

# pV magazine special

## ***The energy transition's hidden giant***

World's largest stainless steel manufacturer  
steps into solar+storage

### ***From Australia to U.K.***

Solar, storage, and VPP markets  
are booming

**Pages 13 – 16**


### ***Storage: materially focused ... on nickel***

Heavyweight investment goes to the  
chemicals for lithium-ion batteries

**Pages 10 – 12 & 19 – 21**

**SPECIAL EDITION DEVELOPED  
IN PARTNERSHIP WITH FoxESS**





**“THE SUN  
WILL RISE  
AND SET  
REGARDLESS.  
WHAT WE  
CHOOSE TO  
DO WITH THE  
LIGHT WHILE  
IT'S HERE IS  
UP TO US.  
JOURNEY  
WISELY.”**

-Alexandra Elle





# FoxESS and Tsingshan: A PV and battery powerhouse

The tipping point is near, where the combination of solar PV and battery storage will revolutionize distributed energy generation, be it for the home or business. According to BloombergNEF and the U.S. Business Council for Sustainable Energy, PV panel prices have dropped by 77% and lithium-ion battery prices by 87% in the past decade. So the time is ripe for battery storage to make solar even more compelling by allowing PV electricity to be stored and dispatched in a more predictable manner.

Chinese inverter and battery storage manufacturer FoxESS is focused on this opportunity and aims to make the combination of lithium-ion batteries and solar attractive and compelling for end users around the world. FoxESS is no newcomer to PV and storage: Its founder and CEO Michael Zhu has spearheaded the global expansion of other leading Chinese PV brands. And on the battery side, the company can tap into an extensive battery materials and battery assembly supply chain developed and run by its parent company, Tsingshan Group. A global Fortune 500 company, Tsingshan is the world's leading stainless steel manufacturer.

The strategic metal nickel forms the common denominator of stainless steel and lithium-ion manufacturing. Most of the world's nickel output is consumed by the stainless steel industry, but new energy applications, such as electric vehicles and battery storage, are fast becoming key markets for the precious metal. Tsingshan Group has mastered the nickel supply chain and operates the world's largest nickel mining, refining, and production hub out of Indonesia.

FoxESS is integrating NMC high nickel batteries produced by the Tsingshan subsidiary Ruipu Energy into its energy storage systems (ESS). FoxESS is also manufacturing state-of-the-art inverters to best integrate the ESS component into the smart home of the future – optimizing self-consumption and the interaction between the home energy system and the utility grid. Adding to its suite of smart energy solutions, advanced digitization software is currently being developed by FoxESS to provide for easy and remote energy management.

Photo: pv magazine/Thomas Beetz



Australia and Europe are of the first markets where the case for solar+storage is already a winner, whether to reduce grid dependency or boost self-consumption in the face of rising electricity rates. FoxESS is targeting these continents with its residential PV and battery storage solutions, and its experience in these markets will undoubtedly serve the company well as it continues to expand its international network. Given the magnitude of opportunity and the meteoric growth of its parent company Tsingshan, it will surely be a fast-paced expansion across the globe.

*Eckhart K. Gouras, Publisher, pv magazine*

4



Photo: FoxESS

### **The new market player**

*Meet the latest CEO to lead in the solar+storage industry.*

10

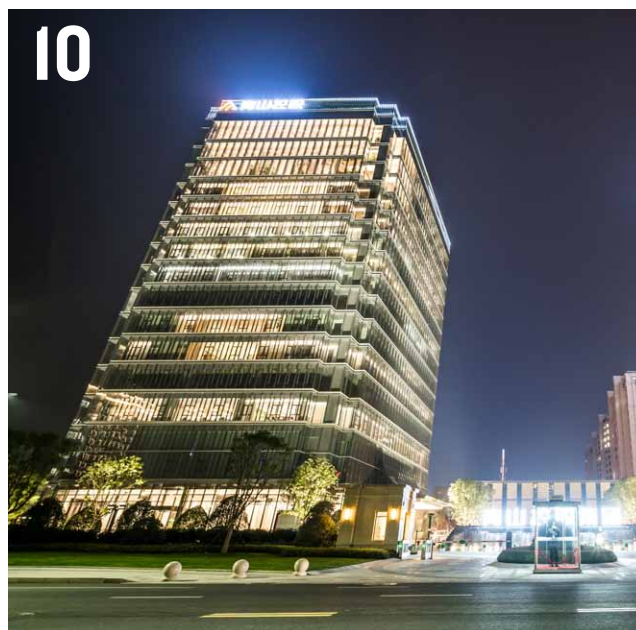


Photo: Tsingshan Holdings Group

### **Owning the supply chain**

*From nickel to energy, Tsingshan Group is stepping into position to dominate downstream applications.*

# Contents

## Highlights ▶

- 4 Stepping into solar+storage:** ...with strong backing. Michael Zhu, co-founder and CEO of FoxESS, introduces the newest mass player to the market.
- 6 Driving the transition:** From steel to storage: The supply chain of the world's largest stainless steel manufacturer shows promise for its bright new energy future.
- 8 A powerful combination:** A new power duo is working to drive PV and storage globally.
- 10 From nickel to energy:** The metal is becoming increasingly sought after for EVs and battery energy storage systems.



## 17

**Batteries included**

*Solar inverters are becoming smarter than ever.*



Photo: FoxESS

## 19



Photo: Tsingshan Holdings Group

**\$700 million investment**

*Indonesia's newest nickel mine is backed by the big bucks – and battery companies.*

**Markets & Trends ►**

- 13** **Shifting all eyes on the U.K.:** After a sector slowdown, the United Kingdom's solar+storage market is showing signs of recovery.
- 15** **Storage – Going virtual in Australia:** Reposit Power CEO Dean Spaccavento talks about the market, policy, and industry changes.

**Technology ►**

- 17** **The new squad eyes batteries:** Next-generation PV inverters are purpose-built for storage integration.
- 19** **Banking on batteries, charging on nickel:** Nickel is quickly becoming the most heavily relied upon cathode material for lithium NMC batteries.
- 22** **Virtually everything is an asset:** Grid operators and consumers alike are benefiting from virtual power plant capabilities.

# Stepping into rooftop solar+storage ... with strong backing

Michael Zhu is the co-founder and CEO of FoxESS, a new player in the solar+storage market backed by large coffers, cheap product resources, and a team of experienced industry professionals. Zhu says his company is stepping into the game with the strength that is necessary to elevate the market and further support the energy transition.

*“The DG market continues to grow fast and there are many new market opportunities to be generated”*

## *So, new to the market. What brought about the establishment of FoxESS?*

With the coming of grid parity of solar PV and the continuous declining costs of power storage, we believe that the global PV generation market is becoming more and more decentralized and moving away from traditional utility-scale power plants to distributed generation (DG). The DG renewable energy market continues to grow fast and there are many new market opportunities being generated.

To take advantage of these opportunities, in September 2019, Tsingshan Group – the world's largest company in the stainless steel industry – decided to take a chance on the promising renewable energy industry. So it invested in and established FoxESS as the entity for the development operation – for the production and sale of distributed renewable energy products, and also as an extended arm for its battery storage.

## *What is the relationship with Tsingshan Holding Group like for FoxESS?*

As the world's largest stainless steel company, Tsingshan Group is a great, visionary company. It has set up a full industrial chain for lithium-ion batteries, and FoxESS is an extended application of its battery business.

We have mature inverter and storage products and solutions, and with the support of lithium-ion batteries from Tsingshan, we are in a powerful position for cost control – so we have sharp competitiveness. Actually, we have been granted infinite support from Tsingshan for exploring markets and global expansion.

## *You have taken over as CEO of FoxESS at a fairly young age, but you have pretty extensive experience with the solar+storage industry. How have you gotten to where you are today, and what has been key to your success?*

I graduated from an Australian university, and after graduation I moved back to China. By chance, I was able to join an inverter company, Samilpower, and to take the responsibility of its marketing to the Australian market. I was lucky for the opportunity to jump straight into the booming Australian distributed PV market, and led the team to obtain the number one market share position for Chinese inverter brands. That was between 2009 and 2013. Then between 2014 and 2019, I moved over to work for SolaX, a storage company where we succeeded in growing to become the world's leading Chinese energy storage brand.

