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AN INTRODUCTION TO THE NIST SMART GRID INTEROPERABILITY FRAMEWORK

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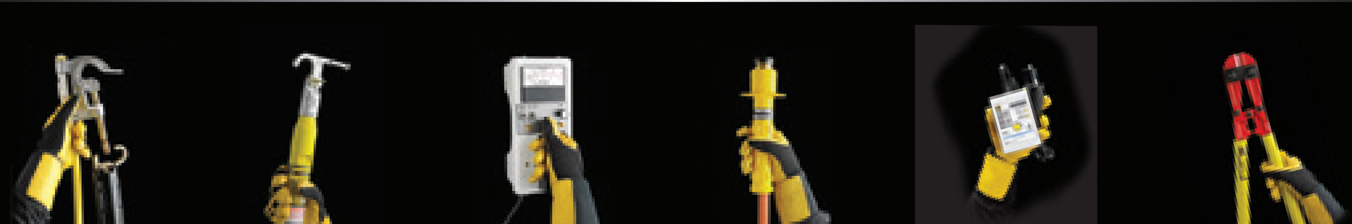

INDUSTRY NEWS

NYSERDA, INTERNATIONAL CLEANTECH NETWORK AND EU TECHBRIDGE ANNOUNCE AGREEMENTS TO COLLABORATE ON DECARBONIZING HI-RISE BUILDINGS IN NEW YORK STATE

Memorandums of Understanding Seek to Identify High-Impact Solutions to Overcome Barriers to Decarbonizing High-Rise Buildings and Stimulate Investment in Clean Energy Economy

June 2021

The New York State Energy Research and Development Authority (NYSERDA), the International Cleantech Network (ICN), and EU Techbridge today announced the signing of Memorandums of Understanding (MOU) designed to enhance collaboration on identifying high-impact solutions to overcome critical barriers to decarbonizing high-rise buildings and stimulate investment in New York State's clean energy economy. The partnerships will focus primarily on NYSERDA's $50 million Empire Building Challenge, which is expected to leverage over $250 million in private investment in building upgrades, testing, and technology. The agreements recognize a shared commitment to carbon-neutral buildings and will accelerate New York's progress toward Governor Andrew M. Cuomo's goal to reduce greenhouse gas emissions 85 percent by 2050 as outlined in the Climate Leadership and Community Protection Act (Climate Act).

Doreen M. Harris, President and CEO, NYSERDA said,

> *"These MOUs will enable us to match global innovators with our most challenging building decarbonization issues to identify replicable solutions that can be used across the state. Our collaboration with ICN and EU Techbridge will increase information sharing and foster valuable partnerships between building owners and international companies, further establishing New York State as a leader in implementing low- and zero-carbon technologies to combat climate change."*

Henrik Bjørnager Jensen, Chair of ICN and International Director at CLEAN, which leads the EU TechBridge project, said,

> *"We are thrilled to be formalizing our collaboration with NYSERDA. We look forward to mobilizing ICN's unparalleled network of innovative small to medium-sized enterprises to help realize New York's ambitious goals to decarbonize the built environment. This partnership will help translate New York's sustainability challenges into business opportunities, driving green growth."*

Mike Mulcahy, Chair of the ICN and CEO of GreenCape in Cape Town said,

> *"The ICN represents 16,000 GreenTech companies from 4 continents. The partnership with NYSERDA provides a tangible opportunity for global co-operation and learning in support of a greener future. The work done through this project will unearth new solutions for the buildings and create the context for international partnerships."*

→

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Under the agreements, the strategic partnerships will support knowledge sharing, matchmaking and investment from leading cleantech providers in the European Union, Africa, North America, and South America to New York to strengthen NYSERDA's ability to learn from the robust global industry of building decarbonization solution providers.

The MOUs focus on overcoming the complex challenges of completing energy efficiency and electrification upgrades in high-rise buildings, a key area of the buildings sector that is being addressed through NYSERDA's Empire Building Challenge. Launched in September 2020, the Empire Building Challenge program is designed to showcase best practices that can be replicated in contexts facing similar challenges and issues through pilot projects and demonstrations of technical solutions. Through the Empire Building Challenge, NYSERDA is establishing partnerships with leading commercial and multifamily real estate portfolio owners and occupants with buildings located in New York State that make a commitment to bringing one or more buildings in their portfolio to carbon neutrality by 2035.

