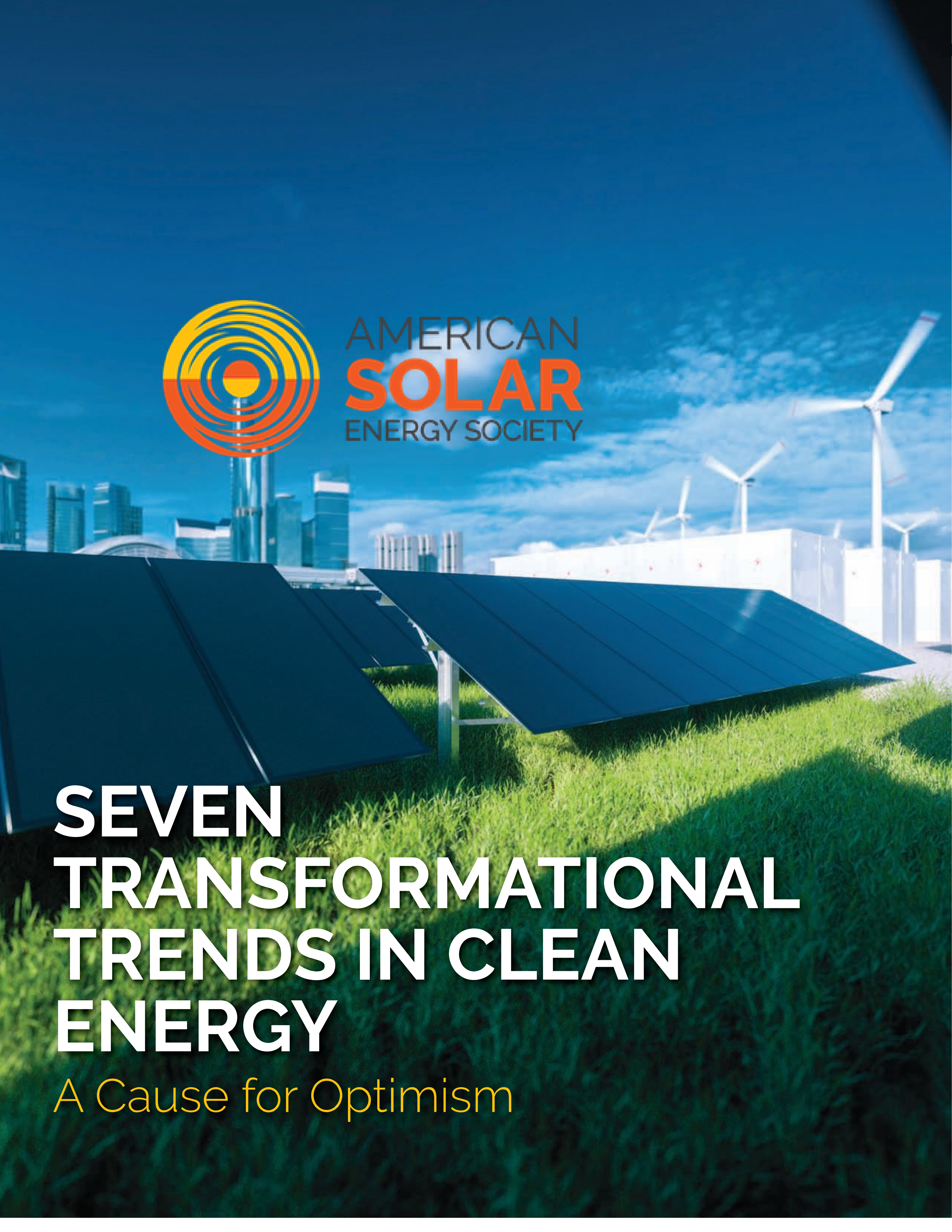

AMERICAN SOLAR ENERGY SOCIETY

# SEVEN TRANSFORMATIONAL TRENDS IN CLEAN ENERGY

## A Cause for Optimism

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By Scott Sklar

Huge trends in the global marketplace are driving how we use energy, communicate, interface, and transport ourselves. These trends are merging so that it is difficult to view them individually; they now appear as intertwined. I will list these trends with supporting information from a number of sources to paint the picture.