Since the foundation of FoxESS, we successfully invited a very senior research and development (R&D) team to join us. Our experienced engineers hail from Samilpower, Zeversolar, SolaX and Eton – and this granted us with technology leadership, mature and reliable product solutions, and sustainability of innovation. Now, we have set up branches and marketing operations in Australia, the United Kingdom, Netherlands, and India for close customer communication and service.



*Michael Zhu worked in the solar energy industry for more than a decade prior to starting FoxESS, where he now serves as the company's CEO.*



Photo: FoxESS

***Wow, quite impressive. So as a new market entry, what is the current business case for FoxESS?***

With the shift of solar PV moving from utility-scale plants toward DG, particularly residential rooftop solar+storage, the requirements for inverters are changing. Not only in sizing – moving away from the previous large, concentrated design to small string style – but also in the requirements of the inverter to be more intelligent grid-connection with storage. So for now, we are focusing our business on small-size string inverters for distributed PV system and household storage solutions – primarily in overseas markets.

***Where do you see the distributed storage market, currently?***

The distributed storage market is just in an early stage of development. Even though some of the key players of the inverter market recorded sales in the billions of Chinese yuan, with gigawatt levels of volume capacity, in the future we will see players having much higher sales values and volume capacity. For residential household systems, I think there will be 100,000 to 200,000 sets of annual sales in the coming three to five years.

Talking about the market, the Chinese domestic market is quite different from overseas markets. In China, because personal electricity prices are much lower than those for commercial and industrial electricity, it is hard to promote residential household PV systems without subsidy support ... However, in Western countries like Australia and the United States, things are exactly the contrary. These will be huge markets for residential projects; specifically, for 5 kW to 10kW distributed rooftop solar+storage systems.

Considering continuous declining costs, we estimate that an annual 15-20% reduction in costs is achievable for inverters and storage systems. Just like silicon products several years ago – that's why we are very optimistic about this market.

***What is your vision for the future of FoxESS?***

We see a bright future for the distributed PV and storage world. With standing and support from Tsingshan Group, FoxESS is targeting the rapidly growing market's needs and providing more and more products and solutions for smart energy. Even a virtual power plant is on the horizon to network distributed energy resources, provide flexible power, and maximize the power utilizing efficiency at minimum power cost and carbon emissions.

We want to be the number one in this field, like Tsingshan has done in stainless steel and nickel production – again. [PV](#)

***“ We have been granted infinite support from Tsingshan for exploring markets and global expansion ”***

# Driving the transition:

Reporting more than \$37.6 billion in revenues last year, the world's largest steel manufacturing company, **Tsingshan Holding Group**, is continuing on its historical path of innovation. Now, the Fortune 500 conglomerate is stepping into the next industrial frontier: the clean energy transition.

**1988** ▶ Establishment of Zhejiang Erhai Automobile Doors and Windows Manufacturing (predecessor of Tsingshan Holdings)



**1992** ▶ Establishment of one of the earliest privately owned stainless steel production enterprises in China, Zhejiang Fengye Group

**1998** ▶ Establishment of Zhejiang Qingshan Special Steel Company, which became one of the largest private stainless steel production enterprises in China

**2014** ▶ Began process to develop new national Chinese charity, Tsingshan Charity Foundation

▶ Establishment of Indonesia Qingshan Stainless Steel Company

**2013** ▶ Subsidiary nickel company began production  
▶ China-Indonesia Business Agreement Signing: Chairman Xiang Guangda signed the Nickel Iron Project Agreement with Chinese President Xi Jinping and former Indonesian President Susilo Bambang Yudhoyono as witnesses



**2015** ▶ Ribbon-cutting ceremony at new nickel smelting plant constructed in Sulawesi, Indonesia  
▶ Establishment of Indonesia Ruipu Nickel Chromium Alloy Company

**2016** ▶ Construction ceremony for Fujian Qingtuo Krupp Stainless Cold Rolling Project

**2017** ▶ Establishment of new subsidiary, Ruipu Energy, to manufacture NMC and LFP battery cells, modules, and packs (6GW current capacity)



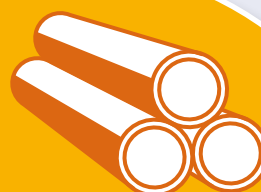


# steel to storage

**2003** ▶ Tsingshan Holding Group was established



**2004** ▶ Tsingshan Industrial Park began production, specializing in stainless steel rods, wires, and pipes



**2011** ▶ Established Tsingshan Business School for long-term talent training



**2010** ▶ Started new subsidiary with RKEF production line and stainless steel wide slab production base

**2008** ▶ Built China's first RKEF production line processing nickel ore directly to stainless steel

**2018** ▶ Establishment of new subsidiary, Qingmei Energy Materials, for production of ternary lithium battery precursor and cathode material  
▶ Invested in battery industry chain project with GAC Group and Guangxin Holdings  
▶ Started construction of Indonesian laterite nickel mine with USD 700 million total investment

**2019** ▶ Invested CNY 100 million to establish new solar inverter and battery storage supplier FoxESS, to cover entire industrial supply chain from nickel ore to energy applications



# A powerful combination to drive solar PV and battery storage globally

FoxESS is a new entrant to the global PV and energy storage markets. Its founder and CEO Michael Zhu is an industry veteran who has led other Chinese inverter manufacturers in the supply of distributed PV and energy storage solutions. FoxESS is backed by Tsingshan Group, which is ranked number 361 among the world's Fortune 500 companies.

Photo: FoxESS



**T**singshan Group was established in late 1980s in one of China's most economically vibrant regions: Wenzhou, Zhejiang province. Started originally from the automotive stainless steel business, Tsingshan has cultivated the industry for more than 30 years and has grown to be the world's largest stainless steel company – covering the entire supply chain, from nickel-chrome ore mining and nickel-chrome ore iron refining to stainless steel smelting and production. In fiscal year 2019, Tsingshan Group recorded \$37.6 billion in revenue and shipped more than 10 million tons of stainless steel. And now, the company is aggressively stepping into position for the energy transition.

Nickel is a strategic raw material for lithium NMC (Nickel Manganese Cobalt Oxide) batteries, which have become the leading lithium-ion battery technology supporting the rise of electric vehicles and energy storage systems. Given its strong position in both nickel mining and production, in 2018 Tsingshan made the strategic decision to enter the new energy industry.

The company has made major investments in Qingmei Energy Materials, a producer of lithium NMC battery materials, and Ruipu Energy, a manufacturer of both NMC and LFP (Lithium Iron Phosphate) batteries. NMC batteries offer a high energy density and are well suited for electric cars, whereas LFP batteries are characterized by a lower energy density and are better suited for electric buses and other applications.

Tsinghan Group's latest investment is FoxESS, a new company specialized in the development, production, and dis-

*FoxESS is entering the storage market with some of the most technologically advanced manufacturing facilities in the world.*



## *“FoxESS can tap into the deep supply chain of Tsingshan Group to provide advanced solar+storage solutions to its customers around the world”*

tribution of distributed generation (DG) products and solutions for the residential PV and ESS market, as well as the commercial solar+storage market.

### **Tapping the market**

FoxESS can tap into the deep supply chain of Tsingshan Group to provide advanced solar+storage solutions to its customers around the world. Company founder and CEO Michael Zhu previously spearheaded the international expansion at Samil Power and Solax, turning both into formidable global brands in the solar industry. In the process Zhu put together an experienced team of business developers and sales executives in a wide range of key PV markets, including Asia, Europe, Australia, and the Americas. He says he has tapped into this network to grow the global footprint of FoxESS and expects the combination of Tsingshan Group and FoxESS to deliver an inverter and ESS powerhouse – first in the residential sector and later expanding into commercial and industrial applications.

### **Smart portfolio**

The FoxESS product range has been planned to encompass a broad smart energy profile, including grid-tied inverters, AC energy storage inverters, and battery storage packs. Since the manufacturer is first targeting the residential solar+storage market, the initial product rollout is focusing on single- and three-phase inverters in the 0.7 kW to 10 kW range. All of the single-phase inverters are “battery ready,” allowing for an easy upgrade to FoxESS storage solutions.