NYSERDA will collaborate with ICN and EU Techbridge on the following key priorities:

- Identifying concrete solutions and knowledge sharing to support the transition to more energy efficient buildings in New York;
- Mobilizing ICN and EU Techbridge's strong clean technology network and encouraging investment and job creation in New York; and
- Providing a forum for exchange on new approaches and solutions within energy efficiency, climate adaptation, and resiliency to foster best practices

High-rise buildings, particularly in New York City, face unique challenges when it comes to implementing carbon emissions reduction measures. These challenges can range from tenant disruption, upfront costs for renovations, and the sheer size and scale of high-rise buildings. The Empire Building Challenge seeks to address these and other market barriers by addressing crucial clean energy innovation gaps, through collaboration with the private sector, to decarbonize high-rise buildings and provide a blueprint so successful strategies can be implemented across many more buildings.

The International Cleantech Network (ICN) is an exclusive network of 16 leading cleantech regions in Europe, North America and South Africa, connecting 16,000 businesses, public authorities and research institutions. The EU Techbridge project, led by the Danish cleantech organization, CLEAN, is a co-funded COSME programme of the European Commission, that brings together five regional cleantech hubs to match innovative European solution providers with North American customers. Both ICN and EU Techbridge have a network of solution providers that focus on decarbonization technologies.

Buildings are one of the largest sources of greenhouse gas emissions in New York State, and integrating energy efficiency and electrification measures in existing buildings will reduce carbon pollution and help achieve more sustainable, healthy, and comfortable buildings. Through NYSERDA and utility programs, over $6.8 billion is being invested to decarbonize buildings across the State. By improving energy efficiency in buildings and including onsite storage, renewables, and electric vehicle charging equipment, the State will reduce carbon pollution and achieve the ambitious target of reducing on-site energy consumption by 185 trillion BTUs by 2025, the equivalent of powering 1.8 million homes. Energy efficiency accounts for 75 percent of the clean energy jobs across New York, and the state's ambitious plan to reduce carbon pollution will result in an additional $1.8 billion in societal and environmental benefits.

Building owners, solution providers, manufacturers and other interested stakeholders are encouraged to visit http://nyserda.ny.gov/EBC for additional details on the Empire Building Challenge and to learn how to partner with NYSERDA, reduce carbon emissions, and get involved in the clean energy economy. For more information about ICN and EU Techbridge please visit their websites.

Today's announcement represents New York's commitment to supporting technology innovation in the advancement of clean energy as an economic driver and critical solution in the global fight against climate change. Governor Cuomo recently announced an MOU with the Confederation of Danish Industry (DI), Denmark's largest private business and employers' organization, designed to enhance collaboration on decarbonizing high-rise buildings in New York State. In September 2019, Governor Cuomo announced an agreement between NYSERDA and the Danish Ministry of Energy, Utilities and Climate to share expertise and knowledge for developing innovative solutions for the development of offshore wind energy, recognizing the shared common interest in advancing this renewable resource as a clean and sustainable energy source.

New York State's Nation-Leading Climate Plan

Governor Cuomo's nation-leading climate agenda is the most aggressive climate and clean energy initiative in the nation, calling for an orderly and just transition to clean energy that creates jobs and continues fostering a green economy as New York State recovers from the COVID-19 pandemic. Enshrined into law through the Climate Leadership and Community Protection Act, New York is on a path to achieve its mandated goal of a zero-emission electricity sector by 2040, including 70 percent renewable energy generation by 2030, and to reach economy wide carbon neutrality. It builds on New York's unprecedented investments to ramp-up clean energy including over $21 billion in 91 large-scale renewable projects across the state, $6.8 billion to reduce buildings emissions, $1.8 billion to scale up solar, more than $1 billion for clean transportation initiatives, and over $1.2 billion in NY Green Bank commitments. Combined, these investments are supporting more than 150,000 jobs in New York's clean energy sector in 2019, a 2,100 percent growth in the distributed solar sector since 2011 and a commitment to develop 9,000 megawatts of offshore wind by 2035. Under Governor Cuomo's leadership, New York will build on this progress and reduce greenhouse gas emissions by 85 percent from 1990 levels by 2050, while ensuring that at least 35 percent with a goal of 40 percent of the benefits of clean energy investments are directed to disadvantaged communities, and advance progress towards the state's 2025 energy efficiency target of reducing on-site energy consumption by 185 trillion BTUs of end-use energy savings.

$6.8 BILLION

About NYSERDA

NYSERDA, a public benefit corporation, offers objective information and analysis, innovative programs, technical expertise, and funding to help New Yorkers increase energy efficiency, save money, use renewable energy, and reduce reliance on fossil fuels. NYSERDA professionals work to protect the environment and create clean-energy jobs. NYSERDA has been developing partnerships to advance innovative energy solutions in New York State since 1975.

