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RESEARCH REPORT

Making Sense of New Public Power DER Business Models

The Business Case for Energy Storage

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Section 1
EXECUTIVE SUMMARY

1.1 Making Sense of New DER Business Models

Pessimists see growth in capacity from solar photovoltaic (PV) panels, advanced batteries, and other forms of distributed energy resources (DER) as the supreme threat to incumbent distribution utilities, echoing the much-ballyhooed utility death spiral storyline. A new report from the National Renewable Energy Laboratory (NREL) is fueling this fire. NREL has dramatically increased its estimate of the technical potential of rooftop solar PV in the United States to 1,118 GW, which represents the equivalent of 39% of current U.S. electricity sales.[1]

Despite these large numbers, optimists see future growth in solar PV as an opportunity for utilities—especially publicly owned utilities—to reinvent themselves, aligning their business strategy with the emerging digital economy and creating new two-way and mutually beneficial relationships with customers.

Where does the truth lie? The key to future success in this emerging market for smart DER solutions is aligning the right technology with the right business model. Maximizing the value of each asset deployed within a network hinges, in turn, upon a controls platform that can anticipate the future, react to changing grid conditions on a sub-second basis, and incorporate contingencies to ensure reliability and resilience. Energy storage technologies, if coupled with state-of-the-art software, can provide this array of services to various energy ecosystem stakeholders, including:

- At the site of a home or business
- At the poles and wires infrastructure that populate the distribution system
- At the high-voltage transmission system that underpins wholesale market trading

It is possible to create win-win scenarios by leveraging the diverse services that energy storage can provide. Advances in software that can optimize DER to provide bidirectional value, along with the bridging capabilities that energy storage brings to the market, can create order out of what would otherwise be chaos.

Why conduct a residential energy storage pilot project in 2016? A survey of 1,000 people conducted by Edelman Berland in late 2015 revealed that 3 in 5 respondents interviewed

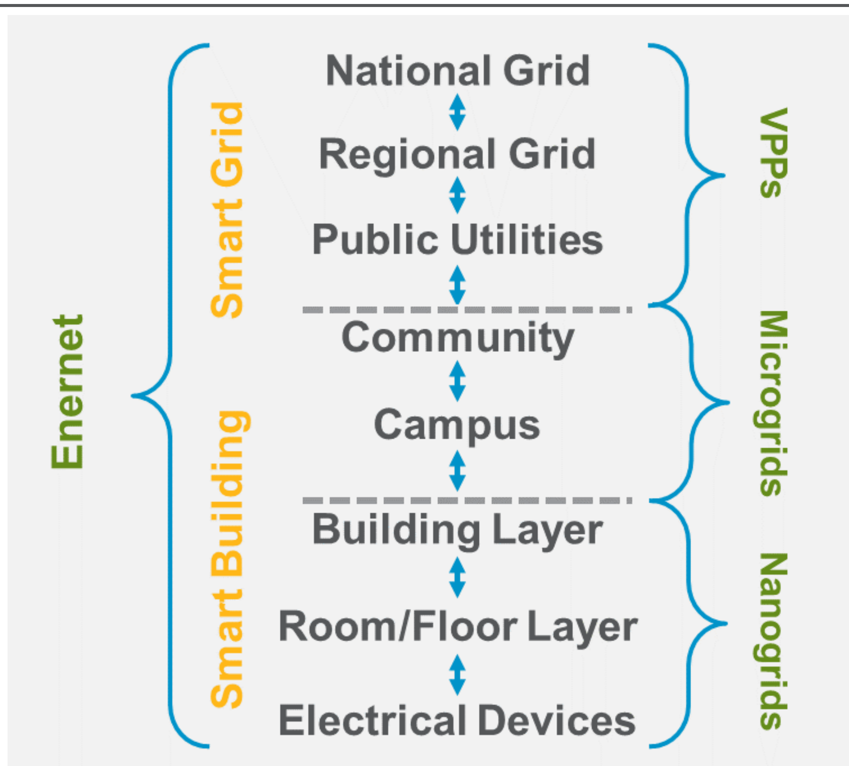
[1] National Renewable Energy Laboratory, “NREL Raises Rooftop Photovoltaic Technical Potential Estimate,” http://www.nrel.gov/news/press/2016/24662

want their utilities to be innovative. Furthermore, the most popular response was this: “I want my utility to use technology to provide me with better service” (68%), followed by, “I care about ways that my utility innovates both inside my home and across the entire power grid” (63%).

This white paper highlights key advantages that public power entities have that are enabling select pioneers to push the innovation envelope in developing new creative relationships with customers if they embrace energy storage in an intelligent way. Public power entities—municipal utilities, rural cooperatives, and other forms—are uniquely positioned to harness the innovation now occurring specifically with solar PV and energy storage systems (ESSs), as well as complementary and supporting technologies that include smart inverters, demand response (DR) and, most important of all, software controls. These supporting IT infrastructures are creating opportunities for public power entities.

Is there a way for everyone to come out as winners? The key is intelligent distribution networks, an ecosystem of solutions that spans concepts such as nanogrids, microgrids, and virtual power plants (VPPs).

Figure 1.1 Emerging Enernet Landscape: Nanogrids, Microgrids, and VPPs



(Sources: Navigant Research, EMerge Alliance)

These three distribution network concepts correlate with major advances occurring with smart buildings and the smart grid (see Figure 1.1). A common analogy is the Internet, which organizations such as the EMerge Alliance have applied to emerging energy networks and dubbed the Enernet, noting the bidirectional exchanges now possible with new IT thanks to advances in telecommunications that have migrated over into the energy sector.

A growing number of cutting-edge DER innovators now offer asset performance software for managing assets and operations. Smart grid analytics are also now available as cloud-based software as a service (SaaS), the ultimate virtualization of energy services. Among these innovators is Sunverge Energy of San Francisco, California, which has deployed solar PV plus energy storage nanogrids that have been aggregated up into both microgrids and VPPs. The key enabling technology for all three of these new aggregation and optimization platforms (nanogrids, microgrids, and VPPs) is energy storage that is smart, scalable, and secure.

Section 2
EMERGING ECOSYSTEM OF DER SOLUTIONS

2.1 Drawing Lines between DER Distribution Network Models

Navigant Research has been sizing and forecasting aggregation and optimization platforms for distributed energy resources (DER) since 2009. It has come up with the following definitions of three approaches to organizing DER technologies so that they provide the most possible value. The most established of distribution network concepts is the microgrid. Borrowing largely from a U.S. Department of Energy (DOE) definition, here is the Navigant Research definition of a microgrid:

> *"A microgrid is a distribution network that incorporates a variety of possible DER that can be optimized and aggregated into a single system that can balance loads and generation with or without energy storage and is capable of islanding whether connected or not connected to a traditional utility power grid."*

There is much less consensus about what differentiates a nanogrid from a microgrid, or even a nanogrid from a relatively simple distributed generation (DG) installation. Here is the Navigant Research definition of a nanogrid:

> *"A small electrical domain connected to the grid of no greater than 100 kW and limited to a single building structure or primary load or a network of off-grid loads not exceeding 5 kW, both categories representing devices (such as DG, batteries, EVs [electric vehicles], and smart loads) capable of islanding and/or energy self-sufficiency through some level of intelligent DER management or controls."*

Last is the VPP. Closely related to both nanogrids and microgrids, here is the Navigant Research definition of a VPP:

> *"A system that relies upon software and a smart grid to remotely and automatically dispatch and optimize DER via an aggregation and optimization platform linking retail to wholesale markets."*

VPPs can be viewed as one manifestation of the concept of transactive energy, transforming formerly passive consumers into active prosumers. In essence, prosumers are active participants in delivering services tailored to their own needs and preferences that also serve the larger grid. Another way to describe the VPP vision of the future is the Energy Cloud, a concept Navigant Research uses to describe how DER can be managed virtually via software that can deploy hardware in a dispersed network.

