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DuPont's Newport, DE Landfill Solar Site

Photo: Tangent Energy

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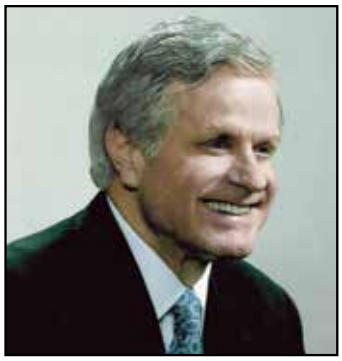

Dick Flanagan
flanagan@world-gen.com

Sometimes a song sums up the situation perfectly: "There's a time to every purpose under the heavens, turn, turn, turn." We turn to elections, we turn the page and we turn to each other.

The industry is turning the clock years ahead with technological investments and advancements and we are pleased to outline their progress in exclusive editorial from around the world.

The issue opens with a cover story converting brownfields into greenfields, on page 4.

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Nokia says the smart grid needs LTE or 4G wireless technology to meet the new demands on the electrical distribution system. Renewables will require real-time adjustment without operator intervention, on page 8.

There are 80 million millennials in the US and Deloitte highlights their increasing influence as a consumer group. They are behind the shift to cleaner sources of energy to reduce their carbon footprint on page 10.

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ABB explains the new FERC 827 ruling on reactive power. Maintaining the integrity of the electrical grid will continue to be a priority, on page 14.

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Mahabala Adiga shares his findings using solar desalination on seawater and brackish water on page 18.

Alums from the Classes of 2000 return to "Back on Campus" with editorial on page 18 & 19.

Fittingly, the issue celebrates the season with a feature on Santa Claus' trip around the world. His trip is analyzed by engineering experts on page 19.

World-Gen is a media sponsor for Power-Gen Week and will be distributed in Orlando.

We are renewing our media sponsorships in 2017 as an online publication with show copies: Feb/March 2017 – Class of 2017; May/June 2017 – EEI, Intersolar, Power Gen Europe; Sept/Oct 2017 – SPI; Nov/Dec 2017 – Power-Gen Week 2017.

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Happy Holidays and Happy New Year!

TURNING BROWNFIELDS INTO GREENFIELDS

BY DICK FLANAGAN

NEW YORK, NY - DuPont installed a 548 kilowatt solar power project on a former Superfund landfill site in Newport, DE. It will generate 729,000 kilowatt hours annually, reducing greenhouse gas emissions by 350 tons a year. The Newport project, developed by Tangent, is owned by Greenwood Energy, a subsidiary of Libra Group. The solar panels were supplied by DuPont Apollo, a wholly-owned subsidiary of DuPont. Greenwood receives revenues from a 20 year power purchase agreement. DuPont receives yearly payments through a 20-year solar land lease. The wildlife habitat at the landfill was enhanced, establishing three pollinator meadows and installing bird boxes at ten locations.

Since the Newport, DE installation in 2013, DuPont has supported five more solar projects on current or former DuPont property. These installations were in France, the Philippines, China and two in the US for a total of nearly 30 additional MWs. In August 2015, DuPont commissioned a 1 MW installation on the Hay Road Landfill in EdgeMoor, DE, its second solar project on landfill. DuPont is in the process of signing a lease for a solar farm on one of its manufacturing locations in North Carolina, scheduled to come online in 2017.

DuPont has been at the forefront of solar innovation. Beginning in the 1950's, DuPont provided the first purified silicon for the Bell Labs experiment demonstrating the first solar cell. Today, DuPont is the leading supplier of specialty materials to the solar energy industry. Over the last seven years, DuPont has introduced more than 110 new Solamet® pastes designed to boost solar panel power output. Tedlar® film is the only backsheet material proven to protect solar panels for 30+ years in all weather conditions. Since 2008, DuPont has been granted nearly 200 PV patents worldwide with 1300 patents pending.

INITIATIVE OVERVIEW

EPA's RE-Powering America's Land Initiative encourages renewable energy development on current and former contaminated lands, landfills, and mine sites when aligned with community vision. RE-Powering supports cleanup of contaminated properties, but does not site renewable energy. Remediating contaminated sites and determining their reuse result from the efforts of a diverse set of stakeholders. Working in collaboration with the National Renewable Energy Laboratory (NREL), the RE-Powering initiative has propelled renewable energy development on contaminated lands. RE-Powering America's Land Initiative tracked and prescreened over 80,000 contaminated landsites covering 43 million acres representing a combined 1,124 megawatts of capacity.

Since the initiative's inception, 179 renewable energy installations in 38 states have been established (as of June 2016.) Examples abound in both solar and wind.

SOLAR PROJECTS

GroSolar designed two landfill farms, Tannery and Marion County. The Tannery Landfill is 2.8 megawatt DC solar farm developed, designed and constructed for the City of Rome, NY. This project was constructed atop a capped landfill. GroSolar worked in partnership with the local utility to manage the installation of 2,400 foot distribution line upgrade. Tannery produces nearly 40% of the city's electrical needs, offsets over 2,300 metric tons of CO^2 each year.

GroSolar designed and constructed the Marion County solar project combining two environmentally sensitive sites. 5.2 megawatts were constructed on a capped landfill and 1.9 megawatts were constructed on a nearby brownfield, within the project's six month schedule. The project utilized a ballasted racking system to avoid disturbing the landfill's cap and produces nearly 10 million kilowatt hours of electricity, the equivalent of removing 7,000 tons of CO^2 from the environment annually.

OTHER SOLAR EXAMPLES

French's Landfill, a Superfund site located in Brick Township, NJ is home to a 6.5 MW solar installation saving $13 million over 15 years, and the Greenfield Solar Farm, a 2.0MW solar array built on a landfill in Greenfield, MA, saving $250,000 in its first year of operation.

WIND PROJECTS

There are a total of 23 wind project installations (634 MW) on contaminated lands, landfills, and mine sites. In Pennsylvania, Stony Creek Wind Farm was built on top of a reclaimed surface coal mine, and Highland Wind Farm was built on top of a reclaimed strip coal mine. The Casselman wind farm is also on top of an old coal mining site.

The Steel Winds project in Lackawana, NY sits on the brownfield site of a former Bethlehem Steel plant. In Wyoming, three wind farms were built on a reclaimed coal mine site: Glenrock, Glenrock III, and Rolling Hills. In Rhode Island, the Coventry wind farm is located on a Superfund site of a former pig farm.

BROWNFIELDS DEFINED

The term "brownfield site" means real property, the expansion, redevelopment or reuse which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant. Cleaning up and reinvesting in these properties protects the environment, reduces blight, and takes development pressures off greenspaces and working lands. It is estimated that there are more than 450,000 US brownfields.

Brownfield grants continue to serve as the foundation of EPA's Brownfields Program.

HEAVY INDUSTRY IS MOVING TO THE CLOUD

BY PETER MALONEY

FINSPANG, SWEDEN - Siemens believes 3-D printing can transform turbine manufacturing and recently opened its Finspang factory to showcase its progress.

Incremental improvements in gas turbine performance are becoming harder and harder to achieve, but technological advances have opened up the potential for large gains in turbine production.

Siemens is investing millions of dollars in 3-D printing, or additive manufacturing (AM), as it is often called in an industrial setting.

In August Siemens added to its AM portfolio with the acquisition of an 85% stake in Materials Solutions Ltd., a U.K. company that pioneered the use of Selective Laser Melting (SLM), which is used to melt or "weld" powdered metal compounds used in additive manufacturing.

Siemens began using AM for plastics in 1989 and began using it in power generation in 2009. The company now has three facilities for additive manufacturing, the newly acquired facility in Britain, a site in Berlin for large gas turbines, and its largest AM site, in Finspang.

