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Dick Flanagan
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The first quarter of the year just closed and we are reviewing the results from companies, the Trump administration and World-Gen. AW Stats measures traffic on world-gen.com and new records were charted for the first three months.

Rick Perry opens the issue and his offices at DOE. He lays out his strategy of going where science leads us with "all the above approach" on page 4.

President Trump signed the Executive Order titled, "Promoting Energy Independence and Economic Growth," contents on page 6.

Michael Pariser of EDF explains how to move beyond REC's and accelerate your company's commitment to clean energy additionality on page 8.

Lyn Corum tells us on page 10 that retail competition and oversupplies are bedeviling California's utility industry. The declining costs of solar and wind resources are boosting their development.

Jim Schretter shows six ways to modernize the grid on page 12. He sees 40 dollars returning to the economy on every research dollar spent.

Bill Rose wants us to embark on a digital transformation on page 14. ABB and Microsoft have developed a strategic relationship on the Azure platform.

Paul Spencer says 150 US utilities are now operating or developing a voluntary community solar program. Even the Trappist monks are going with community solar on page 16.

Paul Winters explores new partnership for the BIO World Congress on page 18. North America has been establishing new commodity markets.

John P.W. Brown advises us on "Avoiding the Technology Trap" on page 20. A living annual roadmap avoids a future technology trap.

Meet the 10 companies selected by BNEF as the 2017 New Energy Pioneers! One hundred and seventy companies applied from 43 countries, and the winners are profiled by Veronika Henze on page 21.

Sean Peasley introduces Next-Gen Cyber Security from DeLoitte and Dragos on page 22.

University of Washington testing Cleantech innovations for spin-offs, Suzanne Offen predicts on page 23.

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November-December 2017 - POWER-GEN - Digital/Print Edition
January-February, 2018 - 30TH ANNIVERSARY ISSUE and CLASS OF 2018.

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BNEF SUMMIT SPEECH

BY RICK PERRY

To my hosts from Bloomberg, thank you for your kind invitation and for this opportunity.

I am humbled to serve in a capacity that has such a wide-ranging impact on our nation's economy and security, as Secretary of Energy.

I get to work alongside some of the brightest minds in the world at our National Laboratories. I get to work with scientists, engineers and others as they seek new and better ways to deliver and conserve our precious energy resources.

And I get to work with dedicated men and women that not only clean up the legacy of the Cold War, but who work every day to keep a potent and effective nuclear deterrent safe for our military.

We're all gathered today to discuss "the future of energy" which I believe is of strategic importance for our country. In fact, it's our energy potential that makes me excited to go to the office every day, to travel this country and to advocate for our interests on an international stage.

You can't talk about the future of energy without talking about its ongoing transformation. Everyone in this room is aware of the evolving fuel mix; the rise of renewables and expanding use of data analytics into how we develop and use energy.

As a former Governor of a rather energy intensive state, I saw it first hand and know many of the challenges but also the opportunities this change brings. In Texas' case, our governance structure and investment community saw the opportunities in wind and Texas now produces more wind energy than all but five countries in the world.

Wind, solar, biofuels and whatever the next energy source is will be part of our 'all above approach.' So is technology, which I think is where we may have some of our greatest potential.

We have witnessed a major transformation of the oil patch as hydraulic fracturing and horizontal drilling have opened

up once unproductive shale formations, literally tipping the balance in the global energy markets. By the way, that breakthrough was assisted by the Department of Energy labs.

We see DOE-sponsored research throughout the economy. I just viewed the carbon capture and sequestration technology at the Petra Nova plant near Houston. This sequesters over 90% of the emissions from a coal fired plant and uses it 80 miles away for enhanced oil recovery.

Science, technology and innovation have made us world leaders across the energy spectrum. If we didn't have the willingness to follow the science on coal, then we would never discover and develop the rare earth elements found in coal...elements that are used in jet engines and even hybrid cars.

It reminds me of a twitter meme I saw recently of a photo of a person...with the words, "wants to ban mining...hybrid car powered by lead, nickel, lithium..."

The days of hand-picked favorite sources of energy are over. Our predecessor led a war on coal that we're working to unravel and remove distortions from the marketplace. We will go where the science leads to develop what our economy needs, and we will not hijack science for pet causes while suppressing it when it doesn't fit a political agenda. At the Department of Energy, we are focused on research and development that can one day be commercialized for the good of our country. That research applies to the "all the above" approach; from fossil fuels, to nuclear to renewables and even to ideas yet to be explored.

Technology, research and innovation have brought us to an amazing point in history. We now see we have more identified energy sources than at anytime in history, and I would venture a guess to say there are some that have not been developed yet.

The last eight years we saw policy-making driven by political agendas. Previous leaders said they were for American energy independence and domestic energy development...they just didn't want to drill for it, mine it, transport it or sell it. Exploration on federal lands

and waters decreased. Permits for vital projects were slow-walked and slow-talked and then just left to wither on the vine. Those days are over. We want policies, better yet, we want actions that make America safer, stronger and freer. I am here to say that one of my main goals is to harness our resources, marshal our technology and science, and deliver on the marching orders the President gave me when I accepted the high honor to serve as his Secretary of Energy: To make the United States not just energy independent, but energy dominant.

We'll accomplish our goal on a number of fronts:

First, we will attack the conventional wisdom that says you can't drive the economy without harming the environment. When I was governor of Texas, we led the nation in job creation. We are also home to a highly industrial state, with a massive petrochemical complex on the Gulf Coast which is conducive to ozone production. Yet we reduced our carbon footprint by 17 percent, and drastically reduced sulfur dioxide and nitrogen oxide emissions...despite adding seven million new residents.

Second, we will ensure that renewable energy finds its way to the grid, and the tremendous resources presented by the wind, sun and hydro are efficiently captured and delivered. Yet while doing this, we will also ensure that our grid reliability...our baseload capacity that is needed to power the economy is not tossed aside in the name of political favoritism.

BASELOAD

I have asked the staff at the Department of Energy to undertake acritical review of regulatory burdens placed by previous administrations on baseload generators. Baseload power is critical to a well-functioning grid. Reliable electricity is a crucial economic driver, but over the last few years grid experts have expressed concern about the erosion of critical baseload resources specifically how it is dispatched and compensated. These politically-driven policies...driven primarily by a

(continued page 21)



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TRUMP SIGNS EXECUTIVE ORDER

On March 28, 2017, President Trump signed an executive order titled “Promoting Energy Independence and Economic Growth” that reverses or materially alters many of the actions that the federal government undertook during the Obama Administration to address climate change. According to the Executive Order, President Trump is mandating these actions to promote development of the nation’s natural resources, ensure that electricity is affordable, reduce regulatory burdens on companies and respect the role of states in environmental regulation.