Table 2.1 puts these related networking platforms into context based on key system characteristics.

Table 2.1 Lexicon of DER Business Models

Capabilities	Nanogrids	Microgrids	VPPs
Grid-Tied	Sometimes	Sometimes	Always
Islanding	Usually	Yes	No
Storage	Most of the time	Often	Sometimes
Geographic Range	Confined to load	Confined to network	Wide and variable
Resource Mix	Static	Static	Mix and match
Grid Connection	Mostly behind the meter	Mostly behind the meter	Mostly transmission node
Market Impact	Retail	Retail first, then wholesale	Wholesale first, then retail

(Source: Navigant Research)

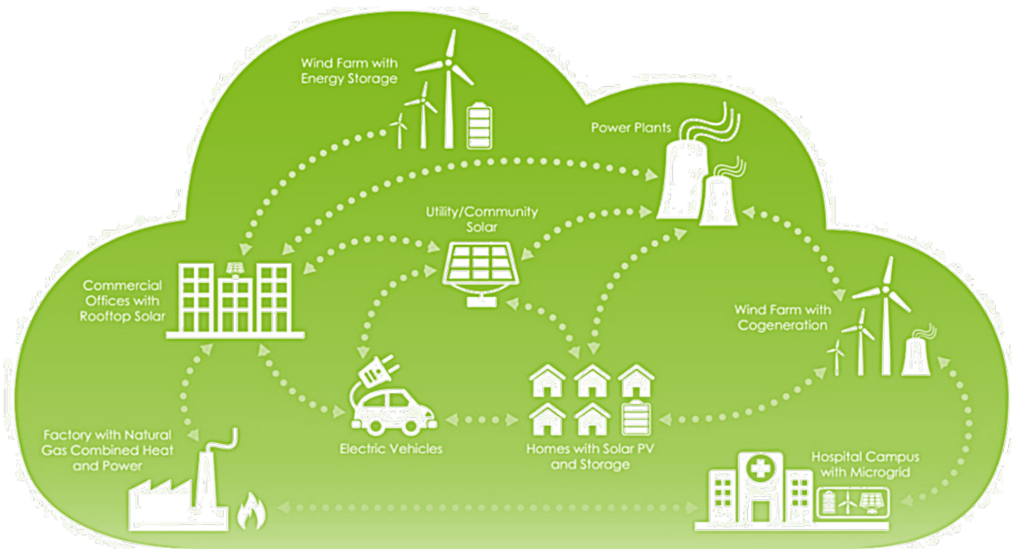
Perhaps the ideal illustration of the Energy Cloud and/or transactive energy is the VPP, which is the ultimate example of the Enernet. A VPP can tap existing grid networks to tailor electricity supply and demand services for a customer, distribution utility, or wholesale grid operator in real time. This is the DER business model that may hold the greatest promise for public utilities looking to reinvent themselves in the evolving DER landscape. Nevertheless, both nanogrids and microgrids can be viewed as building blocks for VPPs, with a primary focus on reliability and resilience. The VPP is more geared toward economic dispatch to serve the larger wholesale market, in essence linking DER previously ignored by the transmission system into viable sources of asset value beyond the site host.

VPPs maximize value for both the end user/asset owner and the distribution utility through software and IT innovations. They deliver greater value to the customer (e.g., lower costs and new revenue streams) while also creating benefits for the host distribution utility (e.g., avoidance of capital investments in grid infrastructure or peaking power plants), as well as the transmission grid operator (e.g., regulation ancillary services such as spinning reserves). As a result, VPPs deliver benefits to a broad array of energy market stakeholders.

However, both nanogrids and microgrids also offer value in the way of bidirectional exchanges. Due to the unique capabilities attached to energy storage devices when optimized by sophisticated software controls, the lines between all three of the DER business models described in this white paper are blurring. This convergence speaks to the transformative role of energy storage in the DER landscape. It also captures trends in the power delivery systems that Navigant has described as the Energy Cloud, which is depicted in Figure 2.1.

> This **convergence** speaks to the **transformative role of energy storage** in the DER landscape.

Figure 2.1 Is the VPP the Ultimate Example of the Energy Cloud?



(Source: Navigant Consulting)

It would be foolhardy to think that past investments in a centralized power system will not be left stranded, even as large coal and nuclear plants are being phased out in key industrialized markets. At the same time, it is clear that a diversity of DER will play an increasing role in the energy future. While the complexity of such a system may seem daunting, the vital role for new forms of distribution networks becomes even more compelling. The Energy Cloud concept sees convergence between large and small energy resources, as well as renewable and fossil generation, with energy storage providing a bridging function that can also link retail to wholesale market optimization.

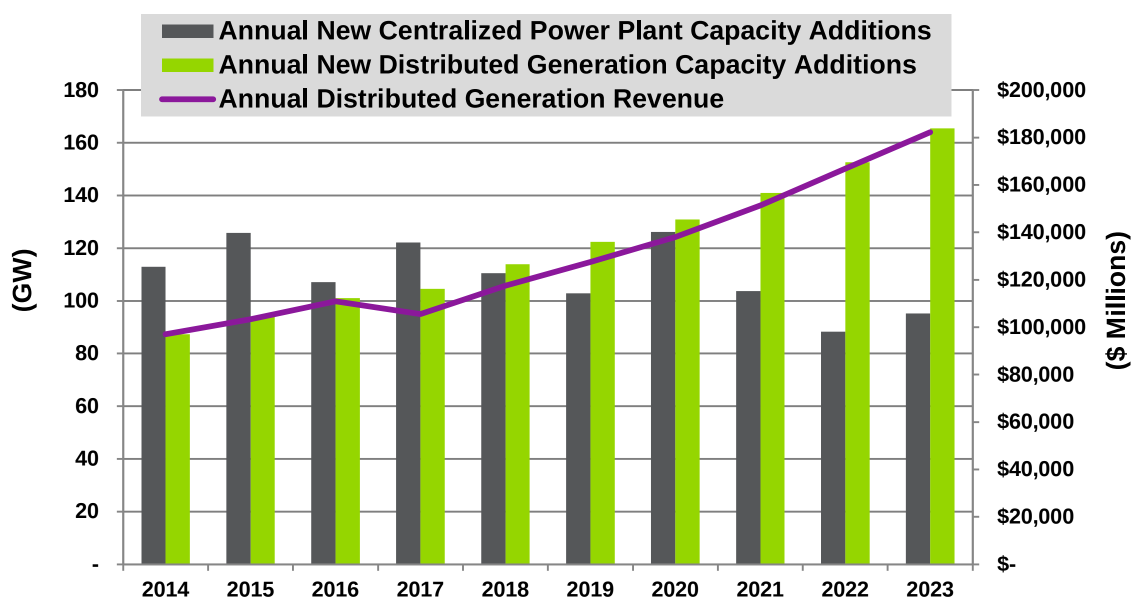
Section 3

DER TECHNOLOGY TRENDS AND COST CONVERGENCE

3.1 Distributed versus Centralized Power

Navigant Research estimates that between 2014 and 2023, different forms of DG will displace the need for more than 320 GW of new large-scale power plants globally.[2] Navigant Research's *Global Distributed Generation Deployment Forecast* report estimates that new DG capacity additions will exceed new centralized generation capacity additions by as early as 2018.

