plants, one of which is the increased need for cleaning to keep module surfaces free of dust and able to achieve high outputs.

Other types of cleaning, whether manual or with a truck, require a lot of person-power and can be very water intensive – a real problem in arid regions, and these do not always result in uniform cleaning. Japanese robotics company Miraikikai now offers an alternative solution, with its automatic, water free module cleaning robot. The robot simply needs to be placed on the end of a row, sensors prevent it from falling off, and it will clean each module individually using rotating brushes and air blowers, so one worker can operate several robots at once. The robot is battery powered and, According to Miraikikai, also designed for minimal electricity consumption, and weighs 28 kg.

The company originally developed a window cleaning robot back in 2004, and has now applied this technology to large-scale solar module cleaning. The solar cleaning robot was launched earlier in 2017 at the World Future Energy Summit in Abu Dhabi.

Through eliminating the need for water, and reducing the number of workers required and electricity consumption taken up by cleaning, Miraikikai estimates that its robot can reduce cleaning costs by up to 80% in comparison to manual cleaning.

Some in the industry have voiced concerns that this type of water free cleaning could result in scratches or other damage to module glass or coatings, however, Miraikikai states that it has conducted an accelerated 20 year durability test alongside a Japanese module manufacturer, which found that the robots caused no damage to the modules.

The array changer

Desert regions have already produced some of the lowest prices worldwide for PV generated electricity. A simple, automated solution for panel cleaning is sure to receive a warm welcome from the owners of projects in these dry and dusty places.

7 5B
Maverick Folding Array

BoS costs have become the bane of the solar industry since panel prices crashed thanks to mass production. One notable effort to cut to the quick is 5B's Maverick Folding Array, which is a pre-fabricated, containerized solar array block that is scalable to virtually any configuration. 5B claims, for example, that a 100 kW project can be unfurled before lunch with a team of three and one forklift.

Cost is king with new technology, and the Maverick aims to please. The company is "already under the wire of the industry holy grail of AU$1.00/W (US$0.76) level, well ahead of the rest of the market," it claims. The company reckons that at scale, a solar farm can be erected for 20% of the cost of a normal array.

Military units, mining operations, Bedouins, and other roving groups will find the solution quite adaptable, and 5B says that the solution will be equally at home in larger, utility-scale applications. The 12 kW modular block design is so that the system can be deployed in six minutes with a two-person team, repacked in nine minutes, and then redeployed in an endless cycle with a zero drop in energy production, the company says.

The company was awarded an Australian patent in February of this year and the company also has international patents pending.

It has deployed 14 of its 12 kW MAVs (170 kW) across four projects and has another 200 kW in production. The technology has already attracted a mandate for a 1 MW project near Sydney, which will demonstrate the system's ability to scale up.

The Maverick started as a backyard prototype in 2014 and evolved into a commercial, mass-produced product as of early 2017. The company currently has a 30 MW per year production capability and is considering an Elon Musk-style gigafactory for production in the near future.

Founded in Sydney in 2013, 5B has been recognized as innovative enough that the Australian Government bestowed an AusIndustry grant in 2017 to assist in the establishment of 5B's production facility. "Simplistically, we describe ourselves as a module logistics company, in that what we have developed is the cheapest and most effective way to get modules from the factory to field," says Chris McGrath, a company founder.

The array changer

Fast deployment with limited resources on the ground can decrease installation costs, particularly in high-wage countries like Australia. A more portable array can also open up interesting market segments, such as mining applications where a short project life can undermine the application of more permanent structures.

A small team from Down Under has delivered big innovation on a more portable platform.

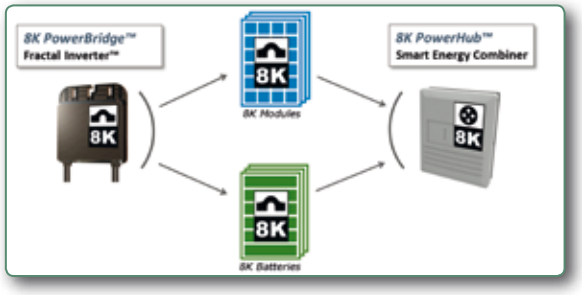
8 Empower

Genesys 8K Modular Smart Home Energy Platform

Developed by Empower, the Genesys 8K Modular Smart Home Energy Platform has one key aim: to streamline the logistics, shipment, and installation process of a rooftop solar PV system. To do this, the Genesys Platform strips away all complications to leave just two physical units – the 8K PowerBridge, which is a module-level fractal inverter, and the 8K PowerHub, which is a smart energy combiner. For installers operating in the rooftop solar PV space, the Genesys platform means that the number of stock keeping units (SKUs) required in the warehouse is reduced to two, making it more affordable and less complex for companies to store and supply the system. As modular technology, the Genesys 8K components are designed for standard household AC wiring, thereby eliminating the need for high voltage D wiring, and thus lowering balance of system costs.

So how does it work? The module-level power electronics (MLPE) inverter operates like a microinverter and is compatible with all modules and batteries. At the other end sits the 8K PowerHub, which is embedded with the smarts to handle AC energy from the solar array, enabling grid-feed, storage, or self-consumption. By shifting from high to low voltage, and from parallel to series connections, the Genesys 8K can deliver expected performance with far fewer components.