The Executive Order requires “particular attention to [the burdens on] oil, natural gas, coal, and nuclear energy.”

The Executive Order includes a general review of all agency actions that could burden domestic energy production and requires reviews or repeals of specific federal regulations.

The most immediate effects relate to review of projects by federal agencies under the National Environmental Policy Act (“NEPA”), coal leasing on federal lands and climate change initiatives within federal agencies.

Longer-term impacts relate to regulation of air emissions from new and existing fossil fuel-fired power plants and regulation of oil and gas development, as well as other programs to be identified that burden domestic energy industries.

The range of actions could reduce burdens on renewable energy development as well.

GENERAL REQUIREMENTS

The Executive Order broadly mandates that all federal agencies “review all existing regulations, orders, guidance documents, policies, and any other similar agency actions . . . that potentially burden the development or use of domestically produced energy resources, with particular attention to oil, natural gas, coal, and nuclear energy resources.”

By July 26, 2017, agencies must submit a draft report identifying regulations and

policies that the agency could “suspend, revise, or rescind” to “alleviate or eliminate aspects of agency actions that burden domestic energy production.”

By September 24, 2017, agencies are required to finalize their proposed actions and then implement the revocations, modifications or other changes as soon as “practicable” thereafter.

The private sector will likely assist agencies in identifying burdens to domestic energy development and recommend suspension, revision or rescission of specific regulations prior to the July 26, 2017, draft due date.

REVOCATION OF EXECUTIVE ORDERS, POLICIES AND REPORTS

President Trump’s Executive Order rescinds prior policy statements, executive orders and reports that established climate change objectives, including the following: Agency Planning; Clean Power Plan; Coal Leasing; Social Cost of Carbon; and NEPA Review.

Generally speaking, these documents established federal policies governing federal agencies in their regulatory and procurement activities, and all relate to climate change issues.

The rescission of these orders, memoranda and reports does not directly affect the private sector, except with respect to coal leases on federal land or projects subject to ongoing or future review under NEPA.

ACTION ON SPECIFIC REGULATIONS

President Trump’s Executive Order also directs the Environmental Protection Agency and Department of the Interior to “immediately take all steps necessary to review the [following] final rules . . . and, if appropriate . . . publish for notice and comment proposed rules suspending, revising, or rescinding those rules”:

IMMEDIATE EFFECTS

The Executive Order takes effect immediately with respect to federal agency policies and guidance (not regulations). The prior executive orders, memoranda and policy-oriented reports may be rescinded by the President, and that rescission is essentially not appealable.

EFFECT ON FINAL REGULATIONS

President Trump’s Executive Order immediately revokes previous executive orders and presidential memoranda, but does not (and cannot legally) change any regulations that are currently in effect.

EFFECT ON PENDING LITIGATION

Most of the regulations that the Executive Order directs the EPA or Interior to revise or withdraw are currently being litigated in federal courts.

RENEWABLE ENERGY

The initial analysis of the Executive Order suggests that more liberal regulation of the fossil fuel sector will reduce the costs of conventional energy and provide additional cost or competitive pressures on development of renewables. But the Executive Order could benefit renewables, as well, by reducing other regulatory burdens imposed by agencies (such as enforcement of wildlife protection laws applicable to wind energy facilities) or reducing the time required for NEPA review of renewable facilities subject to such review.

Other Trump Administration policies, like its proposals for tax reform that could affect tax incentives for renewable energy, could also greatly impact renewable development.

Accordingly, it is uncertain whether the Trump Administration’s actions will have an overall positive or negative impact on renewable energy development.

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ACHIEVING ADDITIONALITY

BY MICHAEL PARISER, EDF RENEWABLE ENERGY



While the purchasing of Renewable Energy Certificates (RECs) has historically been a popular method among corporations to make claims of their carbon impact mitigation efforts, customers are increasingly demanding that carbon reduction “additionality” be achieved by their suppliers’ renewable energy efforts. Customers know that, by demanding renewable energy “additionality” among their suppliers, they can effectively see past those suppliers who merely purchase REC certificates and identify which suppliers actively reduce the world’s carbon footprint by enabling the construction and addition of new renewable energy sources into the world’s electricity grid.

Here are five key questions that corporate energy buyers face when identifying their optimal path forward in pursuing renewable energy additionality...

1. HOW SHOULD I PAY FOR MY RENEWABLE ENERGY ADDITIONALITY?

You and your company’s Chief Sustainability Officer might agree on everything under the sun when it comes to pursuing such a noteworthy cause as renewable energy additionality, but realistically your idea will never gain the necessary traction without the support of your CFO. There are two main purchasing options for a corporate buyer to choose from in its pur-

suit of additionality: outright purchase and ownership of the electricity generation facility (wind farm, solar array, etc.), or the execution of a long term Power Purchase Agreement (PPA) with the energy seller. While some corporate buyers prefer the outright ownership of the renewable energy facility for various reasons, including their ability to monetize tax credits or their leadership’s philosophy on real asset ownership, more than three-quarters of corporate buyers have instead chosen to enter into long-term PPAs (usually 15 years or longer), which can be structured as a physical energy deal or a purely financial contract also known as a “Virtual PPA”. The ownership option requires the buyer to incur significant up-front capital expense (often disliked by the CFO) to complete the purchase of the renewable energy facility, whereas the PPA deal structure allows the buyer to pay for the renewable energy as it is generated during the life of the contract, effectively capturing more of a pay-for-performance deal spirit.

2. HOW SHOULD I PICK WHERE TO GEOGRAPHICALLY LOCATE MY RENEWABLE ENERGY ADDITIONALITY PROJECT(S)?

Corporate buyers tend to prefer to locate their renewable energy projects as close to their physical electric load as possible, and often their load profile is dispersed over a wide geographic footprint. But due to the fact that renewable energy project economics favor the largest-size deals possible, it is usually not economically feasible to execute several smaller-scale projects throughout the corporate buyer’s geographic footprint, and often times the pursuit of onsite renewable energy projects (such as rooftop solar) is not feasible due to physical space restraints or lease restrictions. For these reasons, large-scale offsite renewable energy projects are the most popular

choice for tackling renewable energy additionality, but selecting a location is not as straightforward as picking an offsite wind or solar project located next to the buyer’s largest electric load pocket.

