MICROGRID KNOWLEDGE SPECIAL REPORT

Nanogrids: A New Opportunity for the Solar Industry

How solar installers can expand their businesses—and support the grid—with solar nanogrids for homes and businesses

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Summary

Solar energy has the ability to provide immense benefit to society and the grid, reducing the use of fossil fuels that drive climate change. But solar's full potential isn't being fully realized and, in some cases, is even thwarted.

What's the problem?

Solar alone isn't always controllable or predictable. It lacks the newest technologies that provide protection against outages. With the right design and technologies, however, solar can deliver bigger benefits to solar installers, their customers, the environment and the electric grid. That's all possible by creating a single building microgrid, known as a nanogrid when we put them in homes.

Unfortunately, many solar installers and their customers are unaware that nanogrids are now accessible and affordable. To help boost awareness and understanding of solar nanogrids, Microgrid Knowledge has prepared this six-part special report, made available for free download courtesy of Instant ON.

Chapter I: Nanogrids 101

Nanogrids defined

What exactly are nanogrids? Think of a microgrid, but:

- Smaller, which means quicker and easier to deploy and more affordable
- Localized, so customer centric and able to be tied to other nanogrids, microgrids and the utility macrogrid
- Able to be aggregated, which can create a coordinated response to support other grids in times of emergencies

Both nanogrids and microgrids are forms of local energy—self-sufficient systems with power generation, controls and often energy storage—that serve customers within a discrete footprint. Although they can operate on their own, most North American microgrids and nanogrids are also connected to the central grid. They are able to island from the larger grid and operate independently during power outages. Electricity continues to flow to homes and buildings served by microgrids and nanogrids even as others around them are in the dark. This is a prime reason for their installation, one that is especially important given that the U.S. is experiencing more outages caused by storms, wildfires and other dangerous conditions that affect the safety of communities. Meanwhile, power outages to homes, a prime market for nanogrids, are no longer a mere inconvenience; they can carry significant costs now that more people are working from home. Indeed, COVID-19 created situations where high ranking corporate officials were operating from their houses, shifting the corporations' de facto headquarters to residences that lack the kind of backup energy systems more likely to be found at their office complexes.

But it's not only electric reliability that makes these systems attractive. Because they are tied to the electric grid, they may supply services to it and be paid for doing so. For example, a utility might pay to tap into a nanogrid's battery at a time when demand is high on the electric grid and it needs more energy, such as a hot day when air conditioning use is high.

Nanogrid and microgrid owners also can save money if they use energy from their systems, instead of the grid, during times when grid power is expensive.

Another important benefit of nanogrids is their interconnectivity to a larger scale smart grid. An aggregated network of nanogrids can be very valuable to the grid. Currently, solar is generating power at times of the day when energy is at lowest demand. Besides simply turning off the solar panel production, through a practice called curtailment, the utilities do not have an effective way of managing all the separate points of intermittent connection. They don't have a way to store the solar power effectively. In addition, at times when the utilities need the power most, current independent solar systems cannot necessarily supply it because they lack the intelligent technology to do so. This is partially due to the fact that the solar energy is not being produced at those critical times of the day. Nanogrids can help solve this problem.

How do microgrids and nanogrids differ? Size is one major factor that distinguishes them. Microgrids tend to be larger than nanogrids, and they usually serve the entire building or more than one building. Microgrids also may incorporate relatively complex energy systems with multiple sources of energy. According to a paper published by Bruce Nordman, a researcher at the Lawrence Berkeley National Lab, and Ken Christensen, a computer science professor at the University of South Florida, a nanogrid is a single domain of power — for voltage, capacity, reliability, administration and price.

What does it take to install a nanogrid?

Many existing solar companies and a few new companies are getting into the energy business and recognizing that nanogrids add value when compared to simple stand-alone solar systems. Nanogrids must be professionally designed, built and installed because of safety and technical issues. Installers must understand still evolving standards for net energy metering (NEM), UL certification and communications, interconnection, and requirements for different types of electrical experience, as well as export guidelines that vary city by city and utility by utility. Needed now are teams of experts who can successfully commission and install nanogrid projects. The learning curve is almost insurmountable for small contractors unless they have a team, or partner, that understands the ever changing environment surrounding the various components of a nanogrid.

The right equipment

The right equipment is a critical part of the package and can help determine whether a nanogrid can isolate from the grid. That's key because most homeowners interested in solar and storage seek resiliency and want to be able to maintain power in their home in the event of a power outage.

> During a power outage, a solar system stops operating to prevent the backflow of energy.

It's important for solar installers to understand the equipment necessary to allow the home to be islanded in the event of a power outage. During a power outage, a solar system stops operating to prevent the backflow of energy. (The aim is to protect utility linemen.) This was the case for hundreds of Californians who had their electricity shut off during public safety power shut-offs (PSPS) — despite having solar.

In some cases, even homes with solar and energy storage systems saw their electricity cut when the utility shut down power in their neighborhoods. These systems lacked a key component of a nanogrid, an element that distinguishes the technology from simpler solar plus storage systems — an automatic transfer switch.