Finspang is a town of about 12,400 inhabitants roughly 92 miles (147 kilometers) southwest of Stockholm. It would seem to be in the middle of nowhere, but it has a history of turbine manufacturing dating back to 1913. So when Siemens acquired it in 2003, it already had the tool shops and other infrastructure needed for heavy manufacturing.

Finspang is where Siemens manufactures five of the 18 turbines in its portfolio, including its best selling SGT-800 turbine, which ranges in capacity from 48 MW to 54 MW, and packages another three turbines. In all, nearly half of the company's gas turbine fleet passes through Finspang.

Finspang is also on the leading edge of Siemens' AM efforts with capabilities that run from design and development to manufacturing and testing. The company has been using AM in Finspang since 2009 and shipping turbines with AM components from Finspang since 2013.

PUTTING AM TO WORK

The Finspang facility produces three AM products for Siemens. The company uses AM to make a fuel swirler for its SGT-750, its newest gas turbine.

The swirler is a small cylinder about one-and-a-half inches in diameter that is hollow and fluted. It mixes fuel and air and was designed specifically for the SGT-750. All seven SGT-750s that have been shipped have swirlers made using AM.

Other turbines have swirlers, but not of the complexity of the one in the SGT-750. That could only be done using AM, says Vladimir Navrotsky, chief technology officer in Siemens' distributed generation service division.

Siemens also uses AM to manufacture a small clip that is used to control the amount of cooling air going into the turbine blade. The goal is to have AM produced clips in all of the SGT-800 turbines. AM chips have been in serial production since 2015, and Siemens uses AM to repair and replace burner tips on burners that go into turbines. In the past, the tip was cut off along with some of the body of the burner and a new tip was welded in place. Using AM, the company is able to cut off the burner tip closer to where it meets the body of the burner. The body of the burner is then put in the 3-D printer and the new burner tip is built in place. Siemens is using AM to repair burner tips for both its SGT-700 and SGT-800 turbines and says AM can do the job about 60% faster than is possible using conventional methods.

But Siemens is looking to get the most value out of AM by expanding it to larger components, such as the entire burner. The burner is a critical component of a gas turbine. It sits between the compressor blades and the turbine combustor blades where it mixes air and gas and burns the fuel at temperatures up to 1,500 degrees Celsius.

A burner for a SGT-700 or a SGT-800 is about 700 millimeters long and weighs as much as 20 kilograms. It includes flanges or vanes for mixing air into the fuel mix, as well as nozzles for fuel and, at the end of the unit, the burner tip.

AM also eliminates the welding needed to put together the parts of a conventional burner. Siemens says AM will enable it to use up to 63% less material and to design some elements into the burner tip rather than add them on at a later stage. For instance, conventional burners require external tubing for fuel. With AM, the tubing is incorporated into the design and runs inside the walls of the combustors like veins.

AM also allows flexibility in the design of the burner tips. Different types of lattices can be manufactured into the fuel nozzles of the burner tips. Different lattice patterns allow the burners to burn different fuel mixes, such as biomass or natural gas mixed with other reactive fuels or with hydrogen. Siemens says the wider array of fuel mixes opens the potential for turbines to operate with lower emission levels.

In early September, during a tour of the Finspang facility, Thorbjoern Fors, CEO of distributed generation service in Siemens' power generation services division, said the new fully printed burners would be "ready in weeks."

Next on the horizon for Siemens is the 3-D printing of turbine blades. Like burners, turbine blades live in a harsh environment with high temperatures, but are also subjected to high centrifugal forces and velocities that can reach the speed of sound.

At present the AM materials are not sufficiently developed to handle 3-D printing of turbine blades, Novrotsky says, but Siemens is using AM for rapid prototyping of blades and eventually hopes to use AM for the commercial production of blades.

Using AM for turbine blades could reap even more benefits. Engineering better built-in cooling features into the design and manufacture of the blades and making the

(continued page 21)

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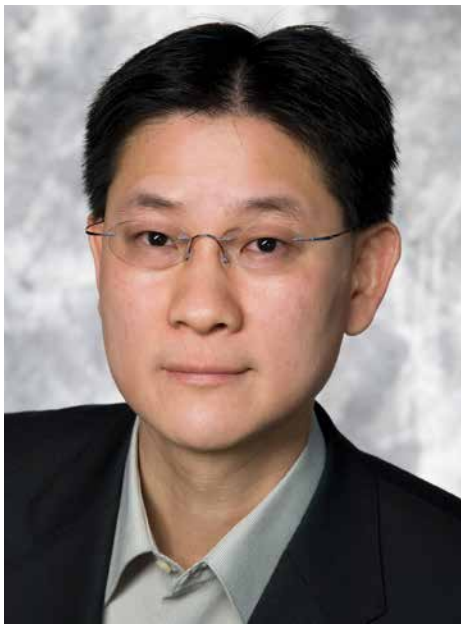
SMARTER GRIDS NEED LTE

BY FAI LAM, DIRECTOR, IP/OPTICAL NETWORKS BUSINESS, NOKIA



Power utilities are in the midst of a significant transformation as they gear up to meet tomorrow's challenges. New approaches and technologies, including distributed energy resources such as renewables, storage and microgrids, are putting new demands on the electrical distribution system. Shifting loads and fluctuating generation from renewables will require real-time adjustment without operator intervention.

Automation of the distribution network will be critical to this transformation. This will require the collection and analysis of data, modeling of the distribution operations for automated decision-making, and the relaying of decisions to utility control centers. None of this is possible without a robust wireless communications network in the last mile or field area network (FAN). The mission critical nature of these operations means that the FAN cannot be subject to interference from other wireless devices or line-of-sight issues. It should be able to handle high bandwidth communications, provide redundant paths and be built on open industry standards.

The good news is that unlike some other technologies critical to our energy future, such as storage solutions, networking technology has already evolved sufficiently to meet the needs of the energy industry. 4G wireless technology, or LTE, has already been adopted worldwide by telecom operators to meet the needs of literally billions of mobile customers. The technology is extremely robust, reliable and scalable.

There are many types of communications systems used by power utilities in the FAN today. In the wireless space, these are typically either some kind of wireless mesh using unlicensed spectrum and subject to interference, or point-to-point microwave subject to line-of-sight issues. The interference issue will only increase as the number of Internet of Things (IoT) devices proliferates. These technologies also tend to be non-redundant and short range. Many are also proprietary, single vendor solutions that lock the utility in, limiting its ability to choose the best options and embrace new applications as they develop.

Currently, most FANs use a mix of these older communications technologies to cover different applications and their associated field devices such as metering infrastructure, quality monitoring or protection. Many of them are based on centralized management systems such as SCADA. Some distribution automation applications, in contrast, will require control and processing to be distributed. More frequent monitoring to handle rapid variances in load and generation will also demand higher bandwidths for data and control traffic. In other words, automating distribution and converging all traffic on a single network demands higher bandwidth and a more reliable network than these technologies can provide.

LTE is well suited to meet this need. It can operate in numerous frequency bands, accommodates different channel sizes and can adapt to different spectrum allocation regimes. While it has been largely deployed in public networks, private LTE networks are possible, either through the use of dedicated utility spectrum (e.g. 450 MHz in Austria and Hungary), or by partnering with mobile providers that can provide dedicated spectrum (e.g. AT&T in the US). The highly regulated nature of LTE spectrum ensures that interference is not an issue. LTE also provides sufficient bandwidth, even for video applications. It is highly scalable and redundant, and avoids any line-of-sight issues common with other technologies.