Selecting a site is not as straightforward as picking the wind or solar project located nearest to the buyer’s largest electric load. Corporate buyers are typically driven to select projects located in the geographic markets where the most financially-optimal deals are available to them. This is primarily based on comparing the project’s offer price (i.e. PPA price in dollars per MWh) with the floating market price. While the optimal economic project may not be as closely located to the buyer’s load as one would prefer, Corporate buyers typically ensure that the project’s location is at least within the same country or regional electric grid (regional ISO, in the United States) as its electric footprint, or located within the “dirtiest” electric regions from a carbon emissions perspective. This ensures a strong sustainability message from a public relations standpoint, while providing the flexibility needed to secure the most economic additionality projects.

3. WHAT TECHNOLOGY SHOULD I CHOOSE FOR MY RENEWABLE ENERGY ADDITIONALITY PROJECT(S)?

Whether your additionality project is powered by wind, solar, biogas, geothermal, or another renewable energy technology, the integrity of your corporate carbon reduction claim will be strengthened by demonstrating that the project is additional. As with the selection of its geographic location, the technology type of your corporation’s additionality project will be overwhelmingly determined by economics. In certain geographic regions such as California, the U.S. southeast and the desert southwest, solar is currently the most

(continued page 22)

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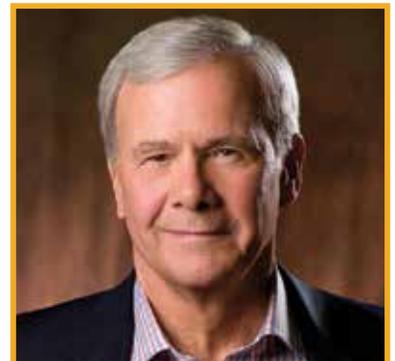
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KEYNOTE SPEAKER



Tom Brokaw

Join us on Tuesday, June 13 for an evening with Tom Brokaw, the legendary NBC newsman celebrating his 50th year of award-winning journalism. Stay tuned for more exciting speaker announcements.

RETAIL COMPETITION, OVERSUPPLIES BEDEVILING CALIFORNIA'S UTILITY INDUSTRY

BY LYN CORUM, CLASS OF 2003



The California Energy Commission approved the licensing of two new power plants on April 12 which may be among the last few gas-fired plants to be built in the state. The discussion among commissioners leading up to the final vote brought starkly into view the impact technology changes, including the renewables industry, is having on the utility industry.

The declining costs of solar and wind resources are boosting their development throughout the country along with regulations to expand their development. Communities are adopting renewables to honor commitments to reduce global greenhouse gases. Development of microgrids and distributed energy resources is surging with manufacturing and commercial companies and government and educational institutions who are seeking to reduce energy costs and secure supplies in emergency situations when power is cut by fire or heavy storms.

Furthermore, the large amount of solar, wind and hydro power production has produced oversupply volumes on the California grid not seen before, according to the California Independent System Operator. In March, the CAISO curtailed about 80,000 MWh, up from 21,000 MWh the same month a year ago.

This is example of the impact of how California's power resources are being driven by the state's mandate to produce 50% from renewable resources by 2030.

California's mandate to end power plant use of once-through ocean water cooling is a major reason new plants are being built along California's coasts to maintain reliability. AES is developing two power plants in Southern California to replace generating stations that must shut down by 2020 to comply with the state mandate.

RELIABILITY & OTC RULE DRIVES REPLACEMENTS

AES originally sent its licensing application to the CEC in 2012 to construct and operate the 939-MW Huntington Beach Energy Project on the site of the original seven, now five generation stations which will be demolished. The project was approved for licensing in 2014. However, AES changed its mind and filed a petition to amend in 2015 and proposed building an 844-MW plant in two stages.

The inspiration for the amendment was an award by Southern California Edison for a power purchase agreement for 644 MW following a need to fill a local capacity requirement. In the first phase, AES will build the 644-MW combined cycle, gas-fired air cooling generating facility. Once it is operational, AES is scheduled to build two 100-MW simple-cycle turbine generators. However, AES does not have a PPA for those generators, but is seeking one from SCE and will not start the second phase construction until a contract is signed.

During the discussion by CEC commissioners before they voted, they acknowledged the changing power landscape evidenced by the small number of new power plant developments they are being asked to site. Commissioner David Hothchild point-

ed out that looking over the state, what is needed is not more power from the grid, what is needed is voltage regulation. "And we don't want to ever be in a situation of unnecessarily having to combust gas to provide those services," he said.

Hothchild said the CAISO wrote a letter to the CEC in November 2015 saying a clutch detaching the generator from the turbines should be the default option to provide inertia and voltage regulation without burning gas to maintain grid stability as variable renewable resources are increasingly added to the grid.

Stephen O'Kane, vice president of AES Huntington Beach Energy told the commissioners a clutch could be added to the simple-cycle turbines in the second phase but they are an option and that phase may not get built if they are not offered a PPA.

DISTRIBUTED ENERGY

AES is moving into distributed energy, and its biggest growth sector in the west is distributed solar and battery energy storage, O'Kane told the commissioners. "What both Huntington Beach and Alamitos (discussed below) are is not the building of new gas plants ... These projects are the closing of plants or the reduction of our reliance on gas-fired power plants."

The Alamitos Energy Center, located in Long Beach at the southern tip of Los Angeles County, will be built as a 1,040-MW plant that will replace the 1,950-MW generating station. It must be decommissioned by 2020 to comply with the state's mandate to phase out once-through cooling.

One generating station has already been decommissioned and is the site of the new facility.



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GRID MODERNIZATION

BY JIM SCHRETTER, CLASS OF 2002



President
Beacon Energy LLC

Optimal grid modernization will lower costs for customers while obtaining higher reliability and better security. According to Mercom Capital Group, private equity and related investments in smart grid companies increased 300% to \$164 million in the first quarter of 2017. However, individual firms and even individual states or power pools lack the common national standards necessary to fully advance a modernized grid. In mid-April 2017, the U.S. Department of Energy (DOE) provided a peer review session on its activities to improve the grid. During the same month, the Solar Energy Industries Association began a series of white papers on the benefits of grid modernization.

Similarly, California and New York regulatory commissions have also been reviewing plans to add rate-based distributed energy resources (“DER”) grid related improvements. Designing the most efficient structures, devices and approaches for incorporating new DERs to benefit all stakeholders is key.