A transfer switch isolates the system from the utility and puts the nanogrid in island mode. This allows the nanogrid to provide power from its on-site resources to the home without backfeeding to the grid. When the outage ends and grid power becomes available, the transfer switch reconnects the home to the grid, allowing power to again flow between the nanogrid and grid. In some cases, other equipment may be necessary, such as a non-export relay that provides redundancy for the utility.

All of this equipment must be managed, which is the task of the controller, the final piece needed to ensure proper function, monitoring and operation. This highly intelligent software-based system also gives the nanogrid capabilities not available to mere solar or solar plus storage systems. With advanced controls, consumers gain visibility into and control of their electricity consumption, which enables the smooth integration of alternative energy sources into the existing wiring infrastructure. They are also able to conveniently participate in utility demand response programs, which offer the household compensation for saving energy at key times. The controller offers automation and load prioritization that allows for maximum compensation with minimum disruption.

Another component beginning to be introduced to nanogrids is the intelligent circuit panel, which offers services well beyond the conventional panel's passive current protection. An intelligent panel combines critical components (smart meter, circuit panel and essential loads panel) to create a single point of control for generation, energy storage and smart devices in the home. So, when there is a grid outage, the panel automatically islands the house and controls loads to ensure safe and seamless transition from grid to island mode and back to the grid. Innovative systems allow the homeowner, via a cell phone, to prioritize energy use for circuits, appliances and connected devices, ensuring that the most important are energized or de-energized as necessary. As a result, the home can operate for a longer period using only on-site energy. The battery power isn't wasted on appliances that are not a priority to the homeowner.

Solar and storage price drops create opportunities

Nanogrids arrive at a time when the price of their main components—solar and storage—are falling.

The cost of installing solar panels has decreased by more than 70% in the last 10 years, according to the Solar Energy Industries Association (SEIA). While the average residential system cost about $40,000 in 2010 before incentives were applied, it's now only $18,000, SEIA says. Prices as of the first quarter of 2020 were at their lowest levels in history for all solar market segments.

The price of lithium ion batteries has dropped by about 80% over the last five years. And, the cost is still falling. Lithium ion batteries are expected to drop at an average annual rate of 6.5% for the next decade.

As for storage, since 2013, the prices for lithium ion batteries, the most common form of battery used in nanogrids, have dropped by nearly 73%, with the combined cost for a cell and pack at $176 in 2018, $474 less than in 2013, according to the Smart Electric Power Alliance.

The National Renewable Energy Laboratory (NREL) says that the price of lithium ion batteries has dropped by about 80% over the last five years. As a result, the U.S. deployed 93% more storage in the third quarter of 2019, compared to the third quarter of 2018.

Navigant Research in August 2019 released a report saying the prices of lithium ion batteries are expected to drop at an average annual rate of 6.5% for the next decade.

The declining costs of solar and energy storage improve the value proposition for nanogrids, especially since utility residential electric rates, by comparison, have been rising.

What does a nanogrid cost? That will depend on whether the household chooses to purchase the system outright or contract for the system under programs designed to protect a household's capital, such as a lease or Power Purchase Agreement (PPA). Nanogrid costs also can be offset if the system sells its output to the grid.

Let's examine the various scenarios.

To understand the economics of an outright purchase, let's look at an average family in California that uses about 880 kWh of electricity a month. The family would pay its utility about $220 a month in electricity costs. In this scenario, the family can offset that usage and gain energy independence and resiliency with a six-year payback. Doing so would require a nanogrid that couples a 6 kW solar system with a 20-kWh energy storage system housed either indoors or out, paired with the appropriate inverter, smart main panel and switchgear, all managed by a microgrid controller with intelligent software. The complete system would cost under $45,000. With financing at 3.99% over a 20-year period, it would cost the household about $270 a month. So, for $50 more a month than their current monthly rate, homeowners would have fixed pricing for their electricity needs—plus peace of mind knowing that they will be able to weather power outages that may come their way. Assuming that electricity costs will rise 3% annually, it will take six years for the escalation to exceed the new payment. From that point on, the financed payment would remain lower than the cost of electricity for as long as the system is running.

The affordable nanogrid

Even though nanogrid costs have fallen, the price tag may seem out of reach for many households. However, financing mechanisms exist that make nanogrids affordable.

Two financing structures—PPAs and Property Assessed Clean Energy (PACE)—can help take the financial burden off homeowners.

With PPAs, there is little or no upfront capital required. A third party owns and operates the equipment. Homeowners simply pay for the energy they use, just as they are accustomed to doing when they buy their electricity from a utility.

PACE financing, meanwhile, reduces challenges about credit worthiness because it is tied to property. A hybrid approach, PACE-secured PPA, combines the two and is a strategy for boosting solar energy in low-income households.

Another option is energy as a service, which is similar to a PPA, with no upfront capital required. The host contracts with a third-party provider that owns and operates the facility. The host makes payments as recurring, short-term operating expenses. Payments continue as long as the owner provides electrical services. Contract lengths vary and are specified in agreements.

These models open up the possibility of utilities or third parties aggregating a network of residential energy storage systems. The batteries could be operated as a virtual power plant (VPP) or to provide other grid services, generating income for battery owners.