NORTHWESTERN ENERGY JOINS THE WESTERN ENERGY IMBALANCE MARKET

The real-time wholesale energy market now includes a Montana-based utility

June 2021

The Western Energy Imbalance Market (EIM), operated by the California Independent System Operator (ISO), has expanded its footprint to Montana with the addition of NorthWestern Energy.

NorthWestern Energy's participation, which began today, caps off a year of significant growth for the real-time energy market, with eight utilities joining already this year. The Western EIM now serves consumers in 10 states, including portions of Arizona, California, Idaho, Nevada, New Mexico, Oregon, Utah, Washington, Wyoming, and Montana. By 2023, 22 active Western EIM participants will represent more than 83% of the load in the Western Interconnection.

> *"We are very pleased to welcome NorthWestern Energy into the family of Western EIM entities," said ISO President and CEO Elliot Mainzer. "This new partnership with NorthWestern will add regional diversity and diverse resources into the real-time energy market and provide additional economic and environmental value to consumers in Montana and across the West."*

Joe Stimatz, manager of asset optimization for NorthWestern Energy, agreed that joining the EIM will bring tangible benefits to the utility's customers.

> *"Our participation in the Western Energy Imbalance Market will provide our customers with economically efficient energy to resolve imbalances and variations in load and generation on our Montana system," Stimatz said.*

743,000 CUSTOMERS

Since its launch in 2014, the Western EIM has been using advanced technology to find and deliver the lowest-cost energy to utilities, while enhancing reliability and reducing greenhouse gas emissions. The most recent quarterly results show the Western EIM has achieved $1.28 billion in cumulative gross benefits for its participants.

NorthWestern Energy provides electricity and natural gas to more than 743,000 customers in Montana, South Dakota, and Nebraska. In Montana, the utility serves customers with an electric generation portfolio that is nearly 70% carbon-free and includes hydro, wind, and solar on 6,809 miles of electric transmission lines and 18,068 miles of electric distribution lines. NorthWestern Energy is well on its way to meeting its goal of reducing its carbon intensity 90% by 2045, with a 50% reduction to date.

Visit the Western EIM website for participant information and quarterly benefits reports.

The California Independent System Operator (ISO) is a nonprofit public benefit corporation dedicated, with its partners, to continuous improvement and secure operation of a reliable grid operated for the benefit of consumers. It provides comprehensive grid planning, open and nondiscriminatory access to one of the largest networks of high-voltage transmission power lines in the world, and operates a $9 billion competitive electricity market. Recognizing the importance of the global climate challenge, the ISO is at the forefront of integrating renewable power and advanced technologies that will help provide a sustainable energy future efficiently and cleanly.

The Western Energy Imbalance Market (EIM) Governing Body is the governing authority designed by regional stakeholders with delegated authority from the ISO Board of Governors to resolve rules specific to participation in the Western EIM.

U.S. DEPARTMENT OF ENERGY ANNOUNCES WINNERS OF SPRING 2021 GEOTHERMAL COLLEGIATE COMPETITION

June 2021

Today (June 16), the U.S. Department of Energy's (DOE) Geothermal Technologies Office (GTO) announced the winners of the Geothermal Collegiate Competition, a national contest that engages students to develop innovative geothermic energy applications to heat and cool buildings, campuses, districts, and communities. Administered by the National Renewable Energy Laboratory, the competition helps students gain real-world renewable energy industry experience and build career skills for the clean energy workforce, with a particular emphasis on engaging with students not traditionally involved with geothermal research.

> *"These students have proposed wonderful ideas for impactful, real-world geothermal deployment. The depth of knowledge about geothermal energy, and the passion they exhibit for their communities, our country, and our planet is truly inspiring," said Acting Assistant Secretary for Energy Efficiency and Renewable Energy Kelly Speakes-Backman. "The Department of Energy is honored to support students and communities in such innovative, inspiring ways."*

In March, GTO announced the 15 finalist teams, which represented 17 academic institutions, including 3 minority-serving institutions, 2 community colleges, 11 public four-year colleges, and 3 private four-year colleges. The finalists competed for cash prizes for first, second, and third place, and honorable mentions for geoscience and stakeholder engagement strategies.

The winning teams are:

- First Place - University of North Dakota, with Reykjavik University. The team researched the use of existing gas wells to generate geothermal energy for heat, food, and jobs in Mandaree, North Dakota, in the Mandan, Hidatsa, and Arikara Nation. Learn more: Mandaree Geothermal District Heating
- Second Place - University of Oklahoma. The submission identifies a number of hydrocarbon wells that can be converted to geothermal wells for heating and cooling in the local community.
- Third Place - Cornell University. The entry aims to achieve carbon-neutral district heating on Cornell's Ithaca campus via ambitious deep-direct use of geothermal energy.