DOE established the Grid Modernization Initiative in June 2014 to update the grid to accommodate profound changes occurring with distributed ener-

gy technologies including solar, storage, other energy resources, and energy management systems and to improve handling cyber and physical threats to reliability. These efforts were aimed at augmenting efficient central station units and allowing electric customers to benefit from major cost reductions in solar, wind, distributed natural gas plants, demand response, distributed management systems, and storage.

In coordination with 100+ industry partners and 13 US Government labs, DOE formulated key programs and activities in 2015 and 2016 that are required to modernize the grid.

During the last month, DOE also conducted a peer review of 88 programs with potential funding of \$220 million, designed to make changes in six key areas.

Central to improvements in the grid are:

- The design and collection of distribution level data (voltage, operating state, temperatures, etc.) including design architecture that facilitates the management, collection and standardization of information.

The communication of real time information providing potentially 100% visibility into what is happening at both the local and broader grid level is critical.

- A method of controlling a modernized grid that facilitates self-healing in real time, reducing unintended loop flows and resulting in lower costs.

- A system of planning that recognizes the grid’s capacity to accept new distributed resources, the value of these resources at their point of location, and new ways to plan for these resources.

- A robust discussion and final agreement on incentives needed by utilities and others to keep stakeholders properly motivated while insuring lower costs and higher reliability/resilience and flexibility for customers.

The DOE programs targeted six key areas (with selected 2020 DOE goals):

Devices and Integrated Systems. Help develop new devices to improve grid utilization to facilitate new distributed resources as well as efficient central station units. Four key activities and goals are to be reached by 2020, including one target achievement of new systems that integrate 100% renewables at the local level and 35% at the bulk level.

Sensing and Measurement. Advance low cost sensors, as well as information and communication technologies needed to properly characterize the grid, with the goal of 100% observability of data. By 2020, progress six activities needed for the proper characterization of the grid.

System Operations, Power Flow, and Control. Design a new architecture that enables millions of new devices to be efficiently integrated into the grid. By 2020, create a next-generation grid operating system that functions like an autopilot reducing necessary reserve margins and improving economics and efficiencies.

Design and Planning Tools. Create grid planning tools that dynamically model the new grid at the transmission and distribution levels. By 2020, integrate distribution system dynamics into stochastic modeling and increase nodes modelled by a factor of 100.

Security and Resilience. Develop hardened and resilient cyber and physical security solutions and real time response to threats. By 2020, improve the grid’s ability to detect, respond, and anticipate threats.

Institutional Support. Provide technical support to regulators and others to facilitate proper incentives to maximize benefits of the new grid and insure a sound regulatory framework. By 2020, assist 20 states in their evaluations of potential changes.

The DOE is well positioned to develop the modern grid by advancing national issues outside of state and power pool boundaries.



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ABB'S PORTFOLIO OF DIGITAL SOLUTIONS

BY BILL ROSE

ABB showcased its digital substation and commercially launched ABB Ability™, a new portfolio of digital solutions, at its bi-annual customer event in Houston.

ABB recently held its flagship bi-annual ABB Customer World event at the George R. Brown Convention Center in Houston, TX. At this customer-centric event, ABB officially launched ABB Ability™, its new digital platform consisting of more than 180 solutions and services, and showcased a broad range of newly-digitalized products, systems, software and services.

By combining ABB's deep domain expertise with network connectivity and the latest digital technologies and innovations, ABB Ability creates powerful solutions and services that solve real business problems and produce tangible business opportunities. ABB Ability's next-generation digital solutions and services are developed and built on Microsoft's leading Azure cloud platform, based on a strategic partnership between Microsoft and ABB.

At the event, ABB introduced its new Chief Digital Officer, Guido Jouret. Speaking at the ABB Customer World keynote session, Jouret said, "Building our solutions on the Azure platform means we can take advantage of all of its capabilities and add value with our domain-specific offering. In effect, we are turning ABB's decades of industrial domain expertise into software offerings that our customers can access through the world's largest and most advanced digital platform. From being a hidden digital champion, we are becoming the partner of choice for customers embarking on a digital transformation. They can now know more, do more, do better, together. We can help them assess, automate, optimize and collaborate."

A key focus was on digital technologies for a smarter transmission and distribution grid, which lies at the heart of the power sector transformation and ongoing energy revolution. The increasing integration of intermittent renewables and distributed

energy sources on the supply side and new demand loads like data centers and electric vehicles bring new challenges. The grid needs to adapt and become more flexible and intelligent to handle these complexities while maintaining stability and ensuring steady, reliable and quality power flow to consumers.

DIGITAL SUBSTATION

One central exhibit at the show revolved around the "digital substation" concept - a key component for enabling a smarter grid. Digital communications via fiber optic cables will start to replace traditional copper connections using analog signals, increasing safety, flexibility and availability, while reducing cost, risk and environmental impact. Digital substations also incorporate Intelligent Electronic Devices (IEDs) with integrated information and communication technology. An IED is a microprocessor-based protection and control device for power equipment, such as circuit breakers, transformers and capacitor banks. A fully digital substation is smaller, more reliable, has a reduced life-cycle cost and is simpler to maintain and extend than an analog one. Other advantages include safety, flexibility, availability, and lower environmental impact.

This intelligence is also being extended to the management of assets through the integration of information and operational technologies, showcased as part of the ABB Ability Asset Health Center solution, combining ABB's vast expertise and installed base with the company's enterprise software portfolio.

DERMS

Also on demonstration was a new distributed energy resource management system (DERMS) being jointly developed by ABB and Enbala. This digital solution will enable customers to efficiently manage the

entire lifecycle of distributed energy resources, like solar and wind. It means that utilities, energy service companies and grid operators are able to keep the grid balanced and optimized in real-time while accommodating intermittent renewable energy and distributed energy sources.

ABB also exhibited a high voltage switchgear with digitally enabled features including an IED-based operating mechanism, fiber optic current sensor and intelligent local control cabinet that enables smooth integration into a substation automation system. It continuously monitors the functions of the switchgear, with real-time simulation and diagnostics, to facilitate pro-active asset management, and can also be used remotely.

"The increasing digitalization of the power value chain is key to addressing new supply and demand challenges faced by the grid, which needs to become more flexible, reliable, intelligent and interconnected," said Claudio Facchin, President of ABB's Power Grids division, in his keynote panel at the event. "As the world leader in transmission and distribution technologies, we are well positioned to shape the transformation of the power sector and strengthen our position as a partner of choice for enabling a stronger, smarter and greener grid."