What is a **virtual power plant?**

A relatively new approach, they are aggregations of distributed energy resources that act together, remotely, to provide power or services to the grid as a single entity.

One example is a pilot project in New Zealand involving 22,000 homes with nanogrids. By setting aside 20% of the battery power from each home, and selling that power into the utility demand response market, the finance company achieved a payback on the cost of the systems in less than one year. In other words, by combining the available battery power of numerous nanogrids and selling it into the market to create an added revenue stream, nanogrids paid for themselves in eight months.

Providing lower cost clean energy to low-income households

Nanogrids are particularly valuable for low-income families, who often bear the brunt of climate change. A federal report noted that low-income families tend to have higher rates of health conditions, are more likely to be exposed to environmental hazards and are slower to bounce back from natural disasters.

Low-income families are often housed in less efficient buildings due to poverty and discrimination. That means they face higher energy costs because property owners often don't install energy saving measures.

Energy purchases per household income

2% or less – middle and upper income

10% or more – low income

Up to 20% – very poor

Further, low-income citizens can't afford energy saving and clean technologies such as solar systems, efficient appliances and electric cars.

Middle and upper income households spend 2% or less of their income on energy, while low-income households spend 10% or more. The very poor are likely to spend up to 20% of their income on energy purchases. They also struggle with the fluctuating prices of electricity.

It's possible for households of all income levels to acquire nanogrids at no upfront cost through alternative financing arrangements like PPAs and PACE. The ability to aggregate and monetize the excess stored energy and efficiencies of a portfolio of nanogrids also opens up the opportunity for finance companies to introduce energy-as-a-service and other forms of creative financing. That's due to the possibility of optimizing energy use, storing excess energy production and monetizing grid support.

How nanogrids derive value

As we've noted, nanogrids have the ability to create value that helps offset system costs. Let's dive into more detail about how they accomplish this.

Pairing energy storage, renewable energy and advanced controls creates possibilities to better manage home energy use, save money and generate income while supporting the grid. With advanced controls that allow for the creation of a nanogrid, the possibilities are even greater.

Consider how a nanogrid compares to a conventional home solar system. Old-style systems may have monitoring equipment that simply tracks the solar energy produced, exported and consumed. But a nanogrid allows solar system owners to take action on that information. With advanced controls, they can switch electricity to appliances on or off, decide when it's best to use solar, switch on a home's pool pump on a sunny day, run loads such as clothes dryers, or charge their energy storage systems. Users can see in real time the energy they use and produce, helping them navigate energy use to generate savings and income, creating a very customer centric system.

Households with nanogrids also can leverage their systems against grid pricing. The grid tends to have an abundance of solar energy, more than it may need, in the middle of the day. That means some of it goes to waste. But with energy storage in the mix, a home can store some of solar's low-cost power and use it at any time, perhaps swapping it out for grid power at another time when electricity prices rise. This is often referred to as energy arbitrage.

The nanogrid user also may choose to dispatch the nanogrid's battery at a time when the utility calls a demand response event. This occurs when the grid is under strain and the utility offers to pay its customers to lower their energy use. To the utility, it appears that the home reduced its energy use because it takes less energy from the grid. In reality, the home is still using energy, but it's coming from its solar-charged battery, not the grid.

Photo credit: Joe Ravi/Shutterstock.com

The Illinois Institute of Technology in Chicago is home to a unique nanogrid in a microgrid. The nanogrid has the distinctive ability to move DC power from solar panels directly to LED lights.

Not only can homeowners benefit from participating in demand response events, they can also yield savings by prioritizing and controlling how and when they use power at home.

When combining an intelligent control system with solar or other energy systems and batteries, homeowners can match household energy use with the solar production curve of their solar panels throughout the day. That means they can use solar energy on-site and reduce their reliance on the grid.

They can also save money by using their solar and storage systems under time-of-use rates, which are higher when demand is high. Solar can be stored and released when these rates are high. California utilities are among the companies that offer time-of-use rates.

While such projects are on the cutting edge, they're becoming more common. Solar installers can help their customers participate in this new world of energy—and help address grid challenges.

With nanogrids, households and businesses can be in charge, deciding how to manage their energy and when to participate in demand response events. In the next chapter, we will examine more deeply how nanogrids serve the greater good, acting as an asset to the electric grid.

Chapter II: How Solar Nanogrids Help Solve Variability on the Grid

Working together, nanogrids can achieve even greater efficiencies than they do individually. A number of projects are underway that aggregate, or pool, power from the batteries in nanogrids. These demonstrate what solar installers can achieve with nanogrids.

For example, the government of Australia partnered with one company to combine solar panels on rooftops with storage and create a virtual power plant. As we described earlier, virtual power plants operate remotely, pulling together a number of independent energy resources from different locations into a network that provides reliable power 24/7. They do so virtually, by contract, not by a physical connection.

Under the plan in Australia, 50,000 homes are being equipped with 5 kW rooftop solar panels and 13.5 kWh batteries. All together, they could provide up to 250 MW of solar and 650 MWh of storage. The Australian government is providing a $2 million grant and a $30 million loan from its Renewable Technology Fund.