For existing PV systems, FoxESS offers an easy way to add battery storage to the residential installation. This overall solution is referred to as the FoxESS SR-A series and involves two key components: the AC charger C series, with a capacity of

3 kW to 5 kW, coupled with a B series lithium-ion battery. Battery capacity extends from 5.8 kWh to 23.2 kWh.

If the end user is looking for an all-in-one solution involving grid-tied inverter and battery storage, the FoxESS SR-B series is the best way to go. In addition to the core components inverter, AC charger, and lithium-ion battery pack, this all-in-one solution offers an intelligent energy flow management system to provide for an optimal flow of energy in the home, be it during periods of heavy PV generation or heavy power consumption inside the home. This integrated solution provides for maximum self-consumption and therefore optimum system profitability.

Digitalization is a key driver at FoxESS and in addition to the intelligent energy flow management system, FoxESS has developed software for its grid-tied inverters to maximize the energy harvest using a real-time precise MPPT algorithm. A


FoxESS plans to roll out additional software and smart home solutions in the near future, including a virtual power plant (VPP) offering. Providing the ability to integrate a cluster of PV- and storage-powered homes, VPPs can not only provide power to their members, but also offer valuable grid services to local utilities.

### **Powerful duo**

The combination of nickel and stainless steel champion Tsingshan Group and distributed generation solution supplier FoxESS is a powerful one. Entering into the market with advanced smart PV and battery storage solutions, the partnership seeks to bring new industry competitiveness to households and businesses around the world. The initial product portfolio delivers a range of options for the residential customer, whether existing PV system owners or households just starting on their

## *“For existing PV customers, FoxESS offers an easy way to add battery storage to a residential installation”*

sophisticated monitoring cloud platform is another key software element developed by the manufacturer. This comprehensive monitoring solution provides free, real-time performance monitoring and remote maintenance to improve system uptime. The monitoring tool can be easily accessed from a computer or mobile device.

DG journey. With lithium-ion battery prices dropping and residential electricity rates showing no sign of going down, the combination of smart inverter and battery storage is becoming increasingly compelling – and the new Tsingshan and FoxESS duo is a testament to the power of an ever-expanding clean energy industry. 

# From nickel to

While more than 70% of global nickel demand is consumed by the stainless steel industry, this metal is becoming increasingly sought after in the emerging markets for electric vehicles (EV) and energy storage systems (ESS). And the world's largest stainless steel company, Tsingshan Group, is offering an entire supply chain – from upstream nickel mining to downstream applications. The company sees the expansion from steel to energy as an industry upgrade.

China-based private stainless steel giant Tsingshan Group is now exploring a new frontier with its entrance into the clean energy industry. Nickel is one of the most crucial raw materials being used for lithium NMC (nickel manganese cobalt oxide) batteries, which have become the leading lithium-ion battery technology behind the rise of electric vehicles (EV) and energy storage systems (ESS).

Jiang Sen, a Tsingshan Group veteran with decades of experience in the company, now serves as its executive vice president. Sen met with **pv magazine** to discuss the development and growth of the group. The company's model has been evolving over time, which is priming it to move into a leadership position to support the clean energy transition, Sen explains. "A better future is ahead of us, and we are happy to be joining to contribute," he adds.

## Upstream expansion

As chemical elements such as nickel and chromium are crucial to Tsingshan's core steel business, the company began to expand into the upstream market for stable supplements at an early stage.

"The most aggressive and successful expansion for us was the acquisition of a nickel ore mine in Indonesia, and the later establishment of a nickel production base there," Sen says.

During the subprime crisis in 2007, Tsingshan Group exhausted all efforts to purchase a nickel ore mine on the island of Sulawesi in Indonesia, to serve as its fundamental nickel supply center. And later in 2013, when Indonesia modified its export policy and executed quota management to nickel mineral producers

exporting worldwide, Tsingshan established a smelting factory in a local industrial park, to accompany its previously purchased mining assets.

After more than \$4.4 billion worth of investment and six years of hard work, Tsingshan Group has obtained the world's largest nickel syndicate – including nickel ore mining, nickel refining, purification, ferronickel production, crude steel production, logistics, port management, trading, and transportation. Its operations have become one of the largest foreign investment projects in Indonesia.

## Taking control

In the stainless steel and nickel mining industry, Tsingshan Group became one of

*“A better future is ahead of us, and we are happy to be joining to contribute”*





# energy

the top controllers of nickel resources in the world. “In 2019, we produced more than 330,000 tons of nickel and the global output was about 2,400,000 tons. And we expect to have another 110,000 tons of new capacity to be commissioned by the end of 2020,” says Sen, noting the importance of Tsingshan’s role in the global nickel supply chain.

The anode materials of NMC batteries consist of lithium, nickel, cobalt, and other metals, with the ratio of nickel to cobalt to lithium being 8 to 1 to 1, which is why these batteries are also called “811” batteries. The power density of 811 batteries stands at 304 Wh per kg, and the combination of increased power density and reduced production costs have made this

battery technology the new frontrunner for EV and ESS applications.

With nickel proportion working in its favor for mainstream lithium-ion battery technology, Tsingshan Holdings saw the prospective opportunity for field expansion, and decided to join the game.

## Nickel to batteries

“Based on Tsingshan’s nickel resources, the company has built up a production chain to take part in the renewable energy market, particularly in the field of lithium-ion battery technology,” Sen says of the company’s strategic decision.

In 2017, Tsingshan Group acquired Ruipu Energy to handle smart production of advanced lithium-ion battery tech-

*Tsingshan Group is expanding its corporate business model to capture the full supply chain, from nickel ore to energy storage.*



Photo: Tsingshan Holdings Group

nology. The company says that its state-of-the-art production facility for NMC and LFP battery cells, modules, and battery packs offers the most sophisticated automatic production lines and robotics used in China to date. Ruipu Energy's manufacturing base in Wenzhou, China, required CNY 5 billion (\$709.5 million) of investment, with a current stated annual battery production capacity of 6 GWh beginning in April 2020.

In October 2018, Tsingshan Group entered a joint venture with Guangzhou Automotive Corporation (GAC) Group and Guangxin Holding Group, to invest in a new vertically integrated company for battery production to include hydrometallurgical nickel-cobalt chemicals, precursors and cathode materials, lithium-ion batteries, and battery packs.

*“The laterite nickels of Indonesia are particularly suitable for battery-grade nickel smelting because of the associated ore of cobalt”*

Adding another link to the battery chain, Tsingshan Group and GEM Company jointly invested in Qingmei Energy Materials to produce precursor and cathode materials for NMC batteries. Qingmei plans to reach 50,000 tons of NMC precursor capacity and 20,000 tons of cathode material output. As the core material for lithium-ion batteries, the joint venture has received support from the world's top five battery giants: Samsung SDI, CATL, Panasonic, LG Chem, and BYD. The company says it began successfully delivering its products in late 2019.

To gain additional battery-grade nickel resources, which have higher qualifications than those of stainless steel, in September 2018 Tsingshan joined GEM, Brunp Recycling, and Hanwa in signing yet another joint venture agreement

for the construction of a plant to produce nickel sulfate crystals from laterite nickels in Indonesia. The partnership has drawn more than \$700 million of investment and is scheduled to deliver 50,000 tons of nickel capacity per year. “The laterite nickels of Indonesia are particularly suitable for battery-grade nickel smelting because of the associated ore of cobalt, a rare and expensive but indispensable element for lithium batteries,” says Jiang. “We have the best resources for batteries.”

### Production to application

After obtaining the capabilities of nickel ore mining, NMC precursor and cathode material production, battery manufacturing, pack designing and testing, Tsingshan Group took the next step on its mission to claim a piece of the battery storage market. It has now invested in FoxESS as its application representative for the battery storage sector. Supporting the entire energy storage supply chain of Tsingshan Group, FoxESS provides its customers with competitive business solutions in PV inverters, AC storage inverters, hybrid inverters, and distributed PV-storage systems.

And with this support, FoxESS now aims to take a leading position in the inverter field, particularly for hybrid inverters in the distributed solar+storage market. Within only a few months of its establishment, FoxESS has built up its distribution network for marketing, sales, and support in Europe, Australia, and India, with plans for additional expansion.