Chart 3.1 Annual Centralized Power Plant and DG Capacity Additions and Revenue, World Markets: 2014-2023



(Source: Navigant Research)

This significant shift in emphasis from centralized to distributed power will be led by technologies such as solar PV and energy storage. These trends are a direct result of the declining costs attached to both of these DER technologies. While government subsidies and incentives will continue to play a role, energy markets are evolving with a greater emphasis being placed on the monetization of the ancillary services that DER can provide

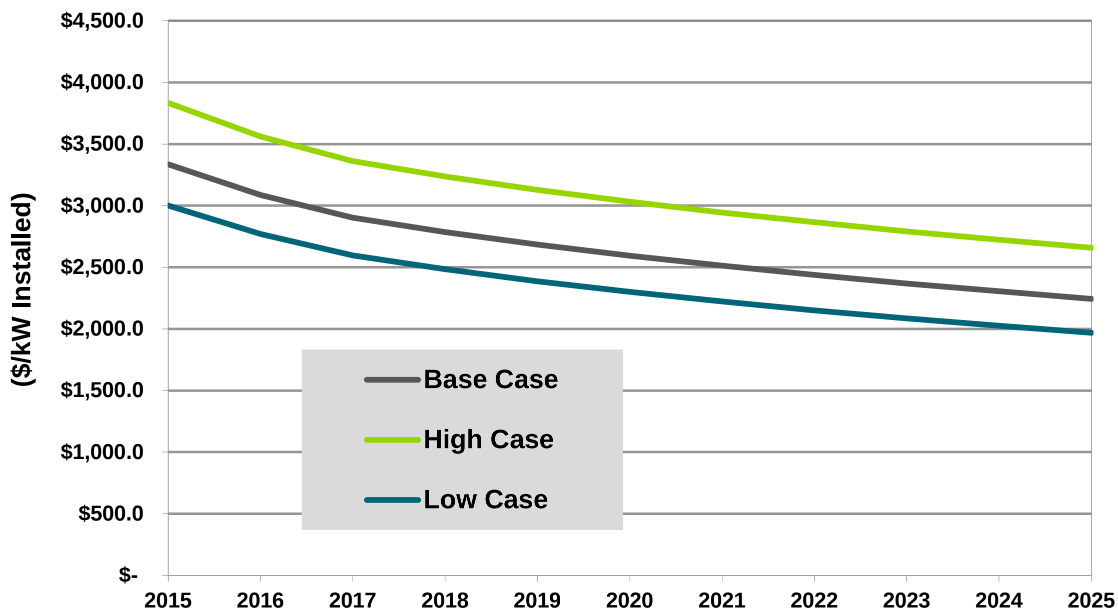
[2] Navigant Research, *Global Distributed Generation Deployment Forecast,* 3Q 2014.

to the larger grid network. Ironically enough, limits on policies such as net metering or feed-in tariffs may actually build the business case for increased penetration of behind-the-meter distributed energy storage technologies. If utility customers cannot fully leverage the storage capability of the larger utility grid, distributed energy storage applications look more attractive, especially as deployment costs come down in regions with high retail residential rates. Anticipating these changes in market conditions, utilities are seeking to reinvent themselves, placing a greater priority on services rather than the traditional focus on throughput of kilowatt-hours.

3.2 Cost Curve Trends for Solar PV and Energy Storage

While solar PV costs have dropped relatively steeply since 2011, it has only been within the last year that energy storage costs have followed a similar downward trajectory. These cost trends are having the biggest near-term impact on the nanogrid market, but are also helping the business case for microgrids and setting the stage for future VPPs. Chart 3.2 shows three different scenarios for distributed solar PV systems sized at no more than 5 kW. Note that by 2025, the base case shows solar PV costs dropping to approximately $2,250/kW.

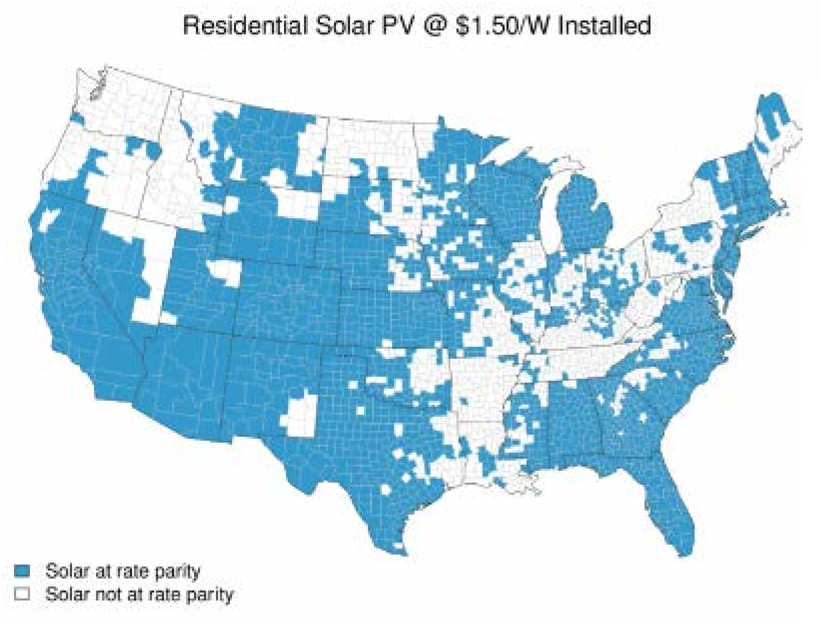
Chart 3.2 Residential Solar PV Price Range, All Scenarios, United States: 2015-2025



(Source: Navigant Research)

To make these generalized cost curves more tangible, consider the map in Figure 3.1, which shows the zip codes where solar PV will be at grid parity when the cost reductions guiding the DOE's SunShot Initiative are reached (from approximately \$3.50/W today to \$1.50/W).[3]