Customers who are already using the portfolio of digital solutions that are now part of ABB Ability include some of the world's leading utilities, manufacturers and service providers, among them Shell Oil, CenterPoint Energy, Con Edison, BASF, Royal Caribbean, Cargill, Volvo, BMW and many others.

Among the new ABB Ability innovations showcased in Houston were: ABB Ability Digital Substation; ABB Ability Asset Health Center; ABB Ability Collaborative Operations; ABB Ability System 800xA; and ABB Ability Smart Sensor.

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INTEGRATING COMMUNITY SOLAR

BY PAUL SPENCER

The electric industry is amid a transformational change, with disruptive forces moving faster than many utilities, regulators, politicians, and ratepayers can fathom. Innovation in renewable energy generation has provoked a shift in both perspective and strategy, with distributed energy resources now viewed as a source of opportunity rather than obligation, and utilities learning how to best integrate them into the grid and build sustainable business models around their growth.

One of the most rapidly expanding distributed generation solutions is community solar. Community solar allows residents and businesses that have traditionally been sidelined from the rooftop market to access the benefits of locally-sited solar.

Community solar continues to demonstrate a proven capability to concurrently serve utility, developer, and customer motives. The tools, services, and expertise for program integration and operation are available and evolving.

The nascent community solar market has blossomed from just two projects in 2010 to more than 100 today, spanning 25 states. In 2016, cumulative operating capacity crossed the 200 MW mark and is forecast to exceed 400 MW this year. The category is expected to be a multi-gigawatt annual market and drive 25% of the annual non-residential PV market over the next few years. By 2020, community solar will represent half of all distributed solar.

Commercial and industrial companies are increasingly approaching community solar as an efficient, cost-effective way of procuring renewables, accessing the grid, engaging employees, and demonstrating leadership in their communities. Retail demand is escalating as consumers become more educated and excited by the model and its value proposition.

Despite the relative complexity in getting a community solar project or program from initiation to sellout, enthusiasm is rising and new markets are opening. Some of

the U.S.'s largest investor owned utilities and most advanced cooperative and municipal utilities are turning to community solar as a cost-effective renewables strategy because it reaches near utility-scale economics, avoids the constraints facing rooftop models, supports RPS mandates, protects against retail rate erosion, and maintains a grid-tied connection with customers.

Utility-led community solar programs are showing significant activity and growth. An example of this collaboration is the recently announced partnership between South Carolina Electric & Gas (SCE&G) and community solar solutions provider Clean Energy Collective (CEC) to develop a 16 MW community solar program in South Carolina. CEC will build, own, and operate the facilities, and integrate its software and services offerings—including customer acquisition, system monitoring, production tracking, bill crediting, and ongoing subscriber engagement. Through this partnership, SCE&G will enable more residents, schools, churches and municipalities to support renewable energy generation than ever before.

Legislative and regulatory efforts shaping the future of renewables increasingly hold community solar as an effective solution for delivering broad access to renewable energy, irrespective of geography and in a way that serves the objectives of all, or at least most, stakeholders. At present, more than half of U.S. states plus DC have enacted or are considering some form of legislation empowering community renewables. The policy framework in these states allow third-party developers to deploy projects, with clearly defined guidelines and predictable economics. This state policy momentum is expected to continue.

Legislation is not a requirement for community solar's progress, however, demonstrated by strong growth in non-legislated markets. Utility-sponsored initia-

St. Joseph' Abbey, a Trappist monastery located in Spencer, MA set aside 200 of its 2,000 acres for a community solar array. NRG Renewable owns and operates the 14.7 MW ac capacity facility, its third community solar farm in the state and happens to be the largest solar farm in the state. The 20 year land lease is comprised of 61,000 Hyundai 350 watt pv panels. M&W was the EPC creating 150 jobs during the year and a half construction completed in November.

tives, by investor-owned, municipal, and cooperatives, have led recent movement to integrate community solar to cost-effectively serve ratepayer demand for renewables. More than 150 utilities across the U.S. are now operating or developing a voluntary community solar program.

Technology, such as CEC's Community Solar Platform software, is serving program integration and management. Progress is accelerating in the areas of consumer and market intelligence, product design, facility monitoring and on-bill crediting systems, and long-term customer engagement. Enterprise-level software is providing utilities, developers, and asset owners the tools to navigate complexities of community solar programming, including customer acquisition, program and regulatory management, billing integration, facility O&M, and customer E&M (the long-term engagement and management of program participants).

This new software-driven community solar industry is enabling an environment where soft costs can and are moving down as quickly as hard costs and is significantly improving the value proposition for developers, asset owners, and utilities alike.

The rapid scaling needed to reach community solar's promise requires a continued focus on innovation and creativity, the persistent pursuit of efficiencies, and expanded partnerships throughout the development process. With every program, solar providers, regulators, utilities, and advocates have a better understanding of the opportunities and barriers to reaching community solar's multi-gigawatt destiny.

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2017 BIO EXPLORES NEW PARTNERSHIPS

BY PAUL WINTERS



The 14th annual BIO World Congress on Industrial Biotechnology returns to Montreal in 2017. The location draws business leaders, investors, and policy makers from Canada, Europe, the United States and around the world. For many attendees, the biggest attraction is the conference's robust business partnering system for networking with other conference attendees. For all conference participants, the high-level discussions and technology presentations in the seven education tracks, plenary sessions, and green-tech investor sessions have a great deal to offer.

The 2017 BIO World Congress will feature discussions and presentations relevant to energy and power generation companies that are seeking to utilize biomass or renewable natural gas. The conference will also highlight the potential to diversify energy production businesses by generating co-products or environmental credits.

North America is rich in biomass resources, but developing new commodity markets for biomass – getting crops harvested, transported and delivered to a bioenergy producer at a cost-efficient price – is a challenge. First-of-a-kind biorefineries have gained experience and developed partnerships while building value chains for biomass. For example, a group of farmers in Ontario formed the Cellulosic Sugar Producers Coop (CSPC) and contracted

Bioindustrial Innovation Canada (BIC) to assess biorefinery technologies. CSPC selected Comet Biorefining to build a cellulosic sugar production facility in Sarnia. Comet formed an offtake agreement with BioAmber Sarnia, Inc. – a joint venture between Mitsui & Co, a trading company, and BioAmber, Inc., which produces renewable chemicals – to move the commercial project forward. Executives from each member of the partnership establishing this new market value chain will participate in a discussion at the 2017 BIO World Congress to share their experiences.