### 1. Transactional Energy, Blockchain Uncover Hidden Value

There are over 70 software solutions for power plant monitoring. Most Operations and Maintenance (O&M) providers use a mixed portfolio of software applications to manage commercial and industrial (C&I) systems, including wind farms and solar parks. As information and operational technologies converge, intelligent building solutions that provide actionable insight using data-driven tools are gaining traction worldwide. Because the intelligent building is fundamentally reliant on creating a data-rich environment, sensors play a crucial role in facilitating these solutions. Sensors capture, communicate, and analyze energy and operational data. This data is useful information to

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direct fundamental changes in operations that result in energy efficiency improvements with substantial cost savings.

The infrastructure that gathers and transmits data to deliver actionable insight is part of what's referred to as the Internet of Things (IoT). Wireless sensors can help deliver holistic and comprehensive insight into operations across systems within a secure, scalable, and open infrastructure. Wireless connectivity provides greater flexibility for sensors and amplify the benefits of intelligent building solutions. Larger networks can increase the number of connected devices, enabling more granular control over building systems. According to Navigant Research, global wireless sensor revenue is expected to grow from $188 million in 2016 to $745 million in 2025, a 16.5% compound annual growth rate (CAGR).[1]

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Demonstration microgrid at Joint Base San Antonio.

## 2. Transactional Energy, Blockchain Uncover Hidden Value

A complex technology with a simple name, blockchain is a transaction-tracking technology that is the underpinning behind cryptocurrency such as Bitcoin and Etherium. When a block stores new data it is added to the blockchain. Multiple blocks strung together enable the tracking and monetizing of energy loads, utility bills, and other energy savings and energy producing options such as on-site renewables. According to recent research from Monash University in Australia, as blockchain industries mature, they allow utility and microgrid market operators to enable "transactive energy" to control the flow of power in the electrical grid, building, or facility, using economic or market-based constructs. Transactive energy can benefit both distributed energy resources (DER) operators and the central grid. It encourages "dynamic demand-side energy activities based on economic incentives and ensures that the economic signals are in line with operational goals to ensure system reliability," according to their research. DER operators are able to tap into new revenue streams by selling services to the grid, abd the grid gains greater stabilization from the services.[2]

## 3. Energy Storage Comes of Age

Energy storage allows energy to be utilized when it is most cost-effective or most urgent. There are a host of options which include batteries, compressed air and storage, pumped hydro, flywheels, weights, molten salts and ice, and even hydrogen. All are susbstantially decreasing in cost and are becoming more sophisticated in their interaction with utility grids, microgrids, buildings, and other infrastructure.

Bloomberg New Energy Finance reported last year that storage investments are booming as battery costs are set to halve in the next decade. They forecast energy storage installations around the world to multiply exponentially, from a modest 9 GW of energy and 17 GWh of power deployed as of 2018 to 1,095 GW/2,850 GWh by 2040. They report, "This 122-fold boom of stationary energy storage over the next two decades will require $662 billion of investment and will be made possible by further sharp declines in the cost of lithium-ion batteries, on top of an 85% reduction in the 2010-18 period."[3]

Although Bloomberg's forecast excludes pumped hydro energy storage, CleanTechnica reported that pumped hydro energy is storage poised for "global domination."[4] Researchers at Australian National University have identified 530,000 potential sites for pumped hydro, suggesting that a massive amount of energy storage capacity is already close at hand. The National Hydropower Association notes that the U.S. has more than 20 GW of pumped storage capacity today, with facilities in every region of the country. Developers have proposed an additional 31 GW, primarily in the West, to support an increasing amount of variable generation that is coming online. New battery materials are also rushing into the global markets, as well as compressed air and liquid storage, flywheels, gravity storage, and hydrogen.

### 4. Microgrids and Hybrid Energy Systems: The Start of the Self-Healing Grid

Technologies and software allow electric grids to stabilize into discrete areas so that when there is a major failure, the electric grid itself can shed the areas impacted and sustain itself. Within the failing grid areas, microgrids are employed which can passively take over to further power critical functions.

The communications network composed of fiber optics, satellites, and cellular towers have now become self-healing grids – when a cell tower goes down, the towers triangulate and take over the loss. Smart data centers also have this self-healing capacity. As data centers go down, others compensate for the loss, and the internet remains operational. The global electric grids are also moving towards self-healing grids with advanced sensors and controls. An electric grid will be able to segment with sectionalizers and reclosers. Within those grid segments, battery storage littered throughout and microgrids are able to passively separate and power buildings or neighborhoods. And when all is better, the system can reconnect and operate as normal. This trend is unstoppable, and will significantly add to resiliency, reliability, and higher electric power quality (no surges, sags or transients, all of which ruin digital equipment), while lowering costs, freshwater use, pollution and greenhouse gas emissions.