Figure 3.1 Residential Solar PV at Rate Parity in DOE SunShot Initiative



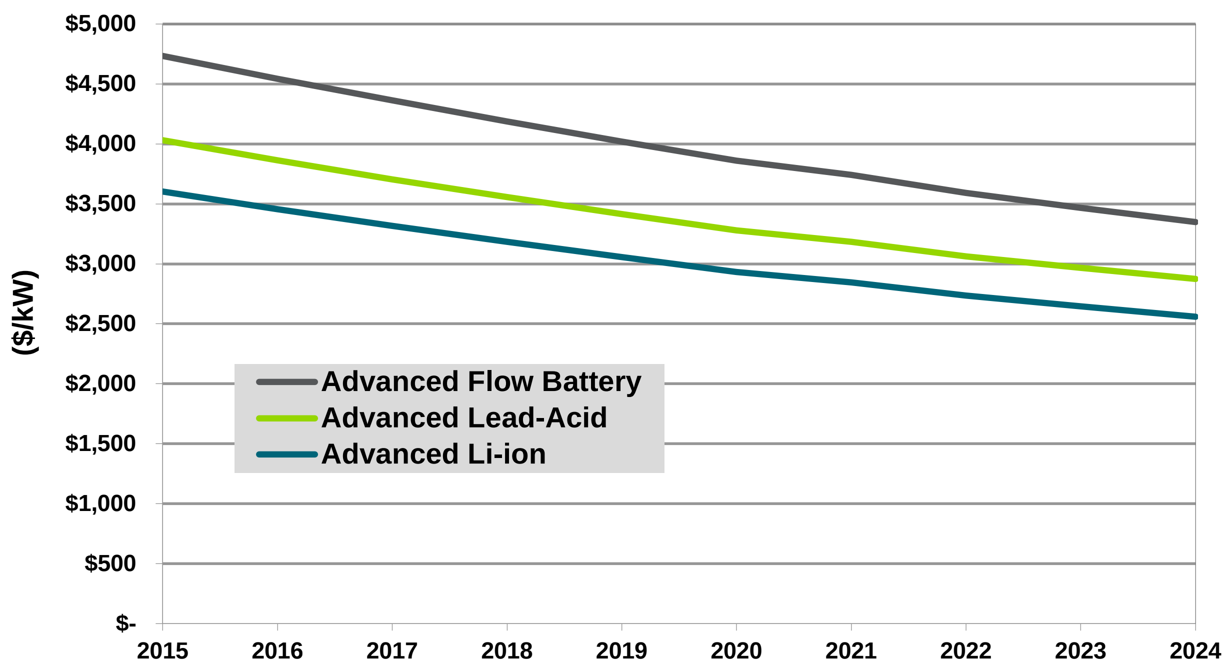
(Source: University of Texas at Austin)

Solar PV technologies are not the only DER technology showing rapid declines in cost. Chart 3.3 comes from Navigant Research's *Energy Storage for Renewables Integration* report published in 2015 and highlights the energy storage system (ESS) cost data underlying Navigant Research's market forecasts. More recent cost data from commercial and industrial (C&I) applications show a much more pronounced cost decline.

[3] U.S. News & World Report, "When Will Rooftop Solar Be Cheaper Than the Grid?", http://www.usnews.com/news/articles/2016-03-31/when-will-rooftop-solar-be-cheaper-than-the-grid

The intermittency of solar PV has long been viewed as a drawback to its widespread deployment as a substitute for 24/7 fossil generation. The primary shortcoming of solar PV is its low capacity factors. Rooftop solar PV in particular can feature capacity factors as low as 20%. If such small systems—whose primary advantage for residential applications is providing financial benefits (offsetting expense peak grid power)—are coupled with energy storage, the value of solar energy is magnified. Energy can be stored and then discharged during times most advantageous to asset owner, be it the homeowner or local utility. These same storage systems can also offer resilience benefits when the larger grid goes down.

Chart 3.3 Average Installed ESS Cost for Distributed Applications by Technology, World Markets: 2015-2024



(Source: Navigant Research)

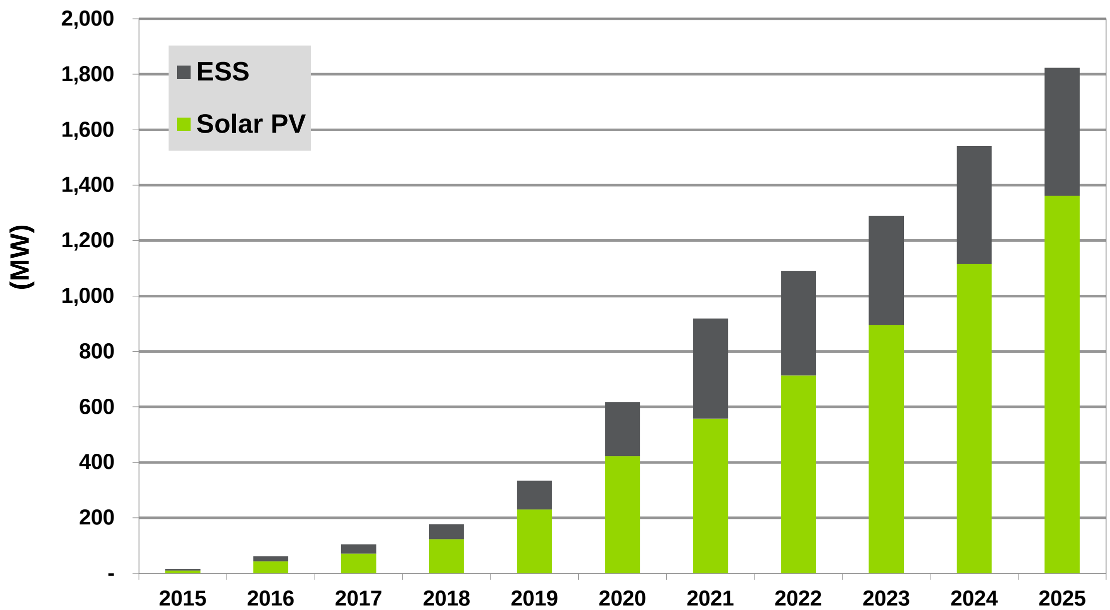
3.2.1 The Value Proposition for Li-Ion Batteries

Why have Li-ion batteries emerged as the lowest-cost option? The low density and high levels of reactivity of elemental lithium give Li-ion batteries very high, specific energy characteristics, making them the technology of choice for mobile devices and EVs. Li-ion batteries are also the leading technology for new stationary energy applications. This is largely because they are already available in mass production and further down the experience curve than many other newer technologies. Li-ion batteries have excellent energy and power densities, high roundtrip efficiency, and decent lifecycle expectations, making them well-suited for grid applications—particularly power-intensive ancillary services. However, stability and thermal runaway remain a significant concern. Li-ion systems require complex thermal management and safety systems. Additionally, compared to other leading battery materials, lithium is a less abundant resource and requires higher levels of processing.

3.3 How Big Is This Market?

Navigate Research has developed market forecasts for nanogrids, microgrids, and VPPs. However, the key common thread between all three of these distribution networks is energy storage in the form of batteries. Zeroing in on just the market for residential solar PV plus energy storage nanogrids in North America, the scale of forecast future growth is dramatic, expected to reach over 1.8 GW by 2025.