Some distributed automation applications adopt a decentralized approach to processing and control, referred to as distributed computing. A local computing device or server, for instance, might acquire line data from voltage/current sensors to control and operate local switches. The response times have to be very short, sometimes even in tens of milliseconds, which is uniquely supported by LTE. Atop LTE, IP/MPLS provides the necessary quality of service and security for connectivity to both distributed and centralized processing resources. IP/MPLS provides high resiliency, security and the versatility to control network performance levels per application.

Beyond distribution automation, private LTE networks will allow the consolidation and convergence of many disparate communication systems now in use, including mobile field operations. With its high bandwidth capacity, LTE will enable seamless integration between back office and mobile workforces, even using video for collaboration between on-site and back office personnel.

Society's pressing need to address climate change is creating new regulatory and market conditions, as well as leading to exciting new innovations in energy technology.

DELOITTE SURVEYS MILLENNIALS

BY MARLENE MOTYKA, DELOITTE'S US ALTERNATIVE ENERGY LEADER

HOUSTON, TX - A motivational trifecta of environmental sensitivity, practicality and affordability is driving residential consumers and businesses to find ways to utilize more renewables and expand energy management practices. The survey highlights the increasing influence of millennials aged 21-34, the largest and most dominant consumer group, as a dynamic force behind the shift to cleaner sources of energy inspired by the desire to reduce their personal carbon footprints.

This trend is really being led by the millennial generation, whose wants and needs are not only relevant, but increasingly an influential factor in the transformation of electricity providers.

We have passed a tipping point! The concept of reducing energy consumption has become engrained, despite record-low energy prices that have reduced the need to cut costs. Seventy-one percent believe climate change is caused by human actions, and 65 percent now say they are "very concerned" about climate change and their personal carbon footprints, climbing 4 percentage points from 2015.

MILLENNIALS LEADING THE CHARGE

Millennials are more concerned about shifting to cleaner sources of energy, are more willing to pay for this shift through a surcharge in their electricity bills, and are also more interested in incentives for saving electricity and purchasing related technologies.

Eighty-six percent of millennials believe the government should be active in setting a vision and path for driving U.S. energy strategy, compared with 80 percent of Gen X (aged 35-48), 76 percent of baby boomers (aged 49-67) and 63 percent of matures (aged 68+).

Although there is a growing willingness among all consumers to pay a surcharge on their electric bills for developing sources of renewable energy, the highest support was among millennials and lowest favorability was among matures.

Millennials also are leading the way in using energy apps, with 34 percent indicating use of software apps to be smarter about energy consumption, compared to 26 percent of the general population.

Fifty-two percent of millennials are receptive to solar, with 60 percent noting that solar does not contribute to climate change.

Forty-six percent of millennials were extremely interested in purchasing a share in a utility-scale solar installation that would allow them to meet some or all of their energy needs.

ENERGY MANAGEMENT

Despite an ongoing commitment to energy management, consumers still have not acted on their intentions to deploy tactics that require greater effort and investment, such as rooftop solar, smart thermostats, and energy efficient doors and windows. Beyond the cost barrier, consumers fear biting off more than they can chew in terms of taking energy-management efforts to the next level.

Most consumers fail to see the merits of "smart" technologies: Only 5 percent have a programmable thermostat with smart phone accessibility, and just 2 percent have a home automation system that can be accessed by a mobile device.

Just over 1 in 10 (12 percent) with basic thermostats plan to upgrade to one that can be accessed or changed via a mobile device or to purchase a home automation system in the next year.

Sixty percent of those who have basic thermostats indicated they don't plan to upgrade because their current device does its job, and 29 percent say it's too expensive.

Despite the strong interest in rooftop solar, there are still barriers. For the third consecutive year, perceptions of being expensive (42 percent) and fears of the panels not working as promised (23 percent) remained the main barriers to residential consumer interest in solar.

SOURCING INCREASING

Consumer interest in sourcing at least one additional service from their electricity providers is growing across generations, and this growing trust in electricity providers could open the door for utilities to evolve business models to offer other services.

Seventy-five percent of residential consumers would consider sourcing another service from electricity providers.

About half (48 percent) of residential consumers are interested in purchasing energy-efficiency services from their electricity providers; the same percentage would be interested in purchasing Internet services as well from their electricity providers.

Other desired services were cable services (38 percent), telephone services (31 percent), home security systems (25 percent) and home automation systems (18 percent).

Only 25 percent of residential consumers would not consider sourcing another service from their electricity providers, with 48 percent attributing "electricity companies shouldn't be in the business of providing these services" as a reason, down from 55 percent in 2015.

"We see similar trends on the business side as we do with residential consumers, with customers leading the way for companies to be resourceful and demanding greater environmental stewardship," said John McCue, vice chairman and U.S. energy and resources leader, Deloitte LLP.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CYBERSECURITY SNAPSHOT

BY MICHAEL KOTELEC,
GLOBAL PRACTICE LEADER, VERIZON ENTERPRISE SOLUTIONS' ENERGY & UTILITIES PRACTICE

With global cyberthreats that continue to increase in frequency and scale, the need for cybersecurity and resiliency is one of the most serious issues facing energy and utilities organizations and their boards of directors today. Protecting confidential customer information and corporate assets is critical to building a trusting relationship with customers, upholding a company's brand, and for the energy & utilities industry in particular, protecting national security.

SECURING THE SMART GRID MUST GO BEYOND BRAND REPUTATION TO ISSUES OF PUBLIC SAFETY

As grid modernization projects are adopted, the importance of incorporating a strong cybersecurity program from the inception cannot be overstated. The energy and utilities sector handles vast amounts of proprietary customer data such as bank account details and credit card numbers. This data, when combined with the critical mandate to protect national infrastructure from external threats, underscores the imperative for organizations to double down on security measures.

Vulnerability to cyberthreats grows as an increase in systems results in more potential entry routes to customer data. This is especially true as energy and utilities companies roll out web-based solutions such as online billing and Internet of Things (IoT) devices like smart meters to deliver efficiencies and enhance the customer experience. Therefore, managing risk while disrupting traditional business models must go hand in hand.

Organizations must understand the security risks and implement plans and systems to safeguard all devices, sensors and things connected to their networks. The goal is to help maintain a safe environment for customer information while also helping protect public safety.

So, what are some of the big cybersecurity issues keeping CIOs and CSOs up at night? In this article, I'll share a snapshot of the cybersecurity landscape within the backdrop of Verizon's annual Data Breach Investigations Report, and will also explain what this means for businesses today, including the critical need for strong cybersecurity strategies and plans. In addition, I'll offer recommendations on steps that organizations can take to strengthen security to better serve their customers, including today's highly digital and mobile consumer population.

DBIR

A recent picture of the cybersecurity landscape will help to set the stage for discussing the major threats to the energy & utilities industry. Verizon's Data Breach Investigations Report (DBIR), now in its ninth year of publication, reflects incident data from contributing organizations across the globe to expose what's happening on the cyber battlefields. The 2016 DBIR provides insights based on more than 100,000 incidents, including 2,260 analyzed breaches, from across 82 countries.

The major plot line of this year's story involves cybercriminals exploiting common errors and human weakness in pursuit of financial gain. Consider the following DBIR statistics:

89% of confirmed breaches had a financial or espionage motive;

63% of confirmed breaches involved leveraging weak, default or stolen passwords; and 30% of phishing messages were opened in 2015, and 12% of targets clicked on the malicious attachment or link.

In addition, the DBIR found that most attacks exploit known vulnerabilities that have never been patched despite patches being available for months, or even years. In fact, the top 10 known vulnerabilities accounted for 85% of successful exploits. Essentially, basic defenses continue to be sorely lacking in many organizations.