Wood Mackenzie's newest report, *US microgrid forecast H1 2020: Coronavirus delays projects and impacts origination*, shows that 546 microgrids were installed in the United States during 2019, more than any other year. Three organizations - PowerSecure, Enchanted Rock and The American Red Cross – installed a combined 67% of these projects. Of these, the Red Cross was the only to integrate energy storage into their projects, pairing them with solar at non-residential locations. Last year saw nearly 50% growth in the number of microgrids. The share of renewable microgrid projects is expected to rise, with WoodMac anticipating solar, wind, hydropower and energy storage accounting for 35% of installed capacity annually by 2025.

A 2019 World Bank report says solar+storage is fueling a global mini-grid surge.[5] They report that "plummeting solar+storage costs could help electrify millions worldwide by facilitating a ten-fold explosion of mini-grid systems." The 19,000 mostly hydro- and diesel-based mini-grids that power 47 million people today could boom to 210,000 systems powering 490 million by 2030. The report said most new mini-grids will feature a mix of photovoltaics (PV) and small wind, with batteries, adding that the 10-15 GW of solar and 50-110 GWh of mostly lithium-ion batteries expected by 2030, would bring 1.5 billion tons of $CO_2$ savings. Mini-grids, unlike microgrids, are not connected to the larger macrogrid.

A 2020 Lawrence Berkeley National Laboratory data compilation maps existing hybrid and co-located plants across the U.S. while also synthesizing data from generation interconnection queues to illustrate developer interest in the next wave of plants. There are at least 125 co-located hybrid plants (>1 MW) already operating across the U.S., totaling over 14 GW of aggregate capacity. Some of the most common configurations include wind+storage (13 projects, 1,290 MW wind, 184 MW storage) and PV+storage (40 projects, 882 MW PV, 169 MW storage). Many other configurations exist, for example, fossil+PV, fossil+wind, wind+PV, hydro+storage, geothermal+PV, CSP+storage, and more. Wind hybrids have been most common in ERCOT (The Electric Reliability Council of Texas) and PJM (an Eastern U.S. grid operator), with PV hybrids coming online in the non-ISO (independent system operator) West, ERCOT, and Southeast.[6]

### 5. Linkage of Interdependent and Interactive Communications, Data, Transportation and Building Systems

Bringing energy intelligence to the grid efficiently balances generation and

> New renewable energy capacity hit record levels last year with almost
> **75%**
> **of new electricity capacity being renewable.**

demand while generating new opportunities to increase revenue streams and cybersecurity. Most of the innovation is at the "grid edge" where power quality and reliability is poor, and allows more decentralized, distributed and clean energy to build market niches.[7]

A November 2019 paper by Sneya Ayyagari and Matt Jungclauss entitled *Innovation Opportunities in Grid-Interactive Efficient Buildings*[8] aptly lays out this new trend: "What if buildings could communicate with the electric grid to save money and reduce their environmental impacts? Buildings drive up to 80% of the peak demand on the grid, and peak demand drives grid investments in generation, transmission, and distribution assets, so there is a huge opportunity to balance building demand with electricity system supply." Through demand management and load flexibility, grid-interactive energy efficient buildings (GEBs) leverage technologies and strategies to address this issue. GEBs optimize energy efficiency, energy storage, distributed energy generation, and load-flexible technologies, as well as interface with electric vehicles to match evolving needs of the electricity system. This provides a more flexible building energy load profile with lower peaks, reducing building operating costs through demand-charge savings.

LF Energy has launched its Digital Substation Automation Systems initiative, creating a more modular grid.[9] It looks to make interoperable substations that are both hardware and software agnostic. A digital substation de-aggregates hardware and software, so you can use commodity hardware in order to run software. This decreases cost as the system will be able to abstract the hardware by creating software-defined hardware, meaning that the hardware used in a substation won't matter, because all hardware will be compatible with the same, open-source, software, essentially creating plug-and-play substations. The idea is to take generation assets like a PV system and think about their generation less from a control perspective and more from an orchestration perspective.