Another company is planning a virtual power plant that aggregates batteries from homes in Herriman, Utah. Six hundred new rental apartments will include batteries that together will provide 12.6 MWh of energy, based on stored solar in the batteries.

Such systems are not only valuable to the solar and storage owners, but together, as virtual power plants, they also can provide a resource option for utilities challenged by the need to meet peak demand for power. Acting as a grid resource, the virtual power plant can provide power when demand is high and help utilities avoid building expensive fossil fuel peaker plants, which lowers costs for ratepayers. More and more, energy storage is seen as a way to help meet this need.

California offers several good examples of how virtual power plants can aid the grid. The state was among the first to advance the idea of relieving pressure on the grid by intelligently distributing the power generated by individual distributed energy resources (DERs) during periods of peak load. Additionally, California demonstrated that the combined power generation, storage and consumption of the networked DERs in the virtual power plant can be aggregated and traded on the energy exchange.

For example, Southern California Edison in 2019 achieved a new world record with a virtual power plant delivering 2 GWh of grid services. In 2018—its first year of operation—the virtual power plant was dispatched 250 times to the California Independent System Operator. The project's fleet of 21 hybrid electric buildings is capable of reducing peak demand by up to 10 MW within minutes of receiving an automated signal from California's grid operator.

> The U.S. needs more than 50 GW of storage to ensure peak demand needs are met.

But California isn't alone in its need for peak power, and therefore virtual power plants. The Federal Department of Energy's National Renewable Energy Laboratory (NREL) said in a recent study that the U.S. needs more than 50 GW of storage to ensure peak demand needs are met. The study found that providing peaking capacity could be a significant market for those who own energy storage systems. This potential is especially promising for batteries that can provide storage for four hours. Adding renewable generation can increase energy storage's potential by altering the shape of demand patterns.

For both solar installers and homeowners interested in installing nanogrids, that's good news. With the right incentives in place, battery owners can provide peaking power to the grid—and get paid for what it's worth. That helps utilities avoid building expensive peaker plants, which lowers costs for ratepayers and helps the grid.

While selling power to the grid from nanogrids may sound like science fiction, a number of factors are coming together to help make these ideas reality. Solar installers and homeowners are important players in this future.

Absorbing excess renewables

Another important challenge on the grid is the need to absorb solar energy and other forms of renewable energy when they produce more than the grid can handle. When this happens, precious renewable energy can be wasted.

In fact, during the summer of 2019, California set records for the most solar power ever coming onto the state's main electric grid, and the most solar power ever taken off the grid because it wasn't needed.

Nanogrids can help solve this problem and make use of solar that would otherwise be wasted because it's possible to free up their batteries to absorb the excess solar. This is an alternative to an "excess supply demand response" program offered by Pacific Gas & Electric (PG&E) and other utilities under which customers increase energy usage to absorb the solar. The excess supply demand response program aims to avoid curtailing solar or paying other states to take excess energy, but the associated boost in energy usage has environmental effects. This program faces challenges, including engaging customers to participate.

One alternative—using nanogrids when solar production is too high—would look like this: Homeowners with nanogrids would continue normal operations. But they would give the utility access to empty batteries that could absorb the excess solar. For example, a project for PG&E from Olivine allows excess generation to fill up batteries when there's too much solar on the grid.

This type of program benefits customers, utilities, the grid and the environment.

Nanogrids not only provide these grid benefits, they also offer public safety advantages, which we examine in the next chapter.

Chapter III: How Nanogrids Assist with Public Safety—Wildfires, Power Outages and Other Challenges

Variability on the grid isn't the only challenge in the electricity industry. Wildfires, storms and other disasters plague the interconnected grid.

Alternatives to public safety power shutoffs

The grid challenges associated with wildfires, especially in California, are significant. To help prevent power lines from sparking wildfires in areas where fires frequently occur, some utilities have begun shutting down the grid during periods of high winds. As described earlier in this report, the practice is called a public safety power shutoff, a de-energization of power lines.

These events are more likely to occur when conditions exist that might cause a power line to fall and spark. High winds (including red flag warnings declared by the National Weather Service), low humidity, or the presence of dry vegetation can fuel fires. In addition, on-the-ground observations, fire threats to electric infrastructure and public safety risks all are considered when such events are called.

> Because they are lower cost and less complex, nanogrids can be deployed more quickly to protect communities and families from shutoffs.

The shutoffs create havoc. Occurrences of car accidents increase as drivers try to get around without traffic lights. The health and safety of people who need electrically-run medical equipment becomes jeopardized. Stores and homeowners lose frozen goods. Schools close. The environment suffers harm as households and businesses turn on fossil-fuel backup generators.

Photo credit: Simone Hogan/Shutterstock.com

Two of California's biggest investor-owned utilities abandoned their 2020 plans to install multiple permanent microgrids. That's due to high costs, complexity, and the urgency of coping with wildfire season. Because they are lower cost and less complex, nanogrids can be deployed more quickly to protect communities and families from shutoffs. In addition, nanogrids help protect California's climate goals better than the temporary diesel-fueled mobile generators that consumers, businesses and utilities are using.