How does this all apply to the energy and utility sector specifically? According to Verizon's research, the vast majority of security incidents across the energy & utilities industry involved cyber espionage (38%) in which state-affiliated actors breach an organization to target intellectual property; crimeware (19%) which is any use of malware to compromise systems, and is typically opportunistic and motivated by financial gain; and, Denial-of-service (12%) which is the use of botnets to overwhelm an organization with malicious traffic and bring operations to a halt.

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Plan now to attend EEI's 2017 Annual Convention

Rapid transformation is taking place throughout the nation's electric power industry. At the heart of this transformation is a clean energy future that is customer-driven and delivered by a modern, reliable and resilient power grid. America's electric utilities are steadily innovating to achieve this vision and ensure that electricity will continue to run our economy and power our lives.

Register today for the EEI Annual Convention—and experience this excitement firsthand in Boston, June 11–14. Tap into an unrivaled opportunity to connect with the industry's top executives and thought leaders, who will explore cutting-edge topics including the utility grid of tomorrow, distributed generation, environmental issues, grid resiliency, electric transportation and much more. In 2016, more than 50 CEOs and senior executives addressed these critical industry issues.

Mark your calendar now to attend EEI's 2017 Annual Convention—the industry's premier strategic networking event.

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NEW FERC 827 RULING FOR WIND FARMS ENSURES SMOOTH GRID CONNECTIONS

BY MICHELLE MEYER, ABB

INTRODUCTION

The electrical grid in the United States is heavily regulated to ensure reliabile and cost effective electricity for consumers. As the U.S. electrical grid continues to evolve by adopting new business models, integrating renewables, and incorporating smart grid technologies, maintaining system reliability takes significant coordination and oversite. The Federal Energy Regulatory Commission (FERC) is an independent regulatory body that oversees the transmission network with the main objective of promoting a safe, reliable, and efficient grid for the energy consumers. Through the establishment of FERC rulings, this entity is able to set operational standards and precedence for how the transmission network will operate.

In a landmark ruling issued on June 16, 2016, FERC Order No. 827 will now require all newly interconnected non-synchronous generators such as wind farms "to be able to provide reactive power at the high-side of the generator substation as a condition of interconnection". Prior to this ruling wind farms and other non-synchronous generators were exempt from providing any reactive power compensation, unless a need was identified through a system impact study.

This article will address the significance of the FERC 827 and the solutions available today to help facilitate the seamless interconnection of wind and solar plants to the transmission network.

BACKGROUND

With declining costs of renewables, extension of subsidies in the form of tax credits, and policies promoting low emitting fuel sources, renewables are becoming a mainstream source of generation on our electrical grid. In order to maintain our system reliability, the rules that govern our grid interconnection policies need to be constantly evaluated and revised to make certain that variable and intermittent sources of power can safely connect to the utility grid. As a result, over time FERC has issued rulings that set standards for interconnecting to the transmission network and verify that these generating facilities would also contribute to the operational performance of the grid.

In 2003, FERC issued Order No. 2003 which set "governing procedures and a standard agreement for the interconnection if generators greater than 20 MW." With the goal of preserving system reliability, FERC Order 2003 placed performance requirements on generation facilities such as the ability to demonstrate low voltage-ride through, include supervisory control and data acquisition (SCADA) ability to transmit data, and maintain a power factor within the range of 0.95 leading and 0.95 lagging at the point of interconnection. This standard procedure and agreement for interconnection of large generation facilities was established to ensure bulk system voltage regulation was maintained and not compromised.

In order to reduce barriers to the adoption of wind power, FERC adopted another ruling to prevent added "unnecessary obstacles to further development of non-synchronous generators." FERC Order 661 essentially exempts wind farms from meeting the interconnection requirements established in FERC Order 2003 unless the transmission provider shows through a system impact study shows that "meeting such requirements is necessary to ensure safety or reliability".

However, as more and more rigid operators were adopting wind and solar power generation, the need for these non-synchronous generation facilities to contribute to the reactive power support of the utility grid has increased significantly. In addition to the high penetration of renewables, regulators have also determined that costs to help wind generation facilities to meet reactive power requirements have gone down substantially since the first ruling was launched back in 2003. As a result, in June 2016, FERC issued a new ruling that will now require all non-synchronous generators connecting to the transmission network 20 MW or larger to provide dynamic reactive power within the power factor.

THE IMPORTANCE OF REACTIVE POWER

Today's electrical grid predominately operates on alternating current (AC) power, where watts that are generated, transmitted, delivered and consumed are in the form of real power. However, there is another form of power that is inherent to AC electrical grids, and that is called reactive power, which is measured in vars. Reactive power does no real work on the electrical grid as in turning on the lights or charging a mobile phone, but whether it is useful or not, reactive power is generated and consumed all throughout the electrical grid.

Reactive power is generated and consumed by equipment throughout the transmission and distribution grid such as transformers, capacitors, reactors and motors. Left unchecked, too much reactive power can overheat electrical equipment and wires and lead to increased line losses. At the same time, too little reactive power

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REDEFINING CALIFORNIA'S POWER GRID

BY LYN CORUM, CLASS OF 2003

Two studies released recently by California's energy agencies chronicle the challenges for the state's energy future. The first is known as RETI 2.0, a multi-agency effort to identify where transmission should be built to ensure renewable resources will fulfill goals the state has set. This work has been ongoing for about ten years.

The second study was released by the California Independent System Operator in response to state legislation, SB 350, and is controversial to say the least. In it, CAISO outlines the feasibility of a west-wide system operator that would allow Wyoming, Utah, Idaho, Arizona, New Mexico, Oregon and Washington to trade power – both renewable and fossil-fueled – with California. The major controversy is over whether states will be allowed to control their own governance over resource planning.

Finally, Southern California Edison is planning for the future power grid in its service territory as more and more customers install roof-top solar systems and other distributed energy technologies. It is working to design a local power grid that will be a plug-and-play platform that integrates DER technologies. Is this beginning to sound like the transformation the telecom industry went through a decade ago?

THE FUTURE FOR RENEWABLE DEVELOPMENT

The California Energy Commission has published an updated report on the Renewable Energy Transmission Initiative, known as RETI 2.0, that concludes that the current aggressive procurement of renewable resources by California utilities has reduced or delayed the need for procuring sizable amounts of new resources until 2030 goals need to be met. At that time California utilities will require twice as much renewable resources as other Western states combined.

The absence of available transmission to bring capacity into California is seen as the biggest issue limiting out-of-state renewable resource development. The report lists some 14 transmission lines already in or near advanced development. They would be built starting in New Mexico, Utah. Wyoming, Idaho, or Arizona and terminate in California, Nevada, Arizona or Utah. The detailed list of transmission projects in development can be found in the report, found at http://www.energy.ca.gov/reti/.

The report also reviews the potential for developers to build renewable resources in the Western States within range of transmission lines and markets. California is seen as the primary RPS-driven market opportunity by developers.

Another constraint, in addition to lack of available transmission capacity, is that of export constraints for California's excess renewable energy generation. The report says the Southwest may find themselves in a similar position within five to ten years.

The work that produced the report is based on outreach to Western states and stakeholders outside of California asking for input on the availability of renewable energy and electric transmission that could contribute to meeting California's renewable energy and GHG objectives.

The CEC collaborated with the California Public Utilities Commission, the California Independent System Operator, the California office of the US Bureau of Land Management and the California Natural Resource Agency to sponsor the work.

Renewable resources supply has become increasingly competitive on an economic basis due to the impact of technology improvements, cost declines and federal tax incentives, says the report. It goes on to say power purchase agreement prices are falling as a result and "there are thousands of MWs of renewable energy in development across the West eager to sign such agreements with off-takers."