Chart 3.4 Solar PV plus Energy Storage Nanogrid Capacity, North America: 2015-2025



(Source: Navigant Research)

Navigant Research estimates that between 30% and 40% of these nanogrids will be aggregated into VPPs. That portion of the solar PV plus energy storage nanogrid market is likely to grow incrementally over the next 10 years and beyond. This will be the result of the creation of new organized markets for ancillary services and efforts by utilities and grid operators alike to manage increased DER portfolios in ways that capture value upstream.

Section 4
PUBLIC POWER CASE STUDIES

4.1 Three Value Propositions, Three Case Studies

Sunverge is a company active in all three distribution markets profiled in this report—microgrids, nanogrids, and VPPs. In some cases, its projects encompass all three concepts in one. All three case studies presented in this white paper involve public power entities. Each leverages the diverse services energy storage can provide if coupled with a software platform that can be finely tuned to prioritize different use cases: onsite customer economic benefits, greater resilience and optimization of the distribution network, and economic trading with benefits accruing to wholesale markets. Table 4.1 sums up the pros and cons of each distribution network model. The truth of the matter is that all three scenarios offer bidirectional value not captured if these systems were not optimized across multiple value and revenue streams thanks to smart storage applications.

Table 4.1 Utility Strategy Comparison: Nanogrids, Microgrids, and VPPs

Strategy	Pros	Cons
Nanogrids	Behind-the-meter innovation does not bump up against utility franchise issues Voltage and frequency issues addressed locally, reducing cascading impacts	May embolden customers to seek greater independence from the grid
Microgrids	Greater economies of scale than nanogrids Can leverage a more diverse resource mix while offering greater resilience benefits	Rate-basing issues not fully resolved Greater complexity translates into more careful (and costly) integration
VPPs	Improved reliability from assets previously viewed as threat Potentially improved customer relationships	Dependent upon right market structures for VPP viability Lack of utility familiarity Regulatory risk

(Source: Navigant Research)

4.2 Sacramento Municipal Utility District

The Sacramento Municipal Utility District (SMUD) is the sixth largest municipal utility in the nation. Since it closed the Rancho Seco nuclear power plant to comply with a local ballot initiative in 1989, SMUD has developed a series of renewable and DER programs to help replace this large centralized source of power.

SMUD has been looking to evolve beyond traditional business models when addressing higher penetrations of solar PV on its distribution grid. Building upon past research that demonstrated the benefits of coupling residential storage with customer rooftop solar PV, SMUD partnered with Sunverge Energy to demonstrate the ability of solar PV integrated with energy storage and DR to help create win-win distribution network benefits for the utility and customer. The project includes elements of nanogrids, a microgrid, and a VPP.

The site chosen was 2500 R Street in Midtown Sacramento, a 34-home single-family housing project developed by affordable housing specialist Pacific Housing, Inc. It seemed like the perfect site to prove out the benefits of solar PV plus Li-ion energy storage because of its reputation as a progressive development seeking net zero energy and the likely prospect of attracting sustainability-minded buyers and financiers alike.

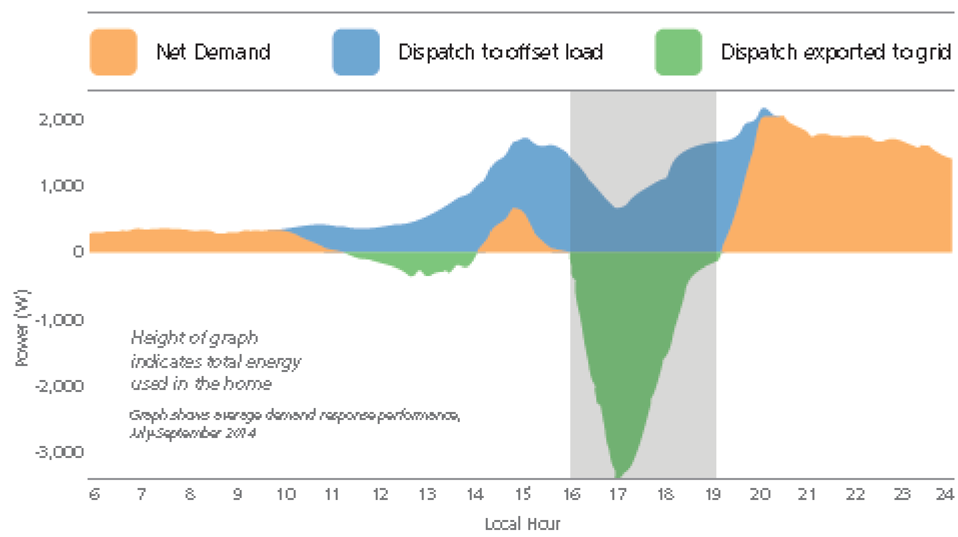
Planning began in earnest in 2010 with construction commencing in 2013 and homes selling out in less than a year's time. Each residence at 2500 R Street Midtown included an energy storage platform bundle made up of a 2.25 kW solar array, the Sunverge Solar Integration System (SIS) ESS, smart plug load controllers, and smart thermostats.

Sunverge's results from this pilot program are impressive, validating many of the assumptions behind this approach to utility management of DER:

- During DR events, 100% of target stored capacity (60% of storage nameplate) was dispatched during each DR event.
- Under peak load reduction scenarios, stored energy was dispatched and net peak load was reduced to zero in residences with integrated energy storage.
- Customers with energy storage realized an incremental 33% reduction in their bills relative to customers with solar PV alone; those on dynamic time-of-use rates with critical peak pricing saved on average more than $50 per month on electricity bills.
- During grid outages, the Sunverge SIS platforms were available to dispatch up to 100% of reserve storage capacity and satisfied critical loads until power was restored in all cases.

Sunverge found electric bills for homes on this single block in urban Sacramento to be 85% lower than comparable homes without solar PV or ESSs. As Figure 4.1 illustrates, the Sunverge SIS can be dispatched to offset demand for grid power to serve loads in the home, but can also export the maximum amount of energy as possible during DR events.

Figure 4.1 Leveraging Sunverge Systems for Utility DR



(Source: Sunverge Energy, Inc.)

"The 2500 R Street Project was our single largest energy storage pilot project to date," stated Lupe Jimenez, project manager for SMUD. "SMUD is currently working on additional opportunities to further prove out the mutual benefits that this type of technology can provide our customers and our utility."

"In the bigger picture," stated Mark Rawson, SMUD's research technology officer, "SMUD is looking at these types of technologies as an important part of the utility of the future. Customers want more choice on how their energy needs are met, and the traditional centralized utility model is changing," he added. "Distributed energy technologies such as PV, storage, and demand response are coming down in price to where they are becoming more and more cost-effective. As an industry, we need to pivot and learn how we can provide new services for our customers that leverage these emerging technologies to benefit both our customers and the utility system."

4.3 PowerStream

The second largest municipally owned utility in the province of Ontario in Canada, PowerStream is one of the few energy companies exploring a utility ownership role in delivering solar PV plus energy storage nanogrids to its customers.