### Owning the supply chain

With the advantages of running an entire industrial supply chain from upstream nickel mining, NMC precursors and cathode material production to battery manufacturing and downstream applications, Tsingshan Group says it is utilizing the whole system to step up as a world-class battery leader.

“Just like our previous successful experience in stainless steel and nickel production, Tsingshan is looking forward to yet another success in the market of lithium NMC batteries,” says Sen. “We aren't looking to be number two.” PV



# Shifting all eyes on the U.K.

The United Kingdom's residential solar+storage market stalled in 2018 due to a policy vacuum. But industry optimism is back, with the market recovering and showing signs of growth as new and unique players continue to raise the bar.

In recent decades, and particularly during the last decade, the residential energy storage and inverter market in the United Kingdom has been piggybacking on solar PV advances. "Storage is following in the footsteps of solar panels, which have become mainstream after relentless cost reductions," said Iain Staffell, sustainable energy lecturer at Imperial College London. While Germany has led the European pack of countries adopting residential storage, other countries are following suit, and industry newcomer FoxESS has shifted its eyes to the U.K. market by setting up new local operations.

In 2019, analyst group Wood Mackenzie released its "Europe Residential Energy Storage Outlook 2019" report, in which it predicted a fivefold increase in residential storage capacity across Europe by 2024. Underpinning the impressive 500% growth projection, WoodMac expects Italy and Germany to achieve price competitiveness with economics in favor of residential storage by 2021 and 2022, respectively. But the analyst group also sees other European markets following suit with mass adoption.

The report projects that the residential U.K. storage market will stay on track with current installation volumes, and that it likely won't achieve grid parity until 2024. However, expedited growth and favorable economic shifts could be in store. The U.K. government has ambitions to achieve net zero emissions by 2050, and this will undoubtedly require a significant uptake in storage. Residential storage economics could turn more favorable as electric rates continue to climb across markets, with increasing demand coming from EVs and growing electrification.

## EV uptake

The EV sector is undoubtedly delivering scale to storage. "The number of EVs on Britain's roads has grown 25% so far this

year, sailing past quarter of a million," said Staffell. There is no sign of this slowing down, either – the U.K. government has set policy insisting that by 2040, all new cars and vans sold in the U.K. should be zero-emissions capable. Toward this end, the government has challenged the industry and researchers to develop the next generation of batteries in the United Kingdom, with a £246 million fund allocated to the Faraday Battery Challenge.

EVs remain popular with the public. Last year's YouGov survey, commissioned by insurance company Aviva, found that 56% of U.K. respondents would likely purchase an EV "if it was available at a price you would consider reasonable." That caveat, "a price you would consider reasonable," is the pivot upon which the EV market tilts.

## Economic drivers

Similar economic drivers inform stationary storage uptake in the United King-

*“Falling installation costs were not enough to insulate the U.K. solar sector from the expiration of its feed-in tariff program”*

Photos: Evergen







*Developers are now optimistic about the future outlook of solar+storage in the United Kingdom.*

*“According to installers, the market has since recovered and looks poised for great gains in the new decade”*

dom. Ricky Singh, CEO of Evergen – one of the country’s leading solar+storage installers – noted that despite the absence of government subsidies in the residential market, the “cost of lithium-ion batteries has dropped dramatically as production has rocketed to meet demand.”

Prices have dropped significantly indeed. “In 2010, lithium-ion batteries cost around \$1,160/kWh and in 2018, prices were about \$300-350/kWh. Price reductions have continued since, although at a slower rate,” said Singh. Evergen estimates that prices will continue to fall to below \$100/kWh by 2024, and even down to \$55-\$60/kWh by 2030.

While economics have strengthened significantly for the expansion of rooftop solar paired with battery storage, the steep price plunges seem to have tailored off. “There is a sense ... that the rate of these cost reductions has plateaued,” said Steven Wallace, procurement director for Project Better Energy, a U.K.-based renewable energy company consortium.

#### **New entrant**

Heavily funded market entrant FoxESS is bringing an alternate offering to the solar+storage space, which could cut down costs. Developing both residential solar inverters and storage products, the newly established company says it has strong ambitions for market dominance. FoxESS is opening locations globally at speed, and has selected the United Kingdom as its European home. An offshoot of the world’s largest steel manufacturer, Tsingshan Holdings Group, the new company already appears to be receiving a warm welcome from U.K. industry.

Developers say that the new company’s solution could resolve some indus-

try headaches. Hardware and software compatibility issues can accrue when two separate manufacturers of inverters and batteries are working independently. “This issue can also impact on after-sales service levels and the warranty process,” said Wallace. “Having a single point of contact is very attractive and will eliminate the disputes that can sometimes occur where systems comprise of inverters and batteries that are supplied by different manufacturers.”

Evergen’s Singh echoed the sentiment. “The industry has lacked a ‘chain of custody’ as regards product warranties,” he said in reference to the latest entrants to the U.K. market.

FoxESS represents a significant step change to the industry, in large thanks to its Tsingshan lineage – which uniquely boasts a complete vertically integrated production line from nickel mines and lithium battery materials down to batteries and packs. Wallace explained that a complete supply chain will offer multiple benefits, allowing for a more streamlined material procurement process, reduced manufacturing costs, and improved quality control.

“FoxESS, being the only vertically integrated player in this space has the advantage to take the price down further offering a shorter ROI, which will always increase customer uptake,” said Singh.

#### **On the rebound**

Growing investment in the sector – supported by promising policies, consumer motivation, and new business models – are all telling signs that the solar+storage market is priming for a healthy boost in the United Kingdom.

This comes as good news after a market slowdown. Falling installation costs were not enough to insulate the U.K. solar sector from the expiration of its feed-in tariff (FIT) program. That blow arrived in 2018, hitting both solar deployment and storage. The FIT ran from 2010 to 2019, enabling the deployment of more than 900,000 rooftop solar PV systems, significant cost reductions, and the rearing of the previously nascent residential energy storage market.

Thankfully, according to installers, the market has since recovered and looks poised for great gains in the new decade. “The future in U.K. solar and storage is the brightest it’s been in over five years,” said Singh. PV

# Storage: Going virtual in Australia

Reposit Power is a market leader in Australia, deploying virtual power plant software that optimizes distributed energy resources and battery usage. The company says that it's the only VPP provider registered with the Australian Energy Market Operator that is not still in a trial phase, as it is the first to appear in the open market. Dean Spaccavento, CEO of Reposit Power, spoke with *pV* magazine to discuss the Australian market, policy, and changes in the industry.

*The impacts of your company's virtual power plant (VPP) services range in scale from residential consumers to grid services. Can you talk us through Reposit Power's position in the market?*

The company itself is six years old. We are probably regarded as the technical leader in VPPs. We're the only VPP provider registered with the Australian Energy Market Operator (AEMO) for ancillary services not in trial – first in the open market. We have more than 20 contracts with various retailers and distribution networks to provide services ranging from your vanilla network congestion management to reactive power control for voltage support and dynamic solar feed-in management and operations. We've had a few different approaches to engage with end users; we had a grid-credits plan, and we've had direct-to-consumer VPP participation whereby we did the financial settlement and paid the consumer directly via our app. We've seen a lot of changes in the market since we've started, but it does seem to be trending toward a system where distributed assets are taken seriously – and we're well positioned for that.