The supply, in some instances, aligns closely with coal plant retirements, but otherwise is geographically and technologically diverse.

Stakeholders have suggested, says the report, that the Energy Imbalance Market operated by Cal ISO and the potential regional market can provide solutions for the excess renewable generation.

TRANSFORMING CAISO INTO A REGIONAL GRID OPERATOR

In October, 2015 Governor Jerry Brown signed into law SB350, the Clean Energy and Pollution Reduction Act. It establishes new clean energy, clean air and greenhouse gas reduction goals for 2030 and beyond. It calls for examining barriers to and opportunities for renewable energy generation, and barriers for low-income residents to energy efficiency and weatherization investments and to zero-emission and near-zero -emission transportation options.

The law also calls for transforming CAISO into a regional organization, contingent upon approval from the legislature. CAISO drew up "Proposed Principles for Governance of a Regional ISO" and revised them in time for a CEC workshop in July. The document is available on CAISO's website: http://www.caiso.com/Documents/RevisedProposedPrinciples-RegionalIS. Its major purpose was to determine whether a policy initiative would materially diminish

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THE FUTURE OF ENERGY STORAGE

BY CRAIG EVANS, CEO, ESS, INC.

PORTLAND, OR - With the growth trajectory that solar is experiencing, more solar is being installed due to dramatically lower installation costs, and considering that net metering certainly appears to be going away, batteries are becoming an asset and in some locations a requirement for further solar integration. One of the big emerging use cases for integrating batteries with solar, is long-duration storage – and the beneficial impacts that 4+ hours of storage will have on the market in terms of how the value of solar and other renewable installations are measured. For example, having the flexibility to engage both power and energy applications utilizing stored solar power is an incredible use case for this resource. With long-duration storage you have the ability to store excess solar production and time shift that energy to when it has higher economic value. The storage allows you to smooth out solar intermittencies throughout the day, address expensive demand charges for C&I customers, and shift that solar power out into the later afternoon and early evening where it is far more valuable to the asset owner and to the grid operator. Certainly the integration of longer duration storage will allow us to deploy even more solar and other renewables.

A 10-kilowatt, 60-kilowatt hour all-iron flow battery from ESS Inc. installed at the Stone Edge Farms Advanced Micro Grid in Sonoma County, CA is primarily for PV smoothing as well as shifting stored solar energy to the evening to power irrigation pumps and a hydrogen electrolizer. The ESS battery system is coupled with a D.C. System micro grid controller that controls the battery using Sun Spec protocols over a Modbus interface. DC Systems optimizes the use of the battery system, locally, on a daily basis. ESS is also able to monitor and control the system back at its headquarters.

The ESS system is an environmentally safe chemistry. It's iron, salt, and water. These abundant and low cost materials are also non-corrosive, so low cost plastic-type materials can be used in the battery modules, which keep capital costs extremely low. The benign ingredients are also non-flammable which completely eliminates a costly fire suppression system.

The system is very easy to install. The IFB ships in a dry state, is hydrated on site and because it is a complete integrated and turnkey system, once the system is grid connected our team can have it fully operational in about a day and a half. Field certified through Intertek. The IFB has a durable and a long operating life in excess of 20,000 cycles, or > 25 years.

The company has done extensive testing of the IFB, cycling it in two different depth of discharge modes.

The first one is operating at very high states of charge, doing very shallow depth of discharge cycles, so between 80 and 90 percent of state of charge (SOC). The second one is deep discharge cycles, going from 95 percent down to 20 percent state of charge. This simulates doing one full cycle a day on the battery. This rigorous testing has validated no capacity loss and very little efficiency loss over its operating life.

When you're doing large-scale PPA's that last 20-25 years, the life of the solar system, you want to couple that with a battery that's going to last just as long, so you don't have to replace the battery multiple times, impacting your levelized cost of storage (LCOS). That's very counterintuitive to a lithium ion battery or a lead acid type battery, which are actually going to fade over time and have to be replaced.

Some of the reasons why ESS is able to achieve these no capacity fade cycles and long-duration capacities are primarily due to the type of battery chemistry used. It's a flow battery. And in a flow battery basically all of the reactions occur in the liquid form. Basically you're stripping the electrons on and off of Iron ions. In our case, on the positive side of the battery, you are changing the oxidation state of iron – Fe^{2+} to Fe^{3+}, as you charge. And when you discharge the battery, the positive side goes from Fe^{3+} to Fe^{2+}. So you're basically going from ferrous to ferric states. On the negative side of the battery, we go from ferrous chloride, which is Fe^{2+}, to plate iron on the electrode surface. And on discharge, the reverse happens.

One of the other reasons, besides operating in the liquid form, is that we have very high capacity, operating with the same electrolyte on both sides of the battery. So, there's no ability to cross-contaminate the battery. In some types of flow batteries, you have different elements on both sides of the battery – iron chrome, zinc iron, vanadium iron. Over time, no membrane is perfect and will result in diffusion. Eventually, the elements from either side of the battery are going to cross over, which is going to contaminate the electrolyte and degrade the performance of a flow battery. Then you have two choices. One, you can either replace the electrolyte entirely, which can be costly and a lot of O&M. Or you can live with that efficiency and capacity loss. The ESS IFB does not have this limitation.

In terms of how we keep our efficiency high over all these cycles – that lends itself to the positive electrode where typically you would see a lot of carbon corrosion.

LEVERAGING DATA FOR SUSTAINABILITY

BY CONSUELO CARMONA MIURA, HEINEKEN ENERGY PROJECT HEAD

SEVILLE,SPAIN - Heineken is the number one brewer in Europe and number three brewer in the world with operations in 71 countries with an annual beer production of 181 million hectoliters in one hundred and sixty-five breweries with seventy-six thousand employees. Sustainability has been a core operating principal for Heineken for 150 years.

In 2010, as part of its ongoing commitment to sustainability, Heineken introduced a comprehensive 10-year sustainability plan that affected all aspects of the operations.

For the Seville brewery this meant reducing water consumption by 25% and reducing CO2 emissions by 40% based on their 2008 levels.

In 2012 when the brewery started approaching its technological limit, the brewery realized it was going to need another tool if it was going to meet the 2020 targets. We knew we were close to the technological limit; it was clear that we needed an energy and water monitoring and reporting system if we wanted to keep moving forward because we spent 80% of our time collecting information and 20% analyzing it when it should be the opposite.

The PI System solution is very flexible and is accessible for everyone.

SOLUTION

In 2012, Heineken España installed the PI System at the brewery in Seville. The brewery also decided that Asset Framework (AF) was going to be a core part of the solution, as we have many silos, non-intuitive tag names and a lot of equipment across the different processes.

AF CAPABILITIES

In addition to organizing data and making it more user friendly, AF has given the brewery increased calculation capabilities.

Now, when machines are defined in AF, the primary sustainability attributes (electricity, water, and thermal energy consumption) are also defined. This means that sustainability data is available for each asset and as roll up data across divisions, in real-time as absolute values, in per shift, per day, and per week totals, and in weekly and monthly ratios that show the amount of water, electricity, and thermal energy consumed per hectoliters of beer produced.

AF has also allowed the brewery to group their data and sustainability metrics based on the roles of the users.

The end result is users see data for their areas of responsibility in a structure they understand.

PI SYSTEM

The Seville brewery has seen several benefits from their PI System deployment.

The PI System has made information easier to access. We spend 10% of our time collecting data and just enjoy analyzing information the rest of the time.

It's totally the opposite of a few years ago.