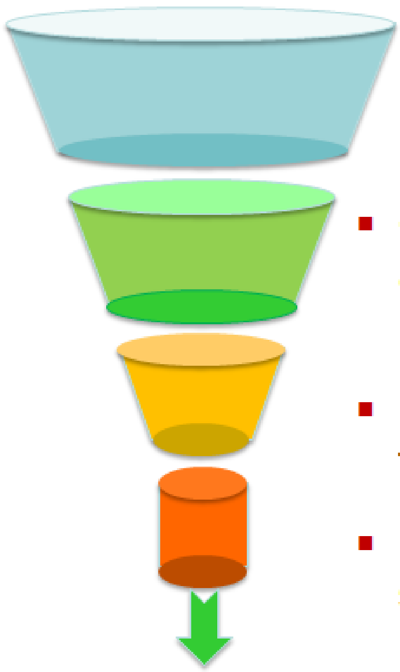
Active in a series of microgrid projects, PowerStream decided to take lessons learned from these early pilots and design transactive energy business models with its residential customers. Partnering with Sunverge Energy, this combination nanogrid/VPP pilot project involves 20 residential units, each to be equipped with a 5 kW solar PV array and 6.8 kW/12 kWh Li-ion battery. Funded by Ontario's Independent Electricity System Operator, the project is designed to enroll homes (which may not be adjacent to each other) on select feeders. The project, dubbed POWER.HOUSE, would provide system benefits as well as meet customer demographic, load, and physical site criteria.

Perhaps the most innovative aspect of the POWER.HOUSE project—beyond the creative aggregation possibilities enabled by the Sunverge energy management system—is the business model, which it refers to as DBOOME (design, build, own, operate, maintain, and energize). Customers have an opportunity to participate in a zero-maintenance solar and storage program with an upfront cost to partially cover installation and a monthly service fee for a 5-year program. PowerStream will own, maintain, and operate the nanogrid systems. (This DBOOME approach is also the model PowerStream plans to deploy for its microgrid program.) In exchange for the customer's upfront payment of $3,500 and ongoing service fee, it is projected that customers will reduce their electricity bills by as much as $100 savings per month. Payback on initial investment for the customers is projected to be around 5 years, alongside additional benefits of resilience and outage management. The POWER.HOUSE program is the first time that net metering has been linked to time-of-use rates in Ontario.

Customer interest in participating in the program was high. The utility identified 112 potential customers, of which 52 signed up and put down a $1,000 deposit to participate before final selections were made. Among the difficult tasks in implementing the project was limiting the pool of participants. The program contracts were signed with 20 prosumers in late August 2015, and full-scale implementation was completed in Q1 2016.

"PowerStream is trailblazing ahead with disruptive energy solutions such as the POWER.HOUSE," said Neetika Sathe, vice president of corporate development at PowerStream. "With the key enabling technology provided by Sunverge, this ground-breaking pilot program enables us to achieve our vision of being a premier, integrated energy service provider," she added. Figure 4.2 shows how PowerStream designed a funneling process to pick the best prosumer partners.

Figure 4.2 PowerStream's Customer Acquisition Strategy



- **System Benefits:** Customers on feeders with congestion, voltage, resiliency needs
- **Customer Demographics:** Income, age, EV drivers, current CDM program participants
- **Energy Profiling:** Identify load profiles that match well with system
- **Physical Limitations**: Requirements for solar, roof space, and configuration

(Source: PowerStream)

4.4 Glasgow Electric Plant Board

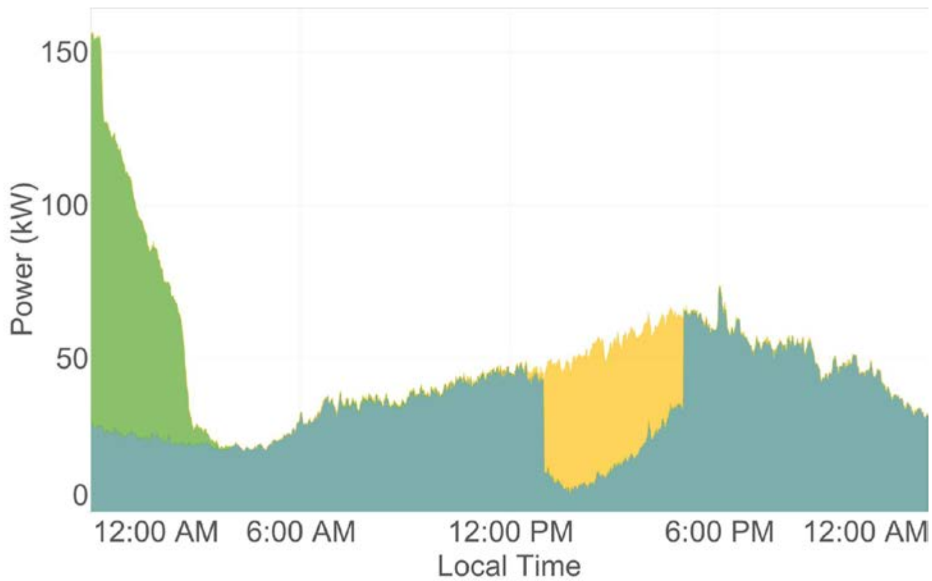
The Glasgow Electric Plant Board (Glasgow EPB) is installing Sunverge systems in 165 existing homes in Glasgow, Kentucky, a small city with a population of 14,000 just 95 miles south of Louisville. The Sunverge SIS devices will not be linked up with solar PV in this project, but rather will capture power from the electric grid when demand and cost are lower. When demand peaks and costs are higher, the utility will order the batteries to release that power and distribute it to its customers, reducing the need to supply additional power from traditional fossil and nuclear generating plants.

This small municipal utility has been reinventing itself in light of the changes sweeping through the industry, an initiative that it has dubbed Infotricity. Because the utility has constructed a municipal broadband network that delivers utility telemetry (as well as data and cable TV service), every household has access to high-speed Internet. Even more important from the utility vantage point are the ubiquitous smart meters. Harnessing the power of social media, the utility set a goal of reducing its demand peak by 25%.

In this use case, rather than relying upon the clean generation from solar PV, the utility is focused on demand reductions. Along with Sunverge ESSs, homes have also been retrofitted with intelligent water heaters and smart thermostats. Customers enrolled in this program see lower bills while having power that is more reliable with backup in case of a grid outage. For the utility, the multiple benefits of the program include the ability to deliver energy from a fleet-level VPP not unlike a large solar PV array or single utility-scale energy storage installation, except the demand savings are being harvested at the point of consumption, avoiding line losses, deferring expensive distribution grid upgrades, and preserving precious land resources.

During the month of September 2015, Glasgow EPB reduced peak load by 64% across the 46 Sunverge systems that were deployed at that time.