Concerns about shutoffs and the elderly, disabled

Local and state officials are concerned about how such shut-offs will affect disabled and elderly residents.

"We're all worried about it for the elderly. We're worried about it because we could see people's power shut off not for a day or two but potentially a week," Gov. Gavin Newsom said about the public safety power shut-offs.

Homeowners who own solar systems may assume they're immune to such shut-offs. But unless they have the proper equipment, they can't separate their systems from the grid. As we discussed earlier, solar energy systems that lack transfer switches—equipment that prevents electricity from backfeeding to the grid—will also be shut down during such events.

Nanogrids with transfer switches can operate independently of the grid when it's shut down because of wildfire concerns. They can be installed in whole neighborhoods that are susceptible to fires and keep power flowing to homes.

Given all of the benefits nanogrids offer, why aren't there more of them? One reason is that they are still relatively new, but another is that they face obstacles that better rules and regulations could solve, as we'll describe next.

Chapter IV: Utility and Regulatory Changes that Would Benefit Nanogrids

In spite of the many challenges that nanogrids address, their growth is limited by regulatory and utility hurdles that prevent nanogrid owners from realizing their many benefits. Utilities, regulators and stakeholders are beginning to identify some of these hurdles and the advantages of overcoming them.

Utilities now face a whole new world, with the influx of renewable energy and other distributed energy resources, the rapid adoption of electric vehicles and the pressures to decarbonize the grid. If they don't change, utilities may eventually become only occasional backup as their customers increasingly opt for on-site generation, predicts a report by Accenture.

To adapt to the new energy environment, utilities and regulators can focus on a number of strategies, including implementing time-of-use rates, using new intelligent meters and taking advantage of new technologies, as explained below.

Tariffs that charge customers for when they use energy

New tariffs could focus on charging consumers for energy depending on when they use energy. One option is time-of-use rates, which change depending on the time of day and provide incentives for customers to use energy during off peak periods. Generally, time-of-use rates categorize a day into on-peak hours, off-peak hours, and, sometimes, mid-peak hours.

Another option is real-time rates. Customers obtain the true price of using energy on an hour-by-hour or minute-by-minute basis through an advanced smart panel. This advanced smart panel automatically implements the customer's priorities and turns off nonessential appliances or loads when tariffs are too high. Real-time rates differ from time-of-use rates because they are constantly changing, while time-of-use rates are generally fixed and do not take into consideration emergency situations throughout the year.

A report by the Wind Solar Alliance notes that with real-time rates and smart controls—smart appliances and smart electric vehicle charging—customers can use more electricity when prices are low and use less when prices are high. This helps utilities avoid the operation of peaking power plants that are generally fossil fuel-based and create air pollution.

New tariffs could focus on charging consumers for energy depending on when they use energy.

Adding advanced smart panels and new hardware technologies that include disaggregated metering and real-time pricing provide many opportunities to support this new world of energy. These technologies allow energy distributors to remotely meter customers and allow retailers to use real-time information to create innovative tariff schemes. What's more, they allow customers to use real-time data to control when and how they use energy. Real-time rates would help nanogrid owners decide when to store energy and when to release it. If utility customers can measure all loads, circuits and resources, they can better control the environment and make informed decisions. Current "smart meters" will not help with real-time pricing because of their aggregated nature. Most smart meters can't act on the information and have no control over how property owners use their energy.

It makes more sense to integrate an advanced smart panel with the ability to take action based on real-time utility events and predefined load priorities. This technology can make the difference, utilizing the information for the customer, either automatically or with property owner intervention. This is what is now missing from many microgrids and nanogrids.

Real-time information can address grid challenges

Utilities can also embrace technology, encouraging customers to buy automated appliances and services that help control peak demand. For example, consumers could track their usage and set appliances to run during off peak periods or when large amounts of renewable energy are on the system.

In this new era of data, renewable energy and new hardware technologies in the energy field, consumers need to be more engaged. Utilities and regulators can provide incentives that entice customers to participate in a dynamic system that allows them to generate, store and distribute energy. With incentives from utilities, more homeowners could acquire nanogrids.

Regulatory changes needed

A number of regulatory changes would reap more benefits for nanogrids by boosting the energy resources they use. These include changes in utility treatment, federal incentives, state policies and wholesale market rules.

Utility IRPs

Utilities play a key role in determining what resources are used in the U.S. when they lay out their long term strategies, a process known as integrated resource planning (IRP). In many jurisdictions, the utility must calculate what mix of resources will prove most cost-effective over time. But, as a Department of Energy paper noted, because traditional IRP models do not consider many of the services that energy storage can provide, the technology does not neatly fit into planning processes. What would help? More sharing of data and best practices, according to the paper, along with better modeling. Utilities also are increasingly producing grid modernization plans that open the door to incorporating more energy storage services.

Tax incentives

Federal investment tax credits (ITC) have played a major role in helping new clean technologies get integrated. But the credits are limited for energy storage and beginning to fall short for solar.