### 6. Financial Tools (On-Bill Financing, C-PACE, and Others) Supporting Technology Evolutions

Already, at least 110 utilities in 33 states offer on-bill financing (OBF). At least 13 states have passed legislation enabling OBF, and programs are under consideration in several more.[10] Such programs are successfully supporting a wide range of products and services that will pay for themselves through avoided utility bills, including electric, heating-fuel, water, and wastewater bills.[11] Examples include:

- Energy efficiency improvements, including whole building retrofit services and high-efficiency new construction;
- High-value energy efficiency improvements such as new high-efficiency major appliances and heating, ventilating, and air conditioning (HVAC) equipment, including solar water heating, grid-integrated water heaters, ice-storage air conditioning, and heat pumps including ground-coil loops for earth coupled heat pumps;
- Both indoor and outdoor lighting, including street lights and security lights, with wired or wireless options;
- Remote, off-grid equipment, such as livestock-watering and irrigation systems using solar pumps;
- Rooftop solar and community solar, with some programs including battery storage and some eligible for both on- or off-grid installations;
- Battery storage and uninterruptible power supplies, including systems for customers needing medical devices or other critically essential needs, and;
- Electric vehicle charging stations.

The property assessed clean energy (PACE) model is an innovative mechanism for financing energy efficiency and renewable energy improvements on private property. PACE programs exist for:

- Commercial properties (commonly referred to as Commercial PACE or C-PACE)
- Residential properties (commonly referred to as Residential PACE or R-PACE).

Established by local governments, PACE allows property owners to finance up-front costs of energy efficiency and renewable energy on their property and building(s) and to pay back over time through a voluntary assessment. The assessment is attached to the property rather than an individual or company. Local governments set up a "land-secured financing district" also known as an assessment district or local improvement district. The local government issues bonds to fund these projects for these districts, which serve a public purpose, similar to how they fund parks, schools, water, and sewage projects.[12]

Residential PACE allows homeowners to finance energy efficiency, renewable energy and other eligible improvements on their homes using private sources of capital. According to PaceNation, as of 2019, over 200,000 homeowners have made $5 billion in energy efficiency and other improvements to their homes through PACE financing, and investments for commercial PACE projects have topped $1,538,240,000.[13]

### 7. Mass Sales Beget Market Penetration and Economic Might

As global sales increase and installed costs of all renewables and energy storage decrease, we see a massive market shift. A recent report from The International Renewable Energy Agency (IRENA) showed that new renewable energy capacity hit record levels last year with almost 75% of new electricity capacity being renewable. New solar power provided 55% of this new capacity, most of which was installed in Asia, with China, India, Japan, South Korea and Vietnam leading the way. Other major increases were seen in the US, Australia, Spain, Germany and Ukraine. Wind power made up 34% of the total, with almost half in China and significant additions in the U.S. Global wind power capacity remains just ahead of solar, with 95% being onshore turbines.

Other green technologies – hydropower, bioenergy, geothermal and marine energy – all grew modestly year-over-year. While small compared with solar and wind power, geothermal energy – tapping the heat of deep rocks – is growing, with Turkey, Indonesia and Kenya leading the way.[14] Zion Market Research reports the global geothermal energy market was valued at approximately $4 billion in 2018 and is expected to generate around $9 billion by 2025.[15]

According to SolarPower Europe's new "Global Market Outlook", which analyzes solar installations in 2019, and forecasts capacity for 2020–24, the global solar sector will reach terawatt scale by 2022 – just four years after the 500 GW milestone was reached. Other milestones to expect in the next few years include solar reaching 700 GW by the end of 2020, and 1.2 TW by 2023.[16]

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Global wind power capacity remains just ahead of solar, with 95% being onshore turbines.

For the first time ever in the history of the U.S. power grid, renewable energy is beating coal. We are witnessing transformative technological change moving at warp speed in the midst of two global emergencies – and climate change and the COVID-19 pandemic. These advanced integrations of technologies with enhanced sensors, controls, and algorithms give us the reliability, agility, resiliency, reliability, and environmental optimization necessary to address climate change, this and upcoming pandemics, and other global challenges. While these changes have the potential to ease these challenges, greater global cooperation between multilateral organizations, national governments, and the financial and banking sectors need to be heightened and accelerated. ■


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