The PI System has also improved data quality. In the old software we were missing efficiency data, ratio data, historical values, we needed more flexibility in graphs. Now we can check in real-time efficiency, power, pressure, and flow and see efficiency values for the last 24-hours, last week and last month.

Since the PI System is easy to use, the Seville brewery has been able to extend their data to new users. Each department has to own their own consumption. With the PI System, they develop screens and control consaumption in real-time.

With improved data and the ability to view sustainability metrics in real-time, the Seville brewery can view real-time operations against both yearly sustainability targets and historical process levels and make dynamic process adjustments.

As a next phase in its implementation, the brewery is planning to switch from fixed yearly targets to dynamically recalculating yearly targets that adjust based on real-time production and current climate conditions.

PI DATALINK AND PI PROCESSBOOK

In addition to improving real-time information access, we use PI DataLink and PI ProcessBook playback to analyze historical problems. Using playback we can analyze second by second what happened in the past.

ABOUT THE AUTHOR

Consuelo Carmona Miura is an Industrial Engineer specializing in Organization and Production; and has a Master's Degree in Thermal Energy Systems, Energy Savings and Efficiency. Miura joined Heineken in 2008, working in TPM (Total Productive Management) for two years.

For the last three years, Miura has worked as a Utilities Manager and Energy Champion and in September begins her role as Electricity European Project Lead.

SOLAR DESALINATION

BY MAHABALA ADIGA

Water shortage and desertification are going to be the major challenges in certain parts of the world and it is going to be the predominant problem in the near future. Water shortage has been observed in California and in areas affected by the expansion of the Sahara Desert and deserts in other parts of the world. It has also alarmed environmental scientists. Most of the available water in the world is seawater and fresh water is only a fraction. Therefore, it is of paramount significance to find alternative methods to desalt seawater into freshwater for an ever increasing human population.

Large desalination plants of a few million gallons per day have been put up in the Gulf region. Earlier plants were based on thermal desalination technologies, such as Multi Stage Flash (MSF) and Vapor Compression (VC) distillation systems. The total energy consumption including both thermal and electrical amounted to more than 150 KWh per 1000 gallons of desalted water. The scene has changed after the emergence of membrane based technologies, such as Reverse Osmosis (RO). Currently with the energy recovery turbines/work exchangers, one can consume only about 10 to 12 KWh per 1000 gallons of water. This amounts to only about 2.5 $ per 1000 gallons of freshwater from seawater. This cost varies from place to place due to variation in the cost of electricity. The future developments in forward osmosis or any other promising technology may further reduce the energy requirement for desalting seawater or brackish water.

Seawater desalination is appropriate in coastal and island regions, where brackish water desalination is important in interior regions of the US main land, such as Arizona, New Mexico etc, where water at 100 to 300 feet below the ground is brackish with 3 to 4 grams of salt per liter. However, whenever one applies desalination technology in such interior regions, one has to ensure zero discharge technology failing which the concentrated reject discharged into the ground is going to increase the salinity of the ground water. The hybrid Reverse Osmosis-Electrodialysis, followed by evaporation-crystallization is one such method to produce fresh water and salt, so that, there is no waste discharge to the ground.

Solar energy or renewable energy application for desalination will further reduce the cost of desalted fresh water. This is due to current international cost of solar cells standing at 25 to 30 Cents per watt of solar cell panel as against about 1 $ in USA. Therefore, solar desalination is much more appropriate compared to conventional energy based desalination. The solar seawater desalination based on such technology may costs less than the conventional seawater desalination

I put up the first directly connected Solar Desalination system in 1981 in an un-electrified village, Avania in Gujarat and later put up a directly coupled solar desalination system in 1986 at Tanote in the Thar Desert in India to provide fresh drinking water to local inhabitants and border security forces. The water was drawn from a well of about 300 feet deep and it contained about 5 grams of salt in one litre and it was desalted to provide drinking water. This type of technology is applicable in places like Arizona, New Mexico, California or any interior places with brackish water to provide safe drinking water.

The hybrid desalination technology was applied again for oil produced wastewater, i.e. oil field brine in Alberta. Currently my team has developed technologies for treating fracwater, i.e. wastewater produced during the extraction of natural gas and oil produced brine i.e. wastewater produced during oil drilling operations.

BACK ON CAMPUS

WITH NIGEL COCKROFT, CLASS OF 2016

World-Gen met with Nigel Cockroft, General Manager of JinkoSolar (US) Inc. at the Jinko exhibit during Intersolar NA to discuss ongoing utility and residential solar sales in 2016. In 2015, JinkoSolar was positioned as one of the top three solar pv manufacturers in terms of sales volume, with over 1000 mw shipped in the US alone. The company has since grown past its competitors, ranking #1 globally for modules deployed in Q1 and Q2 of 2016. "For the first half, we've shipped more modules than any other company and continue to expect this rate for the remainder of the year," Cockroft said.

Cockroft attributes these results to its exceptional post-sales service; JinkoSolar US Inc. continues to have an over 99.97% ontime delivery to job sites. "We import the modules to the ports and warehouses and begin shipping between 40 to 60 trucks a day to different job sites; a large utility project would typically receive 10 to 20 trucks a day," he explained.

Jinko scheduled appropriately during the West Coast ports labor issues: "We were able to keep our almost perfect record by absorbing variable costs to provide superior service. Obviously, we try to build that into the overall cost and pricing expectation."

JinkoSolar (US) Inc. has had zero power output warranty claims since 2011. Cockroft stated that this is due to the high performance of the module, including its aging properties, which should perform better than the warranty. "All the products coming to the US are using DuPont material," he underscored.

"JinkoSolar has quickly become the brand of choice for utility-scale installations due to our high-quality modules and unmatched post-sale service," he pointed out, "I believe JinkoSolar's 1500 volt Eagle modules with DuPont™ Tedlar® backsheets are by far the most robust in the North American market. Offering these high quality modules is yet another step in our effort to provide our customers with the best technology and proven reliable and cost-effective products."

ENGINEERS TAKE THE FUN OUT OF CHRISTMAS

BY R. PALMER

AROUND THE WORLD WITH SANTA CLAUS

There are approximately two billion children (persons under 18) in the world. However, since Santa does not visit children of Muslim, Hindu, Jewish or Buddhist (maybe in Japan) religions, this reduces the workload for Christmas night to 15% of the total, or 378 million (according to the population reference bureau).

At an average (census) rate of 3.5 children per household, which comes to 108 million homes, presuming there is at least 1 good child in each, Santa has about 31 hours of Christmas to work with, thanks to the different time zones and the rotation of the earth, assuming east to west (which seems logical). This works out to 967.7 visits per second. This is to say that for each Christian household with a good child, Santa has around 1/1000th of a second to park the sleigh, hop out, jump down the chimney, fill the stocking, distribute the remaining presents under the tree, eat whatever snacks have been left for him, get back up the chimney, jump into the sleigh and get on the next house.

Assuming that each of these 108 million stops is evenly distributed around the earth (which, of course, we know to be false, but will accept for the purposes of our calculations), we are now talking about 0.78 miles per household; a total trip of 75.5 million miles, not counting bathroom stops or breaks. This means Santa's sleigh is moving at 650 miles per second, or 3,000 times the speed of sound.

The payload of the sleigh adds another interesting element. Assuming that each child gets nothing more than a medium sized LEGO set (two pounds), the sleigh is carrying over 500 thousand tons, not counting Santa himself. On land a conventional reindeer can pull no more than 300 pounds. Even granting that the "flying" reindeer can pull 10 times the normal amount, the job can't be done with eight or even nine of them. Santa would need 360,000 of them. This increases the payload, not counting the weight of the sleigh, another 54,000 tons, or roughly seven times the weight of the Queen Elizabeth (the ship, not the monarch). A mass of nearly 600,000 tons travelling at 650 miles per second creates enormous air resistance.