In June 2020, Democrats in Congress released the Moving Forward Act, which aims to ensure that investments in clean energy will play a major role in any potential economic recovery package. The $1.5 trillion infrastructure plan would boost the use of renewable energy, grid modernization, resilience efforts and microgrids. The proposed legislation focuses on microgrids because of their ability to provide resilience and to integrate innovative technologies into the grid. In addition, the Secretary of Energy is asked to prioritize renewable and clean energy integration in funding programs.

Industry members have said they won't have enough time to meet ITC deadlines for this year that would allow for a 26% credit.

The legislation proposes extending the federal investment tax credit for solar and geothermal energy and re-establishing the original incentive of 30% through 2025. After that, it would be phased out. The existing ITC program phases out residential solar tax credits entirely after 2021, and steps down the incentive for commercial and industrial deployments to 10% by 2022. The bill would expand the tax credit to include stand-alone energy storage systems, as requested by the storage industry. It would also extend tax incentives for carbon capture and sequestration technology for a few more years.

As requested by the SEIA and others, the legislation calls for "direct payment" options for these incentives to help renewable industry players that have lower revenues due to the COVID-19 crisis and can't benefit from tax credits. Recipients would get 85% of the value of the credit in the form of a tax refund.

Industry members have said they won't have enough time to meet ITC deadlines for this year that would allow for a 26% credit. Solar advocates are seeking approval of a program that provides industry members with a choice of the existing ITC or direct cash payments instead of the ITC for all qualified solar energy projects until the ITC expires. They also have been seeking a multiyear extension of the solar ITC and a postponement of the deadlines specifying when projects should be in place in order to qualify for the ITC.

Without Congressional action, the solar ITC will gradually decrease, which solar advocates say could slow solar growth. The incentive began as a 30% tax credit for solar systems on residential and commercial buildings. It stepped down to a 26% credit for projects that begin construction in 2020 and to 22% for projects that begin construction in 2021.

The residential and commercial solar ITC has allowed the U.S. solar industry to expand by more than 10,000% since it was implemented in 2006, according to the SEIA. Solar advocates argue that a long-term solar ITC — as opposed to an ITC that ramps down — is critical to boosting the number of solar projects in the U.S. and supporting decarbonization efforts.

Trade tariffs

The solar industry also faces some challenges related to trade tariffs imposed by the federal government on solar panels beginning in 2018. Tariffs on imported solar cells and modules have sparked the loss of more than 62,000 U.S. jobs and $19 billion in new private sector investment, said a market analysis from SEIA.

The 30% tariffs are imposed on many of the materials that go into solar PV systems. They have slowed the growth rate of solar PV deployment in the U.S. Some of the negative impacts of the tariffs are being counteracted by continuing technology improvements.

Need for state incentives

Another obstacle to getting more solar plus storage on the ground is lack of financial incentives for homeowners.

However, two states — Massachusetts and New York — provide incentives for homeowners. For example, the Massachusetts SMART program is expected to provide 1.6 GW of solar for the grid. It includes special rates for combining solar with energy storage. New York's Value of Distributed Energy Resources also provides incentives for solar and storage. The program compensates projects based on when and where they provide grid electricity, using a solar value stack calculator. This combines the wholesale price of energy with distributed energy resource attributes that benefit the grid, including avoided carbon emissions, cost savings, and savings associated with utilities avoiding expensive investments in power plants. Implemented nationwide, such programs would help give nanogrids a boost.

Allowing DERs to participate in wholesale markets

Distributed energy resources can improve the grid's reliability and resilience and cut costs, but they need to be allowed to participate in wholesale markets, the Advanced Energy Economy argues. With their battery storage systems, nanogrids can act as flexible resources that are capable of supporting the electric grid and help deploy intermittent renewables.

For example, grid operator PJM has a number of markets for ancillary services, which help balance transmission as it moves electricity from generating sources to consumers.

PJM signed a contract with a global independent power producer that will use a 72 MW/72 MWH battery system to provide grid services to PJM, signalling energy storage's ability to compete and provide grid benefits.

Federal-, state- and utility-level measures can increase the storage market — and with it, the nanogrid market. This will provide resiliency and clean power while helping the grid with essential services and saving building owners money.

New state policies growing

A number of states have begun offering incentives for energy storage, which is a big plus for nanogrids.

For example, the Massachusetts Department of Energy Resources (DOER) in March finalized the nation's first Clean Peak Standard (CPS). This is a regulatory tool that reduces the costs and environmental effects of using polluting generation during periods of high demand. The standard requires electricity retailers to buy credits for clean power that can be used during peak demand.

"During these peak periods, the CPS drives the use of energy storage resources to deliver clean energy exactly where it's needed, when it's needed," said the U.S. Energy Storage Association (ESA).

California's Self Generation Incentive Program (SGIP) provides incentives for existing, new and emerging DER. Rebates are for DER on the customer side of the meter, and they go to wind turbines, waste heat to power technologies, pressure reduction turbines, internal combustion engines, microturbines, gas turbines, fuel cells and advanced energy storage systems.

In 2017, California regulators doubled incentives for the program, giving the lion's share to energy storage funding for homeowners and businesses.