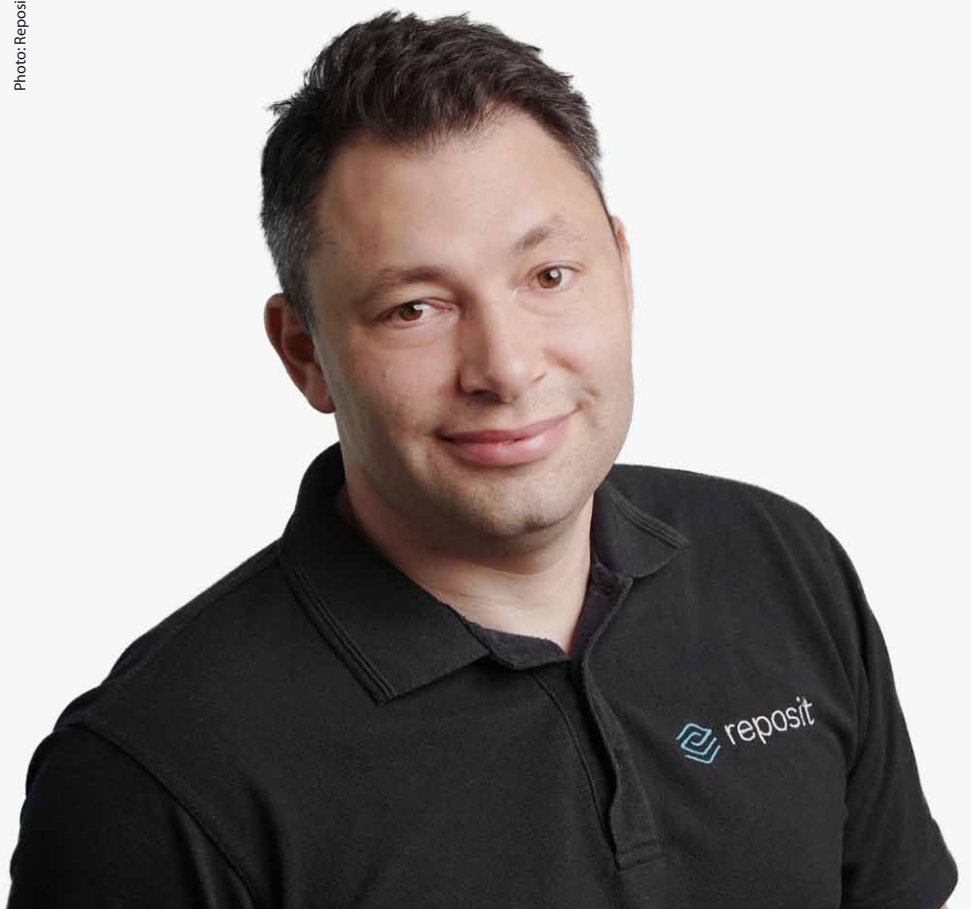
*Unlike some other locations – like California, for instance – Australia does not have energy storage system (ESS) targets. AEMO's Integrated System Plan says it needs 10 GW of storage by 2040. What kind of targets and policies would Reposit like to see?*

A lot of what I'm seeing at the moment, particularly in South Australia, is distortionary government policy creating all sorts of insanity – and not allowing the market to operate and sort out the right solution. State governments need to very carefully consider the interventions they make, when they make them, and for how long. I don't think the federal government can do anything, I think they're paralyzed. I'm not seeing a lot of helpful government intervention at the moment – it is neutral at best.

*Reposit is the VPP software partner for FoxESS in Australia, in a three-year relationship that has helped spawn many VPP projects across the country. What makes the partnership so productive?*

The interesting thing is that when we started talking to FoxESS, they said, 'Listen, we're going to do something different but we're interested in having it do what you need it to do, rather than you having to compromise your software – what do you want?' And we said that we'd like this and we'd like that, we need this kind of control, it needs to be this fast and at this kind of price, it needs to be AC-coupled here and DC-coupled there, and we were pleasantly surprised to find that they listened.

*“State governments need to very carefully consider the interventions they make, when they make them, and for how long”*



Dean Spaccavento is the CEO of Reposit Power.

I think the backing of FoxESS is quite interesting; being the largest stainless steel manufacturer in the world helps to bring costs down, and the battery modules that they currently ship are extremely good. Very cost-effective, very fast, and an excellent choice for stationary storage.

Most interestingly, from an Australian perspective, we told them that these units needed to be able to operate at 50°C (ambient) without derating, and they were able to do that. We're seeing 40°C days regularly now, and in 10 years time, I am thinking we will see 45°C+ and most units on the market derate at 40°C or 45°C. When you've got a VPP running – and its very busy on those hot afternoons – that kind of thermal derate is a bad idea.

Thermal derate is absolutely a concern in Australia and will become a concern more globally as temperatures rise, some of batteries derate at 45°C, and a lot derate at 40°C, making them basically useless.

***As you mentioned, FoxESS's parent company, Tsingshan Group, ensures a uniquely complete industrial chain from nickel mines, lithium battery materials, lithium batteries, and lithium battery packs. Is the market entrance of FoxESS a sign of significant market change?***

FoxESS is able to get the price of an installed kilowatt hour down. That's what

the market needs, and that is what FoxESS can provide. People want a battery that they don't have to think about – and that is what FoxESS's supply chain brings. A supply chain of this magnitude brings scale, certainty of supply, and distribution to solar installers and the like. It also brings scale to the testing process, meaning that having a 10-year warranty means something. Fundamentally the product is well constructed, reliable, and well-priced. That's really how batteries need to be. They're not status symbols, they're an appliance.

***I guess that the euphemism I would use is 'peace of mind', but it is the luxury of forgettability.***

Absolutely. Ultimately, you want your electricity to come as cheaply and as cleanly as possible. A system that can deliver that reliably and effectively over many years without the need for any user input is what the consumer wants.

***“Customers want to protect themselves from failures in the electricity system”***

***How do you see the Australian ESS market evolving over the next five to 10 years?***

The market has left the land of early-adopters and entered the land of early-majority. A good chunk of early-majority doesn't care about the brand, or about the technology. They're doing it because they've got a bit of cash in their pocket and looking to get a jump on a good deal. Customers want to protect themselves from failures in the electricity system – whether they be pricing failures, reliability failures, or whatever else. There is definitely a perception that the electricity system is failing. I'm not sure that's correct, but there is that perception and people are trying to protect themselves against that. There are two types of customers in this early-majority land: There are valuers – who are interested in getting value for money, and there are comforters – who don't want any bad feelings, only good feelings, and they are happy to spend money to get them. So, I think the market is getting to that good place where it is becoming boring, which is to say, established. PV



# The new squad eyes batteries

The residential solar sector has been going through some fundamental changes over the last few years, with new business models and technology approaches being brought to the market. Storage, above all, will make quite an impact on the residential inverter landscape. The market is now witnessing the emergence of new inverter models that are purpose-built for storage integration.

In its debut, the PV industry's latest manufacturer arrival FoxESS is launching a range of residential inverters in various established markets, including Europe, Australia, and North America. The company is making its global push with a variety of grid-tied string inverters, storage systems, and two all-in-one solutions.

The new inverter product offering starts at 0.7 kW capacity and goes up to 10 kW, covering the broad range of needs for residential solar PV customers. The smaller capacity models, the S Series, run from 0.7 kW up to 3 kW. These small and sleek inverters feature a single maximum power point tracking (MPPT) channel, come in single-phase versions, and offer home power generators a low start-up voltage of just 60 V, with the MPPT channel having a range of 50 V to 450 V.

In the slightly larger category, the E & F Series offers capacities between 3 kW and 6 kW, featuring dual MPPT but still single-phase. With the additional MPPT channel, Series E & F inverters provide for more flexibility in system design. The use of multiple MPPT channels has become more popular for installations on complicated roof spaces, or in cases when designs require PV arrays to be oriented in both south- and west-facing orientations simultaneously. For different temperatures, shading, and irradiation levels, there is a unique maximum power point. Increasing the number of maximum power point tracking channels allows for more uniform conditions on each channel, which in turn increases efficiency.

Only the T Series model, ranging in size from 3 kW to 10 kW, come as three-

phase inverters. Depending on the size of the inverter, max efficiencies range from 98.1% to 98.3%. These slightly larger inverters have two MPPT trackers, each of which can accommodate a single string. The T-Series can also be used for smaller C&I installations, which include a remote monitoring app and allow for potential cost savings by avoiding site visits. With an IP65 rating, this inverter model has an enclosure that is sealed strongly enough to sustain rain and dust – making it suitable for outdoor installation.

All three models – the S-, the E & F-, and the T-Series – come battery-ready, with FoxESS emphasizing that their new-to-market devices have been fully optimized for project owners to upgrade their systems with battery storage. To this end, the company also developed its C-Series, a battery charger for AC-coupled solutions, and its H-Series battery. The latter is a 5.2 kWh scalable unit, but other battery variants, both low and high voltage, will be released shortly to allow for maximum flexibility and to offer storage solutions for all applications.