Delivering cost effective biomass supplies to the production facility gate is the first challenge. Consistently delivering biomass that meets the quality standards needed by biochemical, bioenergy, biofuels and biomaterials producers can be seen as the second. With demand for biomass rising, agricultural producers need to understand the quality standards that bioenergy producers require. The Biomass Quality Network Canada (BQNC) facilitates the development of biomass quality standards and test methods in the industrial sectors of biochemical, bioenergy, biofuels and biomaterials. Executives from companies in this network – including CSA Group, Biolin Research and Composites Innovation Centre – will provide perspectives on developing industry methods and standards at this year's BIO World Congress.

North America is also exploiting biogas as an energy feedstock, and companies have begun establishing new commodity markets and value chains to deliver it to customers. Biogas offers unique opportunities as a renewable fuel, a bioenergy carrier and a potential renewable chemical feedstock. European, Canadian and U.S. companies will explore the state of biogas commercialization at BIO's World Congress, discussing experiences in creating markets for producing, aggregating, transporting and utilizing renewable biomethane. Representatives from BP, Oberon Fuels,

Iogen, the Italian Biogas Consortium and the Coalition for Renewable Natural Gas will discuss current challenges and opportunities to scale biogas production.

In addition to building new market value chains for feedstocks, partnerships can help biofuel and bioenergy producers diversify their offerings. Energy producers can generate biobased chemicals and clean energy credits as two potential co-products. Governments around the world have recognized that the new biomass and renewable fuel market value chains help to reduce carbon while contributing to economic growth, new businesses and jobs, and the emergence of new technologies. Translating that recognition into economic and policy support is key to future development of new feedstock value chains. BIO's World Congress will convene experts from trade associations, funding agencies and technology development companies to offer perspectives on the linkages between biorefinery value chains and greenhouse gas emissions reduction. Scheduled speakers include representatives of Sustainable Development Technology Canada, Forest Products Association Canada, EnVertis Consulting and Beta Renewables.

Biobased chemicals can also be used in environmental site remediation, equipment and infrastructure cleaning and maintenance, or even enhanced fossil fuel production. Enhanced oil recovery can be achieved by applying biobased chemicals to address paraffin buildup in oil wells, which is a major industry issue. Biobased chemicals also can be used to remediate catastrophic oil spills and persistent operational spills from pipelines or well sites. At the BIO World Congress, executives and scientists from Keystone Excavating, Inventek Colloidal Solutions, Niven Fischer Energy Services Inc., Zen Earth Corp. and Green Life will discuss how revolutionary applications of biobased chemicals can save costs in oil firms' production operations.

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AVOIDING THE TECHNOLOGY TRAP

BY JOHN P.W. BROWN VI

At Skipping Stone, we've seen organizations get to the end of a technology implementation, live with it for a while, create spreadsheet work arounds and eventually rip it all out and start over. This is expensive, not to mention disruptive to operations, and leads to many uncomfortable conversations with your boss and your boss' boss, etc. People lose their jobs over this and companies lose money because of this. This is the definition of pain. We call this the "technology trap."

The good news is, the technology trap is completely avoidable. By properly managing the three dimensions of technology implementations – people, processes, and technology – you can avoid the technology trap. Below we'll review the steps you can take to avoid the trap and get on the road to better technology implementations.

THE TECHNOLOGY TRAP

Let's say you are part of a retail energy or wholesale trading organization. You've undoubtedly encountered one or more of these common technology hurdles:

- Over reliance on spreadsheets
- Multiple and duplicate data entry points in often duplicate systems
- Error prone processes and/or data
- Resource intensive processes requiring lots of bodies
- Excessive execution time – things just take too long
- Redundant and/or overlapping systems

If so, you may be thinking – "I should update my technology and fix this!" That sounds reasonable. After all, it's not rocket science. It should be easy to put in a new risk/trading/billing/etc. system. We just need to follow a few tried and true steps:

- Create a wish list
- Research the top vendors
- Get some demos
- Pick one
- Negotiate the price

- Implement the solution
- Reap the benefits

Viola - that wasn't so bad!

In this situation, the best-case scenario is that you'll get the solution implemented pretty much on time and within budget and with most of the functionality you wanted. Then people will start using the system and you're cruising happily along. Problem solved. Life is good. You're living the dream.

Then you wake up. You just fell into the technology trap.

After you wake up you find some groups won't use the new system at all. Then you find out you're using even more spreadsheets than before and some business processes are taking longer than ever. Many of your old problems still exist. Some are even worse! You're now seeing problems you didn't even realize you had before, and you just spent a million dollars or more. So, what happened????

Unfortunately, technology is not an end game in and of itself. In fact, unless your "problem" is very specific, technology by itself won't fix it. When companies implement new technology they often make a series of assumptions such as:

- We will become more efficient
- We will reduce errors
- Our processes will improve or just "be better"
- Our people will embrace the change and be more engaged/productive/happier/etc.
- We will ultimately save money
- We will have a competitive advantage

Unfortunately, at some point in the post-implementation, companies come to realize they aren't necessarily capturing the expected benefits. The problem is that technology is only one part of the solution. It is a critical component but not the only component; therefore, companies are only addressing one piece of the puzzle. For technology transformations to be successful you need to address each of three criti-

cal dimensions: People, Processes, and Technology.

People first, then processes, and finally technology. Furthermore, it is an iterative and ongoing process. When you get to the end of the technology piece, you need to loop back to people. This is a complex ecosystem.

ENSURING SUCCESSFUL TECHNOLOGY TRANSFORMATIONS

At a high level, there are three major steps to avoiding the technology trap:

1. Put Your People First: Step one is to assess your team. Do you have the right people? Enough people? Are your people well-trained? Does the team have management support? Are they empowered? If not, develop the plan to correct the situation.

2. Formalize the Processes: Step two is to formalize your processes. Are your current processes documented? If not, document them. Are people trained on the processes and are you enforcing adoption? Then make sure you monitor your processes and work to improve them and fill in any gaps.

3. Tackle Technology: Step three is to update your technology – your original goal. Have you defined and documented your business objectives? Are your requirements documented in sufficient detail to support your business processes? Are the requirements understood by all stakeholders... including vendors?

Have you identified specific and measurable success criteria? If so, make sure you are following the selection guidelines, have proper project governance in place and are adhering to the implementation best practices identified above. Consider initiating an implementation quality review (IQR). After checking these off, don't forget to create your future enhancement roadmap.