Figure 4.3 Snapshot of Weekday in September 2015: 64% Load Reduction



(Source: Glasgow Electric Plant Board)

Putting the Sunverge systems into a larger context, Billy Ray, Glasgow EPB's long-standing superintendent, points out that the utility is the first in the country to reform rates to truly reflect the cost of service via its newly enacted Infotricity Retail Rate, which went into effect in January of 2016. "Glasgow has been lucky to have adopted advanced metering infrastructure [AMI] long enough ago," he said, noting that this allows the utility to compare bill impacts between the old and new systems. "Our proposal has the potential for some sizeable bill increases to about 40% of our customers (assuming they do nothing to change the time of day that they use energy), but it will also would deliver sizeable rate decreases to about 30% of our residential customers that already use energy in an efficient manner." What the Sunverge systems allow, he noted, is for customers to use new technology to maximize internal savings within the new rate structure while also helping the utility reward those customers who respond to price signals in an appropriate way to maximize system benefits.

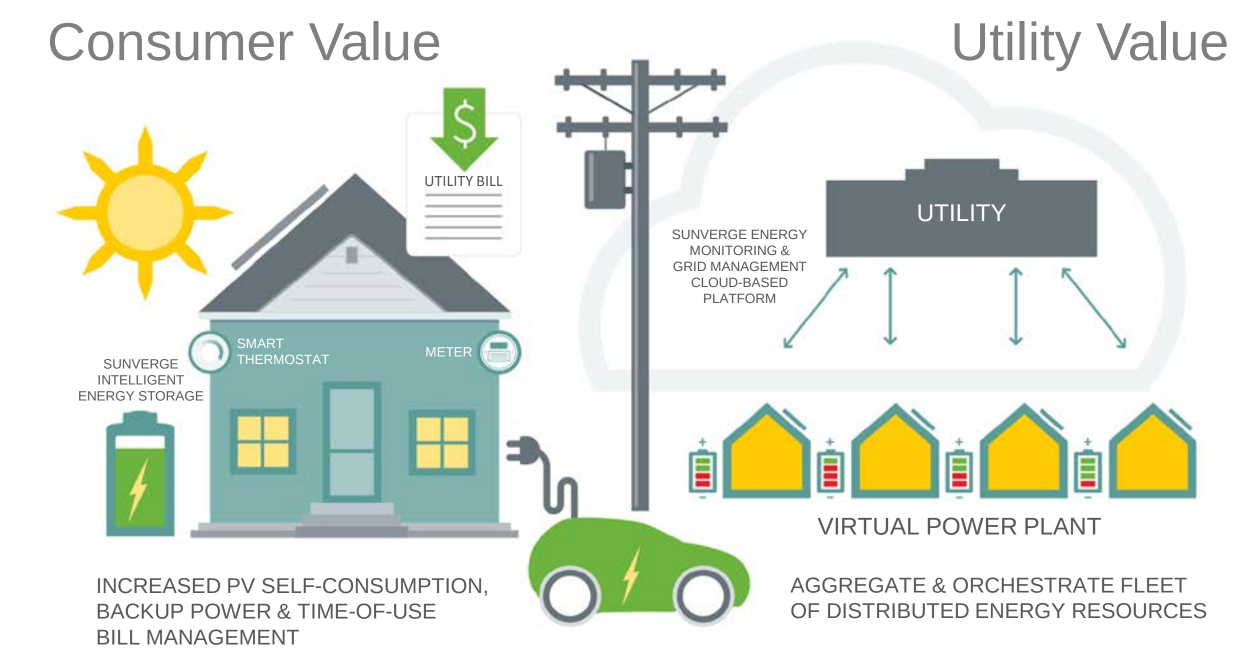
Section 5
HOW SUNVERGE HELPS DELIVER TWO-WAY VALUE

5.1 The Vital Role Energy Storage Can Play with the VPP Model

Many of the utilities working with the VPP model have established pilot programs with residential customers to install energy storage devices, often paired with solar PV, at the customers' homes, creating building-level nanogrids. In most cases, customers will pay an upfront fee for installation as well as an ongoing monthly service fee to the utility for this service. Both customers and utilities can benefit directly from this arrangement. Customers gain greater resilience by having backup power in the event of a grid outage. Utilities accrue a host of benefits, including deferred infrastructure investments, peak load reduction, improved system stability, and a closer relationship with customers. This strategy is often employed by utilities experiencing high levels of distributed solar PV penetration, particularly on distribution circuits.

Nanogrids alone may indeed represent a threat to a utility, particularly if they are owned and operated by third parties with value propositions resting solely on customer benefits. There is another way, as is illustrated in Figure 5.1.

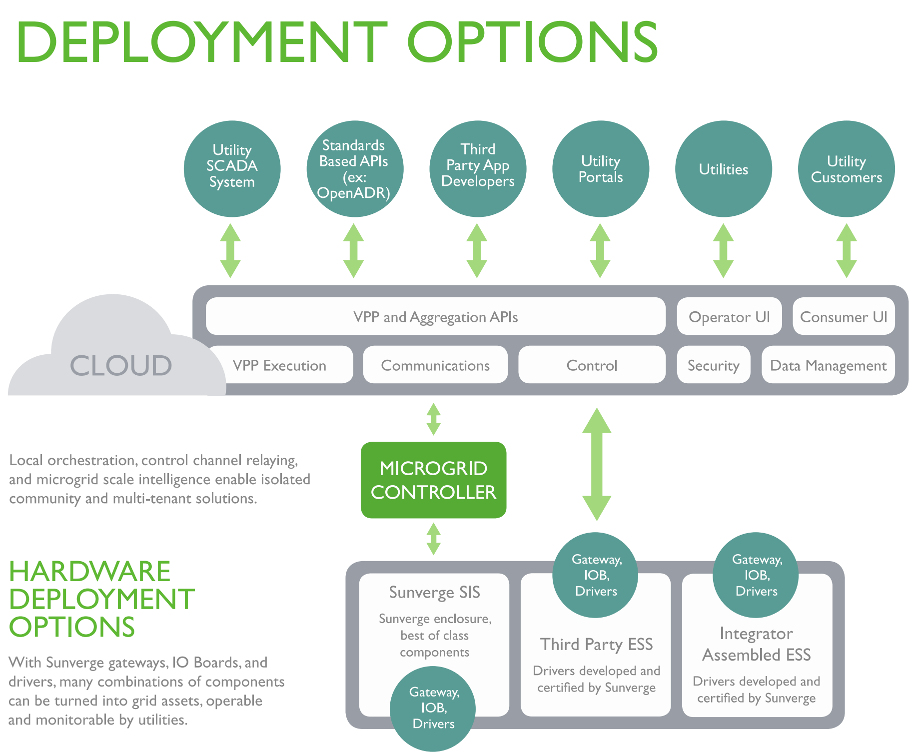
Figure 5.1 The Coupling of Consumer and Utility Value via VPPs



(Source: Sunverge Energy, Inc.)