This would heat up the reindeer in the same fashion as a spacecraft reentering the earth's atmosphere. The lead pair of reindeer would absorb 14.3 quintillion joules of energy per second each. In short, they would burst into flames almost instantaneously, exposing the reindeer behind them and creating deafening sonic booms in their wake. The entire reindeer team would be vaporized within 4.26 thousandths of a second, or right about the time Santa reached the fifth house on his trip.

Not that it matters, however, since Santa, as a result of accelerating from a dead stop to 650 miles/second in .001 seconds, would be subjected to acceleration forces of 17,000 g's. A 250 pound Santa which seems ludicrously slim considering all the high calorie snacks he must have consumed over the years would be pinned to the back of the sleigh by 4,315,015 pounds of force.

So is there really a Santa Claus?

Merry Christmas and Happy New Year

NEXT ISSUE

Class of 2017

February/March 2017

Closing February 28, 2017

BACK ON CAMPUS

WITH SHARON ALLEN, CLASS OF 2007

ON THE EDGE: WHAT SGIP IS DOING TO SUPPORT DER PROLIFERATION

Do you remember the late 1990s, when Apple was very much an underdog fighting for its share of the computer-market bone? IBM's slogan was "Think," so Apple ran with "Think Different."

Today, twenty years later, the company that never did manage to elbow windows computers off the shelf still prevailed by following its own slogan. Consider this: Some 40 percent of U.S. smartphone users are walking around with an iPhone in their pockets.

I recall this marketing success because I want utilities to take a cue from Apple: Think different. If you're not already doing so, now would be a good time to start.

Many utility professionals have already begun to think differently, and I have the honor of working with some of them in the Grid Management Working Group hosted by SGIP. What are they thinking about? Take a look.

GRID-EDGE MONITORING AND CONTROL TECHNOLOGY

We must move monitoring and control technology farther out toward the grid edge. My discussions with utility professionals tell me we're already behind on this evolution. As examples showing why this is so important, consider these experiences from a West Coast utility.

In one case, the utility had grid-scale solar generating at full output as well as a 400 MW pump storage station that was pushing water behind the dam. When the pump station tripped off, voltage jumped and capacitor banks tripped off. While this didn't result in outages, it could have. If a bunch of capacitor banks go down and voltage goes too low, lines will trip off due to instability.

In another case, outages did occur. The utility had an under-frequency scheme in place, and it had to respond within six cycles to be effective. All looked well when low voltage kicked this protective scheme into

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REDEFINING CALIFORNIA'S POWER GRID

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or impair state authority.

Comments from stakeholders are extensive and are collected in the CEC's website, http://www.energy.ca.gov/sb350/regional_grid/documents/index.html. In general, commenters support preserving state authority through its governance structure. Mandatory forward capacity markets were not supported but stakeholders supported a voluntary capacity market. Transmission owners would be allowed to withdraw from the regional grid operator if they were dissatisfied with it. The governance plan will become effective only after it is approved by the governor of California.

EXPERTS COMMENT ON A REGIONAL MARKET

At the 8th Annual Climate & Energy Law Symposium on November 4 in San Diego, the potential impact of a regional ISO on the future landscape of California's and the west's electricity production and movement sparked the following comments from speakers.

Travis Kavulla, a commissioner of Montana's Public Service Commission and president and chairman of the National Association of Regulatory Utility Commissioners, commented on the risks of curtailing renewables or paying them to not dispatch when the power is not needed. Expanding to a regional market avoids this issue. "It's a software solution to optimize billions and billions of dollars invested and paid for by customers in infrastructure."

Travis also said that a regional ISO should bypass supporting public policy and stick to operating the electricity markets. States should have protections to decide on infrastructure capital resource planning, he argued.

DeAnn Hapner, vice president for FERC and ISO Relations at Pacific Gas and Electric, commented that with a regional grid, "There are costs that will likely impact customers." She agreed that integrating municipal utilities, which have separate local governances from investor-owned utilities, into a regional ISO must come into play.

Kavulla added that the corporate leadership of publicly owned utilities is more sensitive to and report to local markets, whereas investor-owned utilities build in costs that support state policies such as subsidizing low-income ratepayers, energy efficiency programs and energy research.

Tim Duane, a visiting professor in Environmental Law at the University of San Diego School of Law which sponsored the symposium, made the point that if you have a more diverse spread of renewables in a few transmission operators, the need for resource adequacy will be diminished to zero and there will be less need for new resources.

John Anders, lead counsel at the CAISO, discussed the implications of moving to a western regional market. He said the risks of not establishing such a market mean the costs of operating the current market may become unreasonable. He predicted a regional ISO would create $1 billion to $1.5 billion in economic benefits and an 8% to 10% reduction of greenhouse gases in California.

SCE REDEFINES ITS POWER GRID

In September, SCE released a short report, "The Emerging Clean Energy Economy" in which it describes how it plans to modernize and reinforce its distribution grid. It reports that in 2015, utility operators performed over 22,000 switching procedures to reconfigure or isolate portions of distribution circuits. As more and more customers install distributed energy resources (DERs) these operations will become more challenging.

As we have become aware, one-way power flows from a few large generators connected at transmission voltage is giving way to two-way variable flows created by many small DERs connected to the distribution system or behind customer meters. Clusters or concentrations of distributed resources could quickly complicate grid operations. Safety and reliability issues will increase in both frequency and magnitude unless a modern grid is created with enhanced capabilities.

SCE sees Distribution System Operators planning and managing the modernized plug-and-play grid with advanced sensors, communications and automation embedded in the distribution grid.

DERs will be able to connect to wholesale markets to sell services under this new grid and receive compensation for providing location-specific services. It could also open up third party markets where the distribution platform could enable markets for energy transactions between customers or marketplaces for new products and services.

Of course, this comes with a price. SCE writes that "rate designs and programs must transition to share the benefits and costs among customers who deploy DERs to meet a portion of their energy needs and those who do not. Rates should account for the fixed costs of the grid so all customers, including DER owners, pay for access to the modernized and reliable grid."

The new proposed rates, which were not discussed in this report, will likely lead to lengthy hearings and debates.

The report is available at www.edison.com/TransformingtheGrid.

SCE CREATES PILOT

To prepare for this transition, SCE has been planning a preferred resources pilot for several years in Orange County which if successful will be a model for the clean energy grid of the future throughout its service territory. The Orange County multi-year pilot will measure the impact on the grid of clean energy options – energy conservation, solar and wind generation and energy storage. The goal of the pilot is to determine the correct mix and proper timing for adding these resources to meet local customer demand. The area was chosen for the pilot because of its proximity to the shuttered San Onofre Nuclear Generating Station and the presumed needs of the communities impacted by the closure.

HEAVY INDUSTRY IS MOVING TO THE CLOUD
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blade walls thinner could result in 0.5% efficiency gains for a turbine like the SGT-800, Navrotsky says.

AM is a "game changer," Navrotsky says. But Siemens is not converting all its turbine manufacturing to AM. "We can't apply AM to simpler components; it would be too expensive," he says.

The company's strategy is to use AM for high tech components, such as burner tips, burners and turbine blades where there is a high potential to add efficiency, enhance flexibility in the design process or reduce costs. Otherwise, the company will use conventional methods to manufacture the rest of the turbine.

As Siemens ramps up AM production for the more complex components, it expects the cost of AM to decline, making it feasible to use in simpler components. Even with the savings of time and materials, Siemens does not see the main benefit of AM as simple cost reduction, at least not yet.