Geosciences Honorable Mention was awarded to the Colorado School of Mines, and Stakeholder Engagement Honorable Mention was awarded to University of California, Berkeley and Rutgers University.

The event also included a preview of the Fall 2021 Geothermal Collegiate Competition on the same topic that will kick off in September 2021.

POWER POINTS

ADAPTING IN A PANDEMIC

ELISABETH MONAGHAN
Editor in Chief

Considering that the international presence of COVID-19 affected almost every aspect of our lives, it's no wonder so many of us are dealing with pandemic fatigue. Perhaps I should speak for myself. While it is a relief to have received my COVID-19 vaccinations, I'm still reticent about being part of large crowds at live performances, sporting events, special event celebrations or restaurants.

It appears the last days of COVID-19 may be on the horizon, but I have a feeling it will take some time to shake off what has been a constant state of anxiety. Even so, there are many. positive signs at this stage of the pandemic including the joy of seeing people's smiles, giving and receiving hugs and reconnecting with friends and families in-person, after a year-plus of only speaking to them on the phone or via Zoom.

The pandemic has left us all a little shell-shocked. After all, few of us knew much about COVID-19 when it first hit. We recognized that it was a big enough deal to convince us to shelter in place or do whatever was necessary to avoid contracting or spreading the virus.

As COVID-19 found its way into new areas, everyone was forced to act with little, if any time, to prepare. From governments and businesses to hospitals and schools, to the entertainment and service industries, and everyone else in between, we had to figure out how we were going to operate efficiently and safely in a socially distanced world.

In this Q2 issue, Sarah Cerruti, who is the director of global customer transformation with ServiceMax, points out that utility companies, which are no strangers to taking immediate action when a natural or human-caused disaster hits, were faced with ensuring the health and safety of their customers and employees, as well as protecting their assets.

"The crisis challenged [utility] operators and service providers alike to find ways of stabilizing operations and keeping assets up and running," Cerruti writes. She also points out that as difficult as they were, those challenges provided a catalyst for the industry to accelerate innovation and transformation.

Before the pandemic, some industries like the electric power sector had made progress with digital transformation to improve their business operations, manage data, automate processes and improve customer service and performance. Other sectors had just begun to embrace or even consider digitization.

Like everyone else, public libraries, which are some of the world's most important "keepers and disseminators of information," were caught off-guard by COVID-19. When they temporarily closed their doors last year, libraries were compelled to figure out quickly how to provide remote access to the information, books and reference materials that previously had been so accessible to in-person visitors. And while many libraries already had begun to digitize their various collections, the timeline shifted from "a good idea to implement sometime down the road," to "we need to do this *now*!"

As the numbers of COVID-19 infections continue to decrease, and we slowly return to in-person socializing, working and learning, we may be fortunate enough to forget the sense of isolation so many of us experienced during the shutdown. We also may forget what it took to respond to the pandemic, but the fact that most of us have embraced or continue to adapt to the changes COVID forced us to make so rapidly, shows that despite the many obstacles and ensuing chaos the pandemic wrought upon us, and even though the road back to stability may be a bit bumpy, the human spirit has prevailed.

If you would like to contribute an article or if you have an idea about interesting technology, solutions, or suggestions, please email me at:

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IN OTHER NEWS…

DOE Solar Decathlon® Competition Prepares College Students for Careers in Energy and Building

This past April, as more of us were receiving our COVID vaccinations, more stories emerged of organizations resurrecting activities and events that had been put on hold on account of the pandemic. Among them was a program that the U.S. Department of Energy created for college-age students. Since 2002, the DOE Solar Decathlon® has provided generations of industry workers in the energy and building sectors. The competition includes a Design Challenge and a Build Challenge.

The *Design Challenge* is a design-only competition in which participants work for one or two academic semesters to design solutions for real-world issues in the building industry; whereas the Solar Decathlon *Build Challenge* spans two years in which participating students design and build complete, functional houses.

Originally, the 2020 Build Challenge competition and exhibition of the participants' buildings was scheduled to take place on the National Mall last summer. Due to the pandemic, the event was postponed, and the exhibition was changed to a local build event, with teams constructing homes in their own communities.

In addition to receiving valuable, hands-on experience, the students also have an opportunity to interact with hundreds of their fellow s competitors from the participating schools and energy industry leaders' organizations.