Resilience incentives in California a boost to nanogrids

In September, the California Public Utilities Commission approved a measure, part of the SGIP, aimed at boosting resilience for people in areas vulnerable to wildfires. It increased the current incentive cap of 50 cents/Wh for batteries to 85 cents/Wh.

To prepare for the next wildfire season in 2020, the commission authorized funding of more than $1 billion through 2024 for the SGIP. The funding prioritizes communities located in regions with high threats of fire and those that have experienced two or more public safety power shut-offs. It also prioritized low-income and medically at risk customers. This funding is also available to critical facilities—hospitals, for example—that support community resilience in the context of power shut-offs and wildfires.

As government policies create additional incentives and regulations that benefit solar and, more importantly, solar plus storage, how will solar installers benefit? We examine that question in Chapter V.

Chapter V: Solar's Transition to Nanogrids — and Why it's Good for Solar Installers

Savvy solar installers have their eye on the nanogrid market—the next phase in solar plus storage—as a potentially large market for their industry. The number of nanogrids in operation is small, but energy forecasters anticipate a significant increase over the next several years.

Watching how quickly the solar market grew is instructive for the future of nanogrids. In each of the last six years, solar has ranked as either the first or second fastest growing source of electricity. Today, the U.S. has enough solar capacity to power 13.1 million American homes, a number that the SEIA expects to double by 2024.

Energy storage, another key component of nanogrids, also is on a fast track. The U.S. deployed a record 311 MW and 777 MWh of energy storage in 2018, numbers that Wood Mackenzie sees doubling in 2019 and tripling in 2020.

The growth of the two technologies are symbiotic because they are increasingly paired into one system. The nanogrid is a system that benefits from this pairing. The nanogrid adds technology for islanding—the ability to disconnect from the grid during a power outage and generate energy independently.

> Now, solar installers can provide homeowners not only with clean and dependable energy, but with longer guarantees of electric reliability, all of which nanogrids provide.

Nanogrids act as a new growth avenue for solar and storage. Navigant Research estimates the global revenue for solar plus storage nanogrids will rise from $1.2 billion in 2015 to $23.1 billion in 2024.

The increasing market in residential solar-plus-storage is mostly driven by consumers' interest in resiliency. With more storms, floods and hurricanes, customers want to know their power can stay on 24/7. This is creating a new niche service for solar installers, and it adds to the value proposition of their product. Now, solar installers can provide homeowners not only with clean and dependable energy, but with longer guarantees of electric reliability, all of which nanogrids provide.

What's more, nanogrids can provide environmental benefits by deploying more zero-emissions energy sources, making use of waste heat, reducing energy lost through transmission lines, helping manage power supply and demand, and improving grid resilience to extreme weather, all while helping solve grid challenges. Boosting the implementation of nanogrids yields advantages to the solar industry, homeowners, grid users and the environment—a win-win for all.

Next, let's take a look at real-world examples of nanogrid projects underway.

Chapter VI: Three Nanogrid Examples in the Real World

Nanogrids in 37 new homes for U.S. veterans

Solar as a renewable resource is unpredictable in nature and hard to scale up and down in line with demand. When it's centrally produced, it suffers from transportation inefficiencies. Most homes and businesses generating solar power locally lack the information and the control capabilities required to generate it effectively and efficiently.

Photo credit: flysnowfly/Shutterstock.com

Instant ON is partnering with All American Homes to build a community featuring nanogrids in 37 new homes for U.S. military veterans in Perris, California. The project will employ a "home as a service" model that the developer hopes to replicate nationally.

Unique use of a large energy storage system

What's unique about this project is its use of a large energy storage system. Each home in the pilot project will have 5 kW of solar, 40 kWh of battery storage, an intelligent circuit panel and advanced microgrid management system. The community center will be equipped with a 1 MW battery powered by CHP system to provide additional resilience.

In addition to providing backup power for the homes, the batteries will participate in demand response markets to provide revenue when the stored power is not needed for blackouts.

Another unique aspect of this project is the use of an intelligent circuit panel and advanced home energy management system, the IO-HUB. The IO-HUB optimizes the energy with metering by load or circuit. This strategy better optimizes how each energy source will be used in the application.

These nanogrids use standardized designs, which makes it easier to finance and deploy these connected communities of nanogrids. They can be tied to larger microgrids, which are ultimately tied to the central grid.

In this project, delivering energy as a service, Instant ON eliminates risk for the customer in a model that shifts their investment out of their capital budget and into their operational budget. The model also is able to bring in the many cost saving measures of a standardized design/build approach. Revenue is generated by supporting the grid with stored power when the stored power isn't being used by the nanogrid host during outages.

Hawaii's affordable nanogrid project supports growth of solar, resilience, independence

To support the growth of solar, resilience, savings and independence in Hawaii, Instant ON is working with Myron Thompson, CEO of CoolXEnergy, past vice president of the Hawaii Solar Energy Association and past president of the Hawaii PV Coalition. The goal is to introduce a simple, affordable nanogrid solution that can provide all these benefits but also be technology and contractor agnostic, allowing for ease of deployment. This will empower more solar companies to progress toward Hawaii's environmental goals.