The cost of manufacturing a burner tip using AM is about the same as the cost of conventional manufacturing, but the AM part has better performance specs and, eventually, could be manufactured at half the cost, said Navrotsky.

Right now AM in Finspang is a research and development effort. "We are not looking at the bottom line because it could be a distraction," Fors said.

He admits that AM has not yet added to Siemens' bottom line, but it has "added value for customers and made us more competitive."

Fors said the company's AM efforts are about taking the manufacturing process "to the next level" and "scaling it up so that down the road we will have cost benefits."

In Fors' vision, making turbine parts using AM is part of a larger process of re-inventing and digitizing the manufacturing process. In that scenario, AM starts in the design phase with computer aided design (CAD).

As Fors points out, combining CAD and AM is a radical shift for design engineers. AM breaks down some of the physical constraints of traditional engineering by making it possible to more readily bridge the gap between conception and execution.

In conventional manufacturing, engineers designed parts within the parameters of the manufacturing process. AM allows almost any design to be realized. To use the company's phrase, "If you can dream it, you can print it."

In addition to giving greater design flexibility, AM also allows for a quicker vetting of design concepts. Prototypes can be quickly made and tested, providing rapid feedback. That results in a less risk averse design process and shorter lead times.

In traditional manufacturing, failure is to be avoided at all costs. It is expensive and time consuming. One of the biggest changes that AM is introducing into manufacturing is an erosion of the built-in conservative bias of engineers. Fors says it is hard to get engineers to adopt that mindset or to think that "to fail is not a big deal, as long as you fail cheaply." Something, he points out, that is made possible by AM.

Design and manufacturing are just two of the steps in the manufacturing process that Siemens hopes to knit together into a single digital process. Those steps – design, processing, post processing, instrumentation and testing – are now islands, says Andreas Graichen, Siemens' group manager in the AM center of competence in Finspang. Instead of islands, Graichen sees those steps being brought together in a seamless digital process that incorporates feedback loops and self healing processes.

Eventually that will enable manufacturing to be handled remotely and even in the cloud. In that scenario, Siemens sees AM resulting in big gains in the manufacturing process, including a 75% reduction in development time, a 50% reduction in lead time, 60% faster repairs and 63% fewer resources used in production.

CYBERSECURITY SNAPSHOT
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RECOMMENDATIONS

What can you do to better avoid falling victim to a damaging and often costly cyberattack? Consider these recommendations for the most common types of attacks on the energy & utilities industry:

Cyber espionage intrusions:

- Patch promptly.
- Track and monitor all inputs: Keep good logs and review consistently to help identify malicious activity.
- Train your staff: Developing security awareness within your organization is critical especially with the rise in phishing attacks.

Crimeware attacks:

- Patch anti-virus and browsers.
- Capture data on attacks.
- Implement configuration change monitoring.
- Monitor user behavior. Put processes in place to track daily system usage, particularly for anyone with access to financial account details or personally identifiable information.
- Denial-of-service (DOS) attacks:
- Segregate key servers: separate critical systems onto different network circuits.
- Have a mitigation plan: Know the details of your DoS mitigation service. Brief key operations staff on the best course of action should an incident occur.
- Test for gaps: Test and update your plan regularly as your infrastructure and processes change, and as new DoS techniques emerge.
- Also, given that many attacks come through vendors, seek out partners that also use strong authentication.

Additional cybersecurity information and resources are available at verizonenterprise.com.

FERC 827 RULING
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can cause system voltage to sag, preventing real power to flow through the lines. In extreme cases, insufficient reactive power resources can result in voltage collapse and even power outages. Because of this, utilities and grid operators have taken careful measures to regulate reactive power so they can deliver nominal voltage under varying load conditions. This is in part the reason why we have strict interconnection requirements for both synchronous and non-synchronous generators, so that each power facility can contribute to the reactive power supply on the utility grid.

REACTIVE POWER COMPENSATION TECHNOLOGIES

To control reactive power on the utility grid or when interconnecting generation facilities, system operators and developers have a variety of technologies that can help implement their control strategies. From smart inverters and advanced wind converters to Static Var Compensators and STATCOMS (Static Synchronous Compensators), the location of the renewable facility and the condition of the surrounding electrical network will by and large dictate the solution required to help meet the local grid codes and this new FERC 827 requirement.

TECHNOLOGY IN ACTION: STATCOMS

Although many modern wind turbines are able to fulfill voltage control requirements by themselves, wind parks as a whole sometimes still need additional reactive power compensation to cover the balance of plant. When Type-I and Type-II wind farms in particular are in operation, dynamic VAR compensation devices can be useful to meet the grid requirements. One of the devices which can enable this is the Static Synchronous Compensator (STATCOM).

STATCOM is one of the members of the FACTS (Flexible AC Transmission System) family. It is a low voltage power electronic based device which acts as a source or sink for the reactive power. The major components of a STATCOM are a DC capacitor, a power converter, filters and a step up transformer connecting it to the grid.

A STATCOM will be able to quickly respond to grid events (with a response time of one to two cycles), providing dynamic voltage control, regardless of the wind farm layout. Even on weak grids, the STATCOM device has the capability to control reactive power and ultimately enhancing the power output of the wind farm.

As our society move towards cleaner sources of power such as wind and solar, maintaining the integrity of the electrical grid will continue to be a priority. Regulatory bodies such as FERC have issues several orders to help ensure safe and reliable connection of non-synchronous generators (i.e. wind and solar) to the transmission network.

As October 14, 2016, the new FERC ruling requires newly interconnecting non-synchronous generators to meet dynamic reactive power requirements. However, for already existing facilities that are making upgrades and making new interconnections, such requests will be exempt from these requirements as it "could expose entities with existing power purchase agreements to unforeseen expenses." This can be subject to change if the transmission provider's System Impact Study shows that meeting the reactive power requirement is necessary to ensure safety or reliability.

For the rest of the newly interconnecting non-synchronous generators, they will be required to meet the reactive power requirements at the high side of the generator substation, and not the Point of Interconnection. This means that in most cases advanced wind turbine converters can provide enough reactive power control, so that no further technology is needed. However, in areas where the grid is weak, or the surrounding load is variable, additional dynamic reactive power compensation is required.

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operation, and a 7 kV line was tripped off. But, there was so much solar on the line, it remained energized beyond the six-cycle time limit, and six more feeders tripped off as a result.

In both of these cases, one problem looms: lack of control. Much of that problem stems from centralized control that takes too long to really react to rapidly-changing conditions from intermittent generation.

THE OPEN FIELD MESSAGE BUS APPROACH

A few years ago, engineers at Duke Energy were trying to coordinate solar and storage installations. To that end, they clocked the round trip from sensors on an inverter to the head-end system, through the computation cycle and then back to the inverter. It took some 40 seconds. This is what got Duke started down the path of OpenFMB™, a reference architecture that provides a framework for distributed intelligence.

Working with Duke and other industry players, SGIP's OpenFMB™ working group shepherded this architecture through the standards process. It was ratified as a standard by the North American Energy Standards Board (NAESB) in March of 2016 and, at SGIP's 2016 Grid Modernization Summit held in Washington, DC November, we launched a collaborative website where people can access the OpenFMB™ code itself.

OpenFMB™ supports grid-edge coordination of distributed energy resources and the grid itself because it facilitates local data exchange on a circuit segment, which enables decision making without centralized system control. That's crucial because Supervisory Control and Data Acquisition (SCADA) systems typically collect grid-status data every four or five seconds, and that's just not fast enough when you have a protective scheme that must operate in six cycles.

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