BNEF SUMMIT SPEECH; RICK PERRY CONTINUED FROM PAGE 4

hostility to coal...threaten the reliability and stability of the greatest electric grid in the world.

Third, we will ensure that nuclear power continues to be part of our energy portfolio, and that American technology is protected. As part of this element of our portfolio, we will ensure there is a rational, reliable and safe plan to dispose of spent nuclear fuel.

Fourth, we recognize a number of factors put the U.S. grid at risk including weather, physical, and cyberattacks. Industry and the Federal government are working hard to prepare for, mitigate and respond to all hazards.

We must meet those threats and keep our energy supply safe and functioning.

Finally, we will acknowledge that energy policy is not just a vital element of US economic policy, but also a vital element of US foreign policy.

We have all seen energy used as a political tool to hold countries hostage. That is an act of economic aggression that needs to be confronted. Our response cannot be lofty words, but a set of clear deeds. One of the most important actions we can take is to use our massive shale gas resources to begin shipping Liquefied Natural Gas overseas.

LNG

Today, I am excited to announce the Department has authorized the construction of the Golden Pass LNG facility near Sabine Pass in Southeast Texas. This facility will create 45,000 jobs during the construction phase, and position our nation as the dominant exporter of Liquefied Natural Gas.

It will be sold to Non-Free Trade Agreement countries allowed under federal law. This project advances our economic interests, pushing our global production capacity to over 60 percent.

We will work with industry, as a partner, to develop new technologies and bring them to market.

2017 NEW ENERGY PIONEERS

BY VERONIKA HENZE

NEW YORK, NY – Bloomberg New Energy Finance (BNEF) announced its selection of 10 companies for the 2017 New Energy Pioneers – game-changing innovators that are revolutionizing the energy sector.

An independent panel of industry experts, assisted by BNEF's analysts and technology experts, selected the 10 winners from over 170 applicants from around the world. Each candidate was assessed against three criteria: potential scale, innovation and momentum.

Michael Wilshire, selection committee chair and head of strategy at Bloomberg New Energy Finance, said: "This year, we were delighted to receive a record number of strong candidates for the New Energy Pioneers program, drawn from 43 different countries. We were struck by the new types of innovation we are now seeing in the industry. A number of our winners apply clean energy technologies to address new market frontiers in sectors such as agriculture, healthcare, remote lighting and energy access. Others have focused on making today's energy industry more efficient through technology or process innovation in areas such as wind, heating installations and access to clean energy finance. We have also seen continued product innovation in fast growing market sectors such as advanced transport and in emerging markets.

"We are very encouraged by the breadth of innovation and creativity shown by these Pioneers and by the impact that they could have on the energy system of the future. We are, as always, very grateful to our group of external judges on the selection committee who had the challenge of narrowing the field of entries to a final set of 10 winners."

The 2017 New Energy Pioneers are: **Envirofit** (USA) has developed a line of smart, clean cook stoves that reduce fuel use, smoke and toxic emissions.

EV-Box (Netherlands) provides electric vehicle equipment and related cloud-based services for individuals, businesses, facilities, and public charging networks.

Fluidic Energy (USA) provides zinc-air energy storage solutions that are long-duration capable (from hours to several days), cost-effective and function within harsh environments, aiming to provide reliable storage to 100 million people by 2025.

Romo Wind (Switzerland) uses its ultrasonic iSpin technology to measure the speed of the wind when it hits the spinner at the front of a wind turbine's rotor.

Skeleton Technologies (Estonia) manufactures ultracapacitors based on patented curved graphene, with high power densities that make electrification and energy savings for automotive, grid, and transportation industries possible.

SunCulture (Kenya) designs, manufactures, finances and distributes solar-powered irrigation solutions that make small-holder farmers profitable by increasing yields and decreasing costs.

SunFunder (USA) unlocks debt capital for the off-grid solar sector by aggregating diversified portfolios of investment opportunities.

Sunna Design (France) develops and produces smart and durable off-grid solar public lighting products, now installed in 40 countries, mainly in Africa.

Thermondo (Germany) offers and installs smart distributed and managed energy solutions for homeowners via a digital installation and maintenance platform.

We Care Solar (USA) designs and distributes compact 'Solar Suitcases'. These are durable, efficient solar powered light and monitoring kits for remote health centers to ensure women can give birth safely with essential light and power.

The New Energy Pioneers program partners are Cycle Capital Management and CohnReznick Capital Markets Securities.

ACHIEVING ADDITIONALITY CONTINUED FROM PAGE 8

economic renewable energy source, but this is in stark contrast to the regions located throughout America's heartland where wind power is often the most economic form of energy available (renewable or otherwise) to corporate consumers. The technology type will be overwhelmingly determined by economics.

4. WHICH SUPPLIER SHOULD I CHOOSE FOR MY RENEWABLE ENERGY ADDITIONALITY PROJECT(S)?

The renewable energy supplier market is extremely fragmented in the U.S. and internationally, so it can seem daunting to feel confident that you've selected the best renewable energy supplier to work with. Seeking out renewable energy suppliers based on their volume of experience (both in terms of years in business as well as the number of successful projects contracted and constructed) is certainly a key component to an educated selection. However, it is equally important to pay close attention to the volume of projects a supplier has successfully executed with non-utility customers such as a corporate buyer, because corporate buyers typically have a lower risk appetite than do utility buyers, and some suppliers are more flexible than others in this regard. Also, working with ...forge a successful partnership with the same renewable energy supplier in both the U.S. and international markets...a supplier who has the financial strength needed to build the project without requiring third-party construction financing will increase the certainty of your additionality project actually getting built, as opposed to hitting roadblocks due to a lack of construction funding.

If your corporation's renewable energy goals include international markets, one additional consideration when selecting a supplier is to determine the extent of their overseas experience. One popular strategy is to forge a successful partnership with the same renewable energy supplier in both the U.S. and international markets in order to

NEXT-GEN CYBER SECURITY

BY SEAN PEASLEY

NEW YORK, NY- Deloitte announced plans to expand its cyber risk platform for end-to-end industrial control systems (ICS) and operational technologies (OT) security with next generation technology enabled by Dragos, a cybersecurity company focusing on securing ICS and OT networks.

Digital transformation has resulted in greater interconnected advanced manufacturing and automation driven operations. Increased connectivity among industrial facilities, supply chains, customers, and operations brings with it new operational cyber risks and the potential for cyberattacks to have more extensive effects. Many organizations have started to focus on securing ICS and OT, but less so on monitoring emerging cyber threats. ICS and OT threat monitoring technology can facilitate a better understanding of the vulnerabilities embedded in these systems.