The system is also plug-and-play, which means that solar owners can simply add storage whenever they are ready, and distributors can meet these needs at very little additional cost or challenge. Empower claims that this approach offers a previously unrealized economic edge to installers, distributors, and residential end users.



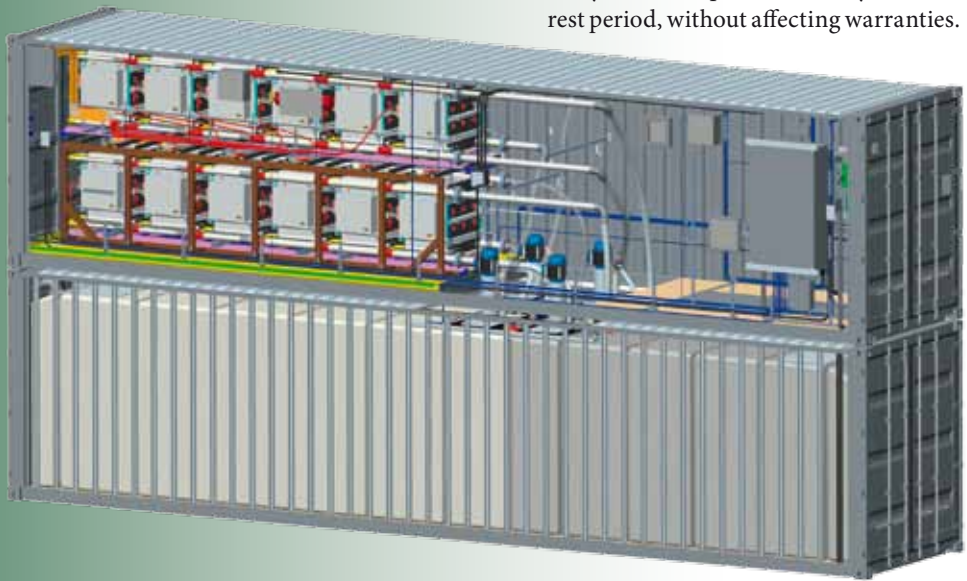
The array changer

Empower's claim that the Genesys 8K Modular Smart Home Energy Platform offers a four times SKU reduction could simplify and streamline logistics and shipments, thus lowering the barriers for smaller and younger companies to enter the PV space, in turn bringing further competition to the sector.

9 ViZn Energy

ViZn Z20 and GS200 flow batteries

The securing of multiple revenue streams is becoming a mantra as to how the economics of battery storage systems stack up. But this means that the batteries themselves must be able to meet a number of demanding performance requirements.



U.S. flow battery developer ViZn claims that its zinc-iron flow batteries can meet both steady and rapid discharge demands, at low and high power. The company claims the systems can be discharged fully without impacting battery life or efficiency. ViZn batteries can also be cycled multiple times a day with no rest period, without affecting warranties.

ViZn adds that its Z20 and GS200 battery systems can be deployed in hotter climates without requiring heating, ventilation, and air conditioning (HVAC) features, meaning more power stored can be discharged and used, rather than consumed by the system itself. The ViZn flow units primarily serve commercial storage, alongside micro-grid applications. With reduced risk of combustion, the company says its systems can be deployed "right where people need the energy: near commercial buildings, schools, hospitals, etc."

ViZn Energy batteries come with a 95% power guarantee, for up to 20 years.

The array changer

While flow batteries may struggle to replicate the rapid cost degressions expected of lithium-ion, ViZn points to a range of advantages including full charge and discharge capabilities, long lifetime, higher temperature operation, and safety.

10 Growatt

SP series charge controller

Chinese inverter specialist Growatt has taken a bold step into the storage market in recent months as it seeks to capitalize on the growing thirst for comprehensive home energy management solutions. Its newest offering is a grid-tied energy storage system that is anchored around the Growatt SP series charge controller and battery, available as SP 1000-S, SP 2000-S, and SP 3000-S. Growatt claims that the system's USP is its compatibility with any grid-tied inverter, enabling customers with solar systems of all ages and types to adopt this system and benefit from its features, which include the opportunity to maximize self-consumption. As a universal storage solution, the system was designed with the growing retrofit market in mind. In many European solar markets especially, dwindling or non-existent feed-in tariffs are making home storage solutions more attractive, and Growatt believes that the best way to reach these potential clients is to offer a battery charger and monitoring platform that is compatible with existing solar arrays. The P series charge controller can support AC charging, which allows system owners to maximize step-based tariffs charging the battery during off-peak periods and discharging during the peak periods of demand.

According to the firm, the system can increase self-consumption by up to 70%, and reduce a standard electricity bill by 30%. A vital part of this system is the inverter itself, and Growatt has rolled out a new iteration, the 8K-11KTL3-S three-phase string inverter, specifically for the anticipated surge in self-consumption at both residential and small-scale commercial level.

The array changer

The universality of the Growatt storage solution means that solar customers of all types – be they newbies to the technology or legacy consumers with an old array on their rooftop – can benefit from the system's flexibility and ease-of-use.

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