The extensive new FoxESS product portfolio also includes all-in-one solutions with its SR-A and SR-B Series, with AC-coupled batteries. Targeted to customers with an existing solar PV project, the SR-A solution includes a modified version of the C-Series charger, H-Series battery with built-in fuse protection, and battery management system. The company says that this 'one box' solution allows for installers and customers alike to easily integrate the system with a plug-and-play commissioning process, without requiring additional wiring and configuration



*The SR-B Series all-in-one solution comes equipped with a string inverter, AC charger, and 5.2 kWh battery. Additional batteries can be added in series (as pictured).*

Photos: FoxESS



*The FoxESS F Series Inverter offers dual maximum power point tracking (MPPT) to provide more flexibility in PV system design.*

of individual components. The all-in-one SR-B product offering, by contrast, is tailored to new solar+storage projects, and includes a grid-tied inverter.

One advantage of using an AC-coupled storage system over a DC-coupled system

*“Increasing the number of maximum power point tracking channels allows for more uniform conditions on each channel, which in turn increases efficiency”*

is that there is the potential to circumvent regulatory constraints. For example, in some markets, such as the United Kingdom, retrofitting DC-coupled storage

requires adding a new feed-in tariff (FIT) meter and obtaining a new license.

“In the UK, retrofitting a hybrid inverter requires replacing the metering solution with a two-way device due to grid capability, which can lead to false readings on the FIT meter,” said Craig Woollaston, marketing manager at FoxESS. “It can also reduce earnings from the FIT owing to efficiency losses in and out of the battery prior to the generation being recorded on the FIT meter.”

These easy retrofitting options are aligned with maturing residential markets, as the first wave of installations under FIT support schemes are expiring their validity. Adding battery storage to boost self-consumption will likely be the most popular option for asset owners to still draw on the advantages of their installation. Flexibility in battery sizing can also help with optimizing the economics of such retrofits. While larger batteries can allow for a higher degree of self-sufficiency, currently self-sufficiency rates of more than 70% are still not cost-effective in most markets. But in years ahead that metric will likely increase further to 100%. Allowing for additional batteries to be attached in series, FoxESS says that its SR-A solution will support solar producers in expanding with the market.

Another highlight of the inverters is the export limitation. By adding storage at a later stage, or with changing national regulations, system owners may be inclined or obliged to change their system's export behavior. This can happen, for example, when a system expires its FIT validity. Typically FITs are paid for 15 to 20 years. When that expires, the system owners may want to keep as much of their power as possible for self-consumption.

In some cases, owners will be able to sell power to an aggregator. In such situations, it can be necessary to fulfill contractual obligations before filling up one's battery. There are numerous reasons why one would want to change a system's export behavior – and FoxESS is offering a solution in which these changes can be addressed without the need to change the inverter. PV

# Banking on batteries, charging on nickel

The nickel compound obtained from mining is six production steps away from the precursor materials for cathodes in lithium-ion battery cells, which are key for cost and performance. If you want to participate in the smart energy future of storage, you have to invest heavily, like Tsingshan Group is doing.

**T**singshan Group has abundant laterite nickel ore resources in Sulawesi, Indonesia, which can be used not only for direct smelting and purification to produce nickel-containing steel, but also for refining high-purity nickel. With nickel quickly becoming the most heavily relied-upon cathode material for lithium nickel manganese cobalt oxide (NMC) batteries, the steel conglomerate is charging ahead with mass investment.

Laterite nickel ore is primarily distributed within 30° of the north-south dimension of the equator, and is concentrated in Indonesia, Australia, and Brazil. The world's largest steel manufacturer, Tsingshan Group, is now taking advantage of these resources to expand its business in the new energy industry.

## Collaborative investment

The company started its journey to nickel production to support its stainless steel business, but the international conglomerate is now using its resources to expand into battery storage, which is a more complex process that requires more than \$700 million worth of investment. Unlike the high purity content used for NMC batteries, nickel for stainless steel only needs to be made of nickel-containing pig iron, without the need to separate the nickel element. To produce the battery precursor material, the separation process starts with the wet intermediate from stainless steel production, and then goes into further purification and refining to obtain nickel salt or pure nickel. The refined nickel then is sent to Qingmei Energy Materials, a joint venture of Tsingshan and GEM, to

develop high-quality precursor for lithium-ion battery cells utilizing some of the world's most advanced production lines.

Currently, the primary lithium battery cell cathode materials that are being commercialized are lithium cobalt oxide (LCO), lithium ion manganese oxide (LMO), lithium iron phosphate (LFP), and nickel manganese cobalt oxide (NMC). Among them, lithium NMC batteries are relatively balanced in terms of both capacity and safety, while also providing excellent comprehensive performance.

*“The production process includes six major areas: production preparation, batching, wet reaction, material cleaning, material drying, and product testing”*

Qingmei Energy Materials has attracted support from the five largest battery companies, including Samsung SDI, CATL, LG Chem, Panasonic, and BYD. It is also backed by more than 200 other related supporting enterprises, financial firms, and investment institutes. Hou Min, the vice president of Ruipu Energy – another Tsingshan subsidiary that is focused on storage and the clean energy transition – manufactures batteries with different chemistries. Min recently sat down with **pvmagazine** for an in-depth discussion





*The Indonesian Tsingshan Industrial Park is a joint venture project between five companies to produce high-purity nickel for cathode materials. The \$700 million investment project to refine laterite nickel ore comes together with Tsingshan Group, with the mining of the laterite nickel ore, GEM, who possesses the production knowhow for NMC precursor, Brump, who produces lithium batteries, and two other companies.*

about the growing number of joint venture projects that are advancing NMC battery technology, and the complexities associated with different chemistries.

The technical challenges associated with producing the NMC precursor are much greater than those related to the production of stainless steel, which has been the nuclei of Tsingshan's traditional business model.

"The production process includes six major areas: production preparation, batching, wet reaction, material cleaning, material drying, and product testing," Min said. "Each section has many quality-control points. The nitrogen concentration, temperature, PH value, drying time, and temperature during the process will have an effect on the impurity content, component content, and tap density

of the product. The purity of nickel in the precursor is very high – it usually needs to be above 99.9% to avoid impurity elements, particularly iron, which will affect battery performance."

#### **Chemistry 101**

"High energy density and good cycling performance are the biggest advantages of NMC lithium batteries," says Min. Voltage is an important indicator of battery energy density, which determines the efficiency and cost of the battery. The higher the operating voltage, the larger the specified capacity. For batteries of the same volume, weight, and even the same ampere-hour, the lithium NMC lithium battery wins out the others due to its higher voltage platform and longer battery life.

In the NMC compound, "Ni," nickel, is



Photo: Tsingshan Group

formance of the lithium-ion battery, and its cost directly determines the cost of the battery too.”

### Cost benefits shifting cathode combinations

Through different ratios of the combined three elements (Ni-Mn-Co) in the lithium NMC battery, a variety of cathode materials are derived. They are generally divided into two categories: Ni-Mn isometric and high nickel. The Ni-Mn isometric batteries come in two cathode combinations: 1-1-1 and 4-2-4. The cathode combination of 1-1-1 is one-third nickel, one-third manganese, and one-third cobalt. Due to the high costs of cobalt, battery manufacturers are steering toward nickel-based systems, such as 5-3-2, and 8-1-1 combinations. With lower costs, higher energy density, and longer life cycles than cobalt-based cells, high nickel is considered to be the most promising cathode material for the next generation of lithium-ion batteries.

*“The performance of the positive electrode material directly affects the performance of the lithium-ion battery, and its cost...”*

the most active element to increase energy density, but too much will cause instability of the battery. “Co,” cobalt, the most expensive element in the cathode combination, improves stability and extends battery life. Cobalt also determines the charge and discharge speed, and efficiency of the battery. And “Mn,” manganese, can lower internal resistance to increase the safety and stability of battery.

“Normally, lithium-ion batteries use graphite or the like as a negative electrode, or anode, a non-aqueous solution as an electrolyte, and a lithium alloy material as a positive electrode, or cathode,” says Min. “Since the positive electrode material occupies a large proportion (with mass ratios of positive and negative 3:1 – 4:1), the performance of the positive electrode material directly affects the per-

In recent years, research and commercialization of nickel-based lithium batteries have made great progress in China, Japan, and South Korea. The development and use of NMC battery materials has gradually transferred from 1-1-1 to 5-2-3, and now even 8-1-1 batteries are being applied to some electric vehicles today. From the perspective of both production costs and energy density, the application of high nickel materials for Lithium-ion battery technology appears unstoppable.