One benefit for utilities is that the VPP model presents an opportunity—especially for utilities that missed opportunities to be at the forefront of the distributed PV market—to approach energy storage as an opportunity instead of a threat. When customers adopted distributed solar PV, most revenue was accrued by third-party installers instead of utilities, often in spite of some utilities' efforts to limit adoption. In contrast, utilities that embrace the VPP-led strategy are positioning to sell hardware and services to retail customers in addition to electricity. Additionally, many utilities are offering solar PV plus energy storage products to customers, which gives these utilities a second chance to jump into the solar PV market. These utilities are in a position to optimize their own grids by deferring investment in distribution equipment and lowering fuel costs by using VPPs to deliver ancillary services, shave peaks, shift load, and deliver flexible capacity to the grid. The solution packages being offered by Sunverge can be fine-tuned to meet a variety of objectives. As noted earlier, these range from reducing costs to end-users (prosumers), optimizing DER to support distribution level concerns (such as frequency, voltage, and backup power resilience services) and the overall wholesale transmission grid. Figure 5.2 offers a comprehensive view of deployment options spanning software and hardware.

Figure 5.2 Sunverge Solution: From Cloud to Hardware in the Ground



(Source: Sunverge Energy, Inc.)

5.1.1 New Energy Arbitrage Offering

Sunverge is adding sophisticated predictive analytics to its cloud-based DER management platform, making it the first energy storage company to offer this kind of control to utilities. This open, extensible platform acts as the connecting hub from the edge of the grid to the generation side and is compatible with most upstream standards and legacy transmission control systems.

The algorithms predict load and solar generation through the course of the day, accounting for everything from the likely amount of sunlight to the load conditions of the grid. They have been painstakingly designed to provide maximum value with minimum intervention by either the utility or the consumer and continuously improve their predictive abilities as new data is generated by the consumer's installation.

Using a simple interface, utilities can preset several parameters concerning when and how the consumer's storage is charged or drawn down. These include specifying peak rate and shoulder periods per the customer's tariff, during which stored energy use is preferred; setting time periods during which the consumer's storage unit is allowed to charge itself using grid power, typically when low-cost power is most abundant; and identifying critical peak days that prioritize the use of stored power to offset peak load.

The algorithms use those settings, along with historic data for that specific home or business, to determine the exact behavior of the storage assets at that location. Should actual conditions vary from the predicted case, the software will apply intelligent corrections to maintain the most efficient operation possible within the set parameters. Consumers thus obtain the maximum value from their own generation (or, in storage-only installations, from charging as much as possible with the lowest-cost power).

For utilities, more precise and intelligent management of the charging and use of stored power behind the meter offers numerous benefits. First, it reduces the overall load created by DER, which can delay or eliminate the need to upgrade feeders and substations in areas where DER are widely deployed. In conjunction with the Sunverge platform's ability to aggregate DER into VPPs, predictive analytics also represent a powerful energy arbitrage tool. Storage can be charged from the grid at lowest-cost times, while any power exported to other consumers through a VPP occurs primarily at times of high demand.

To sum up, the new energy arbitrage offers a number of features to both utilities and prosumers, including:

- The ability to respond to variations in load and PV that are different from historical patterns.
- The ability to minimize export of solar power to the grid during the middle of the day by ensuring there is enough battery capacity available to store expected solar generation.

- The ability to reduce imports during peak periods by ensuring that there is enough energy stored in the battery to offset load during these periods.
- The ability to identify peak and shoulder periods specified in the customer's tariff to maximize the use of energy storage during periods of high power prices from the grid.
- The ability to specify periods where the unit is allowed to charge from grid. This may be useful for customers with a morning peak period in their tariff; these customers will be able to store energy in the battery at night when the power price is cheaper and use it to offset load in the morning when the price is higher.
- The ability to specify critical peak days, when the electricity retailer has increased the power price during the peak period. On these specific days, the algorithm will prioritize offsetting the peak load over all other functions in order to maximize customer bill reduction.

5.2 Conclusions

Utilities face increased demands to reduce the stress that DER installations can place on the grid. At the same time, consumer adoption of solar PV (and now energy storage) is driven largely by the promise of realizing bill savings by generating their own power or storing low-cost energy for use during peak times. These two forces might seem to be in opposition, but in reality, DER can deliver significant economic benefits on both sides of the meter—but only if managed properly. Doing so requires a dynamic approach that adjusts for the complex interaction of many factors of demand, storage capacity, and energy price. The energy arbitrage offering from Sunverge can accomplish this difficult task.

Public power entities are uniquely situated to leverage value from prosumer assets and foster innovation at the distribution network level. Their self-governing structure, scale, and lack of conflicts between shareholders and ratepayers create opportunities to explore new energy service delivery models. While all three distribution networks profiled in this white paper—nanogrids, microgrids and VPPs—deliver DER synergies, it is the VPP model that holds the most promise in terms of systemwide benefits. The key enabling technology to make these new emerging organizing structures reach their full potential is smart energy storage.

Section 6
ACRONYM AND ABBREVIATION LIST

AMI .... Advanced Metering Infrastructure

C&I .... Commercial and Industrial

DBOOME .... Design, Build, Own, Operate, Maintain, and Energize

DER .... Distributed Energy Resources

DG .... Distributed Generation

DOE .... Department of Energy (United States)

DR .... Demand Response

ESS .... Energy Storage System

EV .... Electric Vehicle

Glasgow EPB .... Glasgow Electric Plant Board

GW .... Gigawatt

IT .... Information Technology

kW .... Kilowatt

kWh .... Kilowatt-hour

Li-ion .... Lithium ion

NREL .... National Renewable Energy Laboratory

PV .... Photovoltaics

SaaS .... Software as a Service

SIS .... Solar Integration System (Sunverge)

SMUD .... Sacramento Municipal Utility District

VPP .... Virtual Power Plant

W .... Watt

Section 7

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Section 9
SCOPE OF STUDY

This white paper was developed based on previous reports by Navigant Research covering emerging markets for energy storage, nanogrids, microgrids, and VPPs. Interviews with Sunverge Energy, Sacramento Municipal Utility District, PowerStream, the Glasgow Electric Plant Board, and other market participants were also incorporated, as were primary and secondary research.

Note that this white paper is not an endorsement of Sunverge Energy. Rather, it attempts to place the concepts underlying the company's approach to management of DER for public utilities within the context of evolving distribution networks designed to provide bidirectional value and win-win solutions for a broad range of energy market stakeholders.

SOURCES AND METHODOLOGY

Navigant Research's industry analysts utilize a variety of research sources in preparing Research Reports. The key component of Navigant Research's analysis is primary research gained from phone and in-person interviews with industry leaders including executives, engineers, and marketing professionals. Analysts are diligent in ensuring that they speak with representatives from every part of the value chain, including but not limited to technology companies, utilities and other service providers, industry associations, government agencies, and the investment community.

Additional analysis includes secondary research conducted by Navigant Research's analysts and its staff of research assistants. Where applicable, all secondary research sources are appropriately cited within this report.

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NOTES

CAGR refers to compound average annual growth rate, using the formula:

CAGR = (End Year Value ÷ Start Year Value)$^{(1/steps)}$ – 1.

CAGRs presented in the tables are for the entire timeframe in the title. Where data for fewer years are given, the CAGR is for the range presented. Where relevant, CAGRs for shorter timeframes may be given as well.

Figures are based on the best estimates available at the time of calculation. Annual revenues, shipments, and sales are based on end-of-year figures unless otherwise noted. All values are expressed in year 2016 U.S. dollars unless otherwise noted. Percentages may not add up to 100 due to rounding.

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