The IO-5M, normally a portable 5-kWh battery that typically requires no professional installation or permitting, allows for quick integration. The second and key piece of this nanogrid is the IO-HUB. This replaces three components: the conventional smart meter, electricity panel and essential loads panel. It can monitor and control energy consumption and can be used at the customer's premises with the capability of controlling in a granular fashion—down to individual circuit levels. In addition to standard circuit breakers, the unique architecture includes an array of highly reliable hybrid smart switches, which are capable of connecting and disconnecting manually—or automatically—in response to current overload, short circuit, sparks and overheating.

Controls monitor and reacts to variable pricing

The IO-HUB has the ability to monitor and react to variable pricing information, allowing consumers to operate appliances when rates are low. It provides real-time information such as abnormal consumption, unstable power or frequency, power outages and more. With an integrated revenue grade meter, the hub provides a utility bill that is itemized to show how much energy was used and the costs associated with each circuit.

"By adopting the IO-HUB, property owners can reduce the size of battery storage, thus reducing costs," said AJ Perkins, president of Instant ON. "This solution would help Hawaii in meeting the state's 100% renewables by 2045 mandate. It also aligns with the utility's grid modernization strategy."

He added: "It's important to stop viewing locally produced power as backup power for our strained grid. Instead, we can flip the conversation so that the building is primary and the grid is secondary. This empowers the customer, allowing for change at a quicker pace. We can leverage distributed energy resources as our primary sources of power and treat the grid as the energy 'highway' for energy sharing."

Adding fuel cells to boost resiliency and redundancy

The electric grid is experiencing rapid innovation, and DERs are increasing in number, diversity and geographic breadth. Integrating DERs onto the grid creates interoperability challenges. For grid transformation to be successful, we must resolve this problem. While stakeholders—utilities, vendors, regulators and researchers—are working to solve this issue, chaos still reigns.

The information available is both confusing and inconsistent. Also, while undertaking a community nanogrid resiliency project, a challenge arose in trying to ensure that there was enough power generated from solar to support the home and supply the 40-kWh batteries. This issue, combined with the intermittencies and unavailability of solar in the evening, led the company to look for supplemental power to help fill the gaps in solar.

Instant ON is working with a university research center and a utility to integrate a fuel cell into a residential solar nanogrid.

Instant ON is addressing this and other challenges with another project in California. The company is working with a university research center and a utility to integrate a fuel cell into a residential solar nanogrid. The BlueGen small scale SOFC technology provides an opportunity to demonstrate zero carbon fuel and reduce cost in ways that will lead to a resilient, zero carbon energy solution. The solution can be cost effectively and broadly deployed across small commercial, multifamily residential segments as well as targeted loads in medium to large commercial buildings.

Integrating a 1.5-kW fuel cell powered by natural gas provides about 13,000 kWh of low emission electricity per year. The waste heat produced in the process of generating electricity can be used to heat water. The fuel cell creates not only resilience and savings for the home, but also another source of redundancy to ensure power will always stay on. By integrating a secondary generation source, we can also reduce the size of the battery. The fuel cell can produce energy 24/7 with fewer emissions than traditional grid power and at a lower cost. All the while, the fuel cell allows the home to avoid time-of-use rates that may be higher when there's no solar production.

With two of California's largest investor owned utilities abandoning their plans to build permanent microgrids for 2020 and the inevitable wildfire season approaching, the need to protect homes from the devastating public safety power shut-offs of 2019 is a top priority. When you add the COVID-19 stay-at-home orders imposed on millions in the U.S., consistent, reliable power in the home becomes a necessity. Many buildings and homes simply cannot rely on solar-only microgrids because of space constraints, weather challenges or shading. Instant ON focuses on creating alternative solutions to help ensure that communities are not forced to transition to dirty power solutions, such as diesel generators.

Pilot project takes on interoperability challenges

This pilot project in California addresses many interoperability issues.

"We are integrating a nanogrid/microgrid with different technologies, devices, manufacturers and contractors involved. The project will provide many useful insights. Too often, the industry doesn't see challenges until a system doesn't operate as designed," Perkins said.

"As someone intimately involved with the trail-blazing DER efforts in California and elsewhere, and because California is the recognized global leader in the efforts to integrate DERs into grid operations, DER interoperability in California is a high priority for us," said Perkins, who has worked with Lockheed Martin Energy on utility driven incentive upgrades and with the California Energy Alliance to help guide policy in California.

The value of microgrids to protect homes and businesses from power outages is becoming increasingly important in the face of outages spurred by severe weather. What's more, the COVID-19 pandemic is shining a light on the importance of resilience at this time. Advanced microgrids will serve to mitigate the economic impacts of power disruptions and will be able to interact with, connect to and disconnect from one another and the central grid.

INSTANT ON

About Instant ON

Today's microgrid revolution has brought greater energy reliability, cost savings and sustainability to commercial and industrial facilities. But the household was largely left out of the equation—until now. The Instant ON nanogrid offers a simple but robust microgrid solution designed not only for businesses, but also the home. Instant ON partners with solar contractors and their customers to help them take the guesswork out of system design and optimization with a vetted and tested nanogrid solution.

For more information, contact: partner@instanton.energy