“I do believe that NMC battery is the trend, and 8-1-1 will become more and more popular in the coming future,” Hou stressed with confidence. “This makes nickel the core element of lithium batteries, as we are using much more nickel in 8-1-1 than older cathode combinations such as 5-3-2.” PV

# Virtually everything is an asset

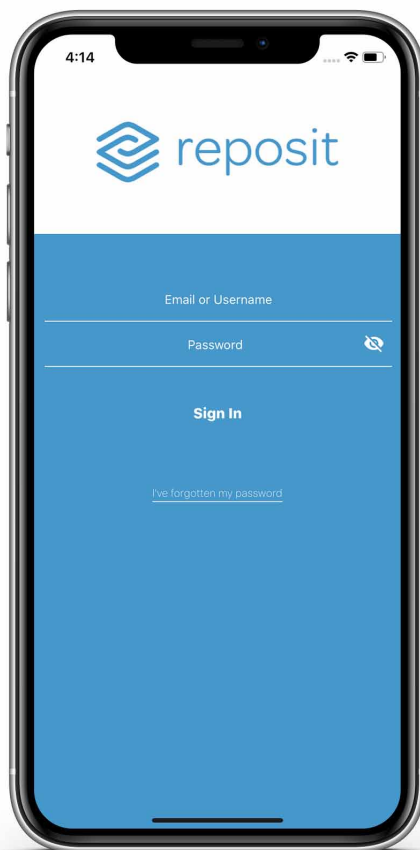
The transition toward a decarbonized energy future requires stakeholder collaboration across the industry. And if you want to balance interests and keep the lights on, you have to balance the grid. This was a key lesson learned in Europe in 2012 when the first virtual power plant (VPP) was conceived. Today, there are about 50 different solutions available in the market. And with the entrance of FoxESS, it will be 51 in August 2020, when the company plans to bring its own VPP platform to the market.

created two challenges for power utilities and distribution system operators. The first is the rather obvious fact that homeowners began to generate their electricity, which translated to households purchasing less electricity from their power utilities. But the second problem is rather less apparent, as it pertains to the operation of the grid.

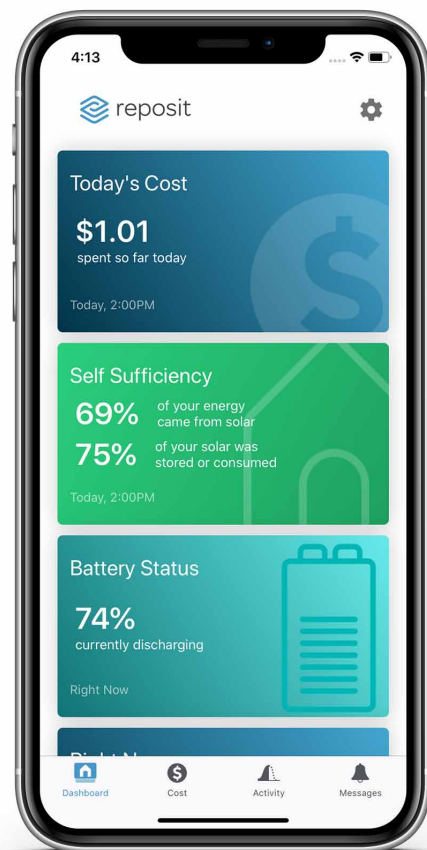
Utilities and grid operators need to work in tandem to ensure that demand and supply are always perfectly balanced. If there is a sudden spike in demand, power plants need to ramp up instantaneously to manage this. And if demand drops, power production needs to fall as well, or else a blackout will occur. Histori-

The energy transition in Europe has made the conflicting interests of various stakeholders across the energy landscape apparent, so much so that new technological solutions had to be developed to overcome the challenge. With distributed energy resources (DERs) becoming more popular, high levels of deployment have

*“Since VPPs were first introduced, the power plants of the future have developed and expanded capabilities quite significantly with a quickly advancing smart energy infrastructure”*



LOGIN



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cally, this challenge has been met by using market drivers and ancillary grid services.

For example, large industrial consumers of electricity could be financially penalized on their electric bills for having a highly fluctuating consumption profile. The idea was to incentivize such consumers to aim for steady energy consumption and in turn, make it easier for power operators to ensure grid stability.

Through ancillary grid services, power suppliers are providing fast frequency response and other short-time power reserves to support demand. With sudden electricity demand spikes, power stations have the ability to produce a few additional megawatts of capacity to feed into the grid if there is a demand signal, but plant owners who offer this charge a hefty bill for that extra power.

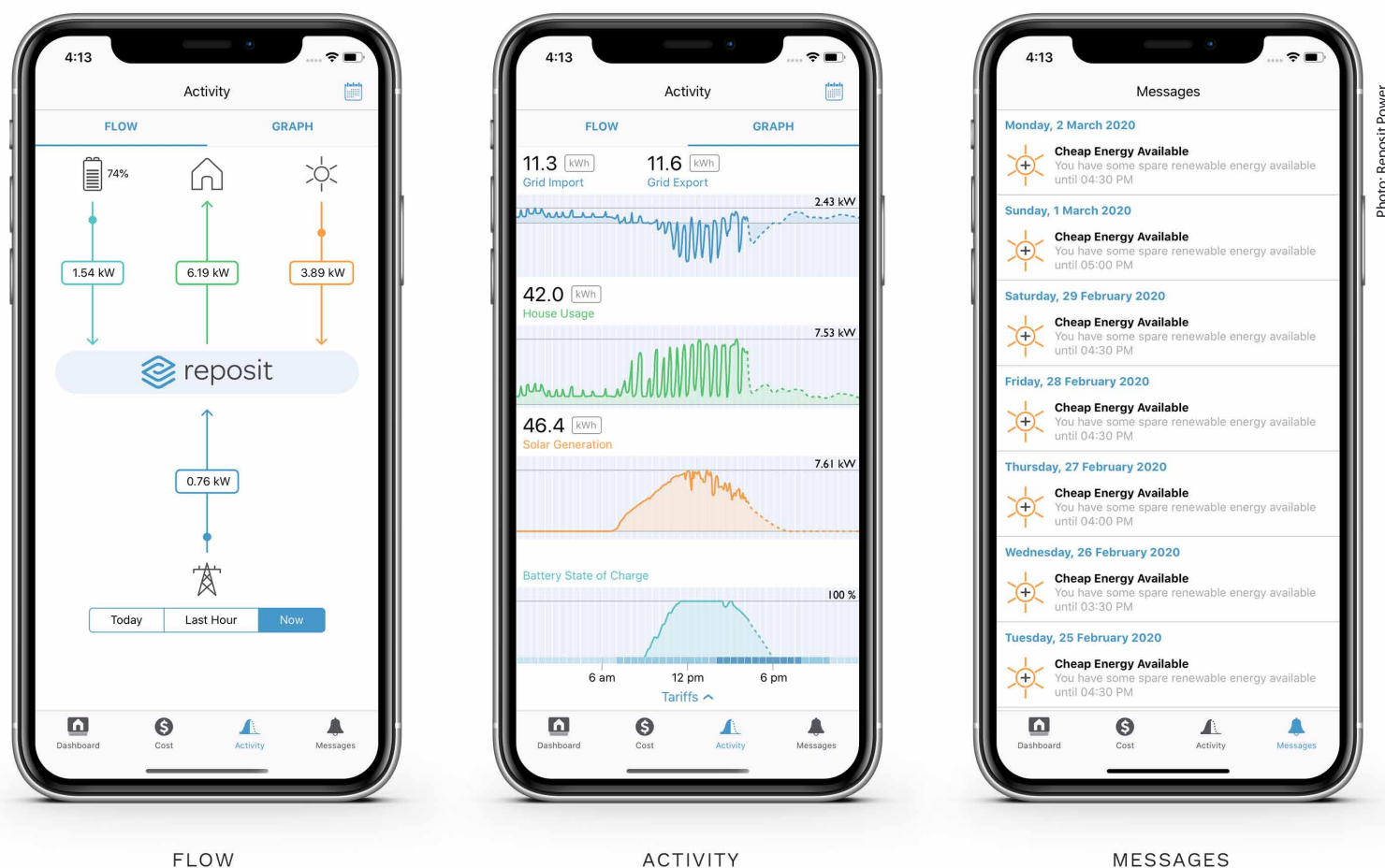
With an increasing number of variable DERs, such as rooftop solar PV systems, entering into the grid, this has introduced challenges for additional frequency response requirements and for electric utilities to balance energy loads.