Deloitte Risk and Financial Advisory Cyber Risk Services' end-to-end ICS offering, enabled by Dragos technology, can help organizations manage their cyber risks in the ICS and OT environments by using a

combination of innovative cyber security products and services. This combination brings hunting and reconnaissance capabilities that now allow organizations to look beyond internal data to threat documentation found in external databases. Beyond securing ICS and OT systems, this combination of cyber risk services and technologies can provide a more complete picture of an organization's ICS and OT threat landscape through active monitoring that can better inform scenario planning and response.

Ed Powers, principal, Deloitte & Touche LLP, and U.S. leader for Deloitte Risk and Financial Advisory Cyber Risk Services said "A decision to include OT and ICS as a part of a broader cyber risk management program can improve a company's understanding of the potential damage resulting from a cyberattack and can bolster the efficacy of its cyber risk mitigation strategy."

continue working with a provider who is already familiar with the specifics of your corporate energy goals and risk limitations.

5. DO I NEED A TRUSTED EXTERNAL RENEWABLE ENERGY ADVISOR? IF SO, THEN HOW DO I CHOOSE ONE?

While many corporate buyers of renewable energy additionality successfully select projects and execute deals without the support of an external consultant or broker, many corporate buyers do avail of such assistance and the marketplace of such advisors is almost equally as fragmented as that of project suppliers. An easy first step for any corporate buyer considering renewable energy additionality would be to contact a non-profit organization dedicated to

educating corporate buyers and providing a marketplace where buyers could directly interact with renewable energy suppliers, advisors, and fellow buyers.

Ultimately, the likelihood of enlisting an external advisor will depend on your corporate team's bandwidth and willingness to put in the time to roll up your sleeves and educate yourself on the market and on the deal process, which has become easier to do in this increasingly mature corporate renewable energy market. The service fees charged by an external consultant (usually in the form of a success fee paid by the seller) are not insignificant, and its impact to the overall project economics should always be evaluated before deciding to contract a consultant.

UW LAUNCHES CEI

BY SUZANNE OFFEN

SEATTLE, WA - The Clean Energy Institute (CEI), a research unit at the University of Washington (UW), created the Washington Clean Energy Testbeds from a 15,000 sq. ft. former sheet metal fabrication facility to increase the rate at which breakthrough science and engineering discoveries turn into market-adopted clean energy technologies.

“The process of taking a clean energy research discovery and making a prototype, then rigorously testing and refining it for market readiness, requires equipment and expertise that is expensive to acquire, and rarely available when and where you need it,” said CEI director Daniel Schwartz. “As a result, too many start-ups have great ideas, but fail before fully demonstrating their technology. Amazingly, lack of easy access to facilities and expertise is often a barrier for big companies, too.

The Washington Clean Energy Testbeds centralize these resources to help shorten the time between clean energy idea to prototype, while reducing the capital and providing the expertise a company needs to get a viable product in the hands of customers.”

The Washington State Legislature provided UW \$8 million to plan and design the Testbeds. CEI engaged UW faculty, regional cleantech leaders, and national research institutions like the Pacific Northwest National Laboratory (PNNL) to create a facility that serves clean energy innovators.

For comparison, access to public energy research and testbed facilities often involves a competitive application and approval process. The Washington Clean Energy Testbeds’ open-access model requires only an initial consultation with Testbed management to ensure project feasibility and safety. Open-access is ideal for researchers and companies that want to rapidly advance their ideas.

“I wish these Testbeds existed when EnerG2 was developing its advanced carbon materials for energy storage,” said

EnerG2 CEO Rick Luebbe. “This specialized facility connects clean energy startups to a supportive university, talented people, and the necessary instruments. It’s unlike anything in the country and offers a smart solution for slashing the time and funding needed to de-risk a technology concept.”

Professor J. Devin MacKenzie, a seasoned cleantech entrepreneur and global expert in electronic materials and emerging manufacturing methods for energy devices, displays, and communication, will lead the Washington Clean Energy Testbeds. MacKenzie has founded and led five startup companies and holds over 110 patents and publications. In addition to leading the Testbeds and teaching at UW, he is currently the chief technical officer of Imprint Energy, a UC Berkeley spinout developing flexible, high-energy batteries based on large-area print manufacturing.

The “Scale-up & Characterization” portion of the Testbeds offers a platform for prototyping authentic-scale solar and storage devices as well as testing manufacturing processes. The lab includes a 30-ft-long multistage roll-to-roll printer for solar cells, batteries, sensors, optical films, and thin-film devices and is the only one of its kind in the United States. The “Scale-up & Characterization” lab also includes a controlled humidity and temperature room to enable specialized fabrication under precise atmospheric conditions. The collection of characterization instruments in the lab form a unique roster of capabilities tailored specifically for supporting scaled energy devices and modules. They allow for rigorous testing of new devices using solar simulators, environmental test chambers, battery cyclers, electron microscopes, X-ray spectrometers and other instruments.

WRF Innovation Professor Venkat Subramanian and Kyocera Professor Jihui Yang from UW will use the “Scale-up and Characterization” lab for their work with the Battery500 consortium. Battery500 is a U.S. Department of Energy (DOE) pro-

gram led by PNNL that aims to develop next-generation lithium batteries that have more than double the “specific energy” found in the batteries that power today’s electric cars.

Another research initiative housed at the “Systems Integration” lab includes the Transactive Campus Energy Systems project. This first-of-its-kind regional partnership with UW, PNNL, and Washington State University seeks to develop and demonstrate the technologies to cost effectively balance energy use among buildings, campuses, and cities.

ABOUT THE CLEAN ENERGY INSTITUTE

The Clean Energy Institute (CEI) at the University of Washington (UW) was founded in 2013 with funds from the State of Washington. Its mission is to accelerate the adoption of a scalable clean energy future that will improve the health and economy of our state, nation, and world. To accomplish this mission, CEI supports the advancement of next-generation solar energy and battery materials and devices, as well as their integration with systems and the grid.

The institute creates the ideas and forms the people needed to generate these innovations, while facilitating the pathways to bring them to market.

ABOUT THE WASHINGTON CLEAN ENERGY TESTBEDS

The Washington Clean Energy Testbeds in Seattle provide users customized training and access to state-of-the-art fabrication, characterization, and computational instruments for innovations in clean energy devices and systems.

The Clean Energy Institute at the University of Washington operates the facility.



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