In recent years, not only have power utilities lost money from homeowners buying less electricity, they have also incurred costs for ensuring stable grid operations. The fast growth and large-scale adoption of solar PV has supported individuals and businesses in their efforts to gain energy independence. It has been in alignment with policymakers' carbon reduction and renewable energy targets, while also creating challenges for electric utility companies in the regulation of supply, demand, and grid operation.

In 2012, solar energy companies found a solution to the challenge: virtual power plants (VPPs). The new cloud-based power plants were set up to aggregate residential solar generating assets to better predict power output. By layering weather forecast data over thousands of small-scale assets, it made it possible to make accurate projections of the energy they produce.

Since VPPs were first introduced, the power plants of the future have developed and expanded capabilities quite significantly, with a quickly advancing smart

*FoxESS has partnered with Reposit Power for virtual power plants in Australia.*



energy infrastructure. In August 2020, FoxESS plans to bring the latest technological phase of VPPs to the market. These advanced VPPs include the processing of consumption data. With demand-side response, VPP operators have the ability to play with enormous capacities of flexibility, even with limited installed solar capacity. The smart VPP learns patterns, such as when a homeowner is typically home and how much power is being used during that time. The system then matches that data with the adjacent households that are also participating in the VPP, allowing neighbors to maximize the use of their assets for the grid. For example, charging a vehicle or doing the laundry at the most convenient, cost-effective hour of the day for the grid.

*“With an increasing number of variable DERs, such as solar PV systems, entering the grid, this has introduced challenges for additional frequency response requirements and for electric utilities to balance loads”*

Furthermore, the solution offers the opportunity for small assets within one neighborhood to manage both demand and supply via the VPP. If an EV or home storage battery system of one customer is fully charged, these assets could be used to supply power on demand and feed into the grid if a neighbor wants to wash their laundry. Currently this is not typically possible due to regulatory regimes prescribing that a power producer must provide a minimum power capacity, such as 5 MW in Germany, for example. However, the EU has plans to lower that figure to 100 kW in its member states.

This self-managing of flexible loads also helps to ease stress for grid operators, as VPPs can also provide fast frequency response and similar ancillary service products. By aggregating thousands of assets, they cumulatively surpass

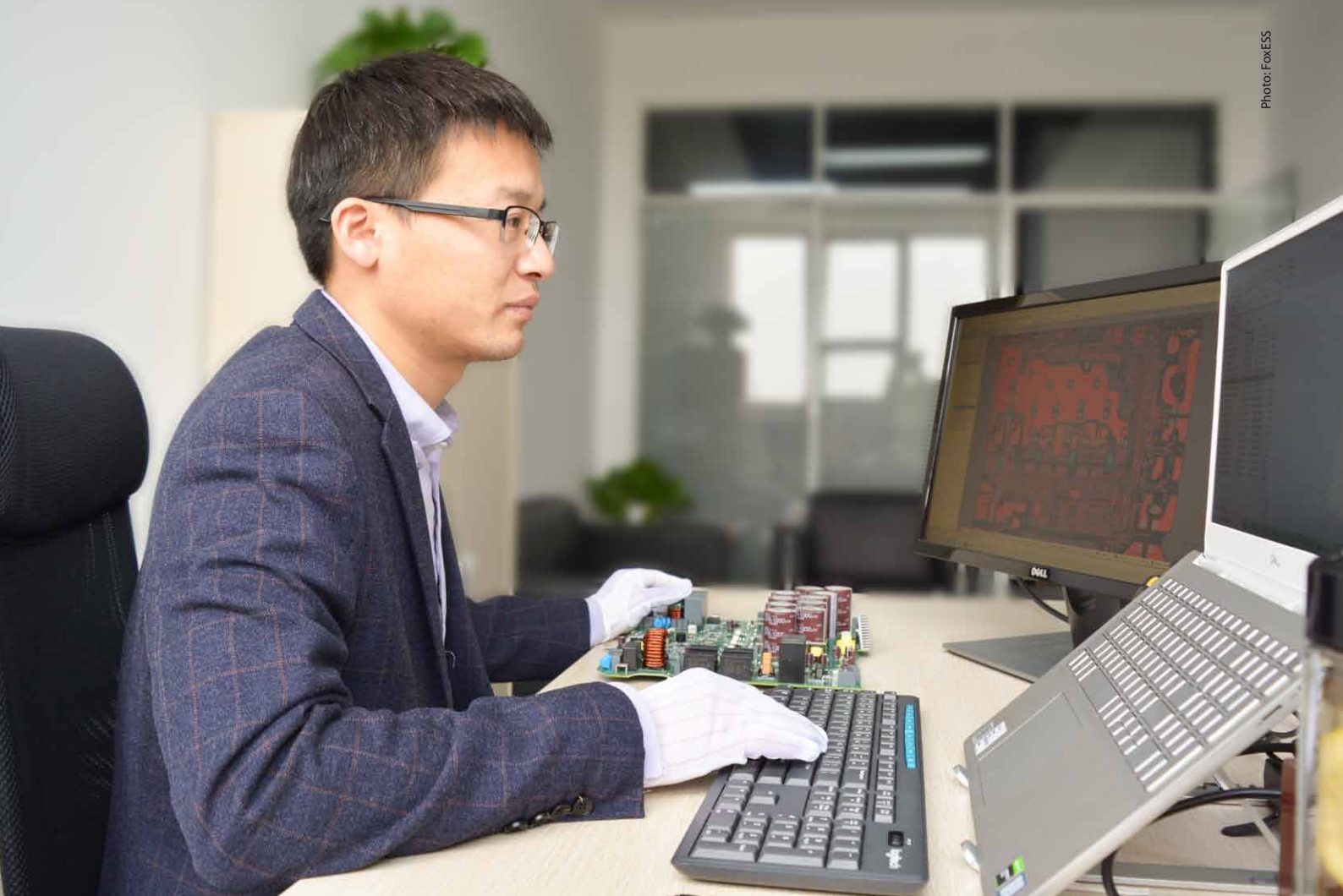
the minimum threshold capacity for generators that want to supply such services.

The future is looking bright for stakeholders across the energy sector thanks to VPPs. Solar and other DERs have morphed from energy assets incurring a higher requirement for ancillary services to becoming providers of such services. And they can do so cheaper and more effectively than their coal and gas counterparts. As coal and gas generators cannot ramp up in split seconds, they need to continuously produce power for ancillary services, whether or not the services are required. But DERs such as solar PV and battery storage systems, on the other hand, can supply the power required within milliseconds – these alternatives don't have to burn fossil fuels to remain idle.

And by being able to provide this service, cheaper VPPs can lower the cost of running the grid. Homeowners who participate in VPPs can use the technology as an alternative to remuneration schemes of feed-in tariffs. In some markets, such as Germany and Japan, the first batch of DERs and solar PV projects are expiring their feed-in tariffs, and VPPs show promise to provide a different market for such assets. With the limitations of self-consumption, VPPs offer ways to make some money off rooftops.

The value potential that VPPs can provide to all stakeholders in the energy landscape is driving companies, such as FoxESS, to further develop the technology. They are making it more versatile and adaptable to new needs, and capable of incorporating more and more types of loads and assets. And Europe is set to become a big player in the future of VPPs yet again.

While Europe was responsible for introducing the technology to the world in 2012, since then the North American, Australian, and Japanese markets have overtaken the continent in terms of the deployment of such systems. But with the EU setting ambitious decarbonization goals, Europe is quickly catching up by implementing regulatory elements that will allow for the demand side of the exchange ledger. With the market already very integrated currently, it provides an ideal environment for rapid adoption of the technology. Navigant Research forecasts that the European VPP market will surpass a market value of \$3 billion per year by 2028. [PV](#)



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