Describing the role the Solar Decathlon plays in shaping the future of both the participants, as well as climate change, Energy Secretary Jennifer M. Granholm said, "Our fight against the climate crisis is a lot like a decathlon, with all kinds of individual contests we need to get through — and we can't win unless we do well in them all. Today's decathletes are tomorrow's architects and engineers who are going to help us achieve President Biden's ambitious and achievable clean energy goals and build our net-zero future. I can't wait to see their big ideas come to life in neighborhoods across the country and around the world."

More than 465 collegiate teams have participated in the Solar Decathlon since its inception. The program has expanded internationally, involving more than 23 countries. This year, the competition introduced its first-ever virtual village, which showcases zero energy homes designed and constructed around the world by 2020 Solar Decathlon Build Challenge teams, which the public can view by visiting https://www.solardecathlon.gov/virtual_village.

To learn more about the competition, visit https://www.solardecathlon.gov.

Photo credits: Jennifer Scheib, Dept of Energy.

AN INTRODUCTION TO THE NIST SMART GRID INTEROPERABILITY FRAMEWORK

AVI GOPSTEIN

Technology is changing everything about our lives. Ubiquitous communications and improving information management technologies have changed how and where we work, our options for interacting and playing with others and how we shop for goods and services from groceries to transportation. But while modern communication has been transformational for our individual lives, its impact has been far less visible in the electric power grid.

Even as utilities have modernized their own communications and information management systems to improve system efficiency and reliability through the use of new technologies, the outward appearance of the grid has remained largely static. For the most part, power is still generated at centralized facilities and then transmitted through a complex network of wires that are positioned and sized to carry electrons to far-away customers for instantaneous use.

But while electric grids may still look the same as 100 years ago, conditions have been far more dynamic underneath the surface. The form, function and business model of the grid are transforming as power systems adapt to changing technologies and societal expectations. This hidden evolution of a critical infrastructure that permeates every aspect of modern life will become more visible as technologies such as smart meters, solar photovoltaics and electric vehicles become a greater presence in our everyday lives.

Yet the ongoing evolution of power systems is far more complex than the adoption of a few standalone technologies. Modernizing an aging infrastructure with more capable and smaller-scale devices requires increased communication and information exchange within and between grid systems. Improved data availability allows utilities and system operators to better characterize grid functional needs and value the contributions provided by customers and third parties.

The transition to information-driven ecosystems has the additional benefit of accelerating modernization. Where the pace of power system innovation was once governed by the centuries-old timelines of large-scale construction projects and evolutionary learning-by-doing processes, a grid built around information exchange can innovate, incorporate new technologies and improve operations at a speed more reminiscent of information technology and software platforms. And while substantial innovation is necessary, the changes underway in the electric grid can bring with them a sense of uncertainty regarding the role and contributions of organizations and equipment throughout the grid — to say nothing of the value brought by new entrants. →

To address the changes taking place in the grid, earlier this year the National Institute of Standards and Technology (NIST) published an update to its Framework and Roadmap for Smart Grid Interoperability Standards[1]. This fourth release of the Smart Grid Framework addresses information exchange and physical interoperability within the context of accelerating technological change, rapidly falling prices for modern energy technologies, increasing proliferation of low-cost sensors and network-enabled devices, and an associated surge in the amount and granularity of available data. The document describes the relationship between interoperability and the functions of a modern and sustainable grid and provides a strategic framework to understand and address gaps — ranging from a lack of interoperability assurance through standards to limited assessments of operational and economic benefits — that currently limit the pace of grid modernization.

Energy is a complicated space that permeates every aspect of modern society, and the power grid is intertwined with issues that touch on everything from greenhouse gas emissions to cybersecurity. This complexity can inhibit progress towards modernization as stakeholders adopt sometimes conflicting positions or objectives for the grid. Yet even within this complex space, there are technical issues on which progress would be universally beneficial.

For example, improving the ability to manage and exchange information across the grid will yield benefits in overall system flexibility, observability and operational resilience. These benefits will also increase dramatically over time as our electricity, transportation and communications infrastructures become increasingly integrated. Efforts to enhance grid interoperability are therefore no-regrets strategies that have the potential to improve many aspects of grid function today and will unlock significant value in the future.

The NIST Smart Grid Framework was written to help all stakeholders understand the impacts interoperability will have on grid operations, economics, cybersecurity and standards. It provides conceptual models to help us understand different roles within the system and the relationship between energy delivery and information exchange (see **Figure 1**). The Framework provides strategies for enhancing interoperability and improving system cybersecurity. It is a lot to take in, so answering a few basic questions about the Framework allows us to focus our conversation and highlight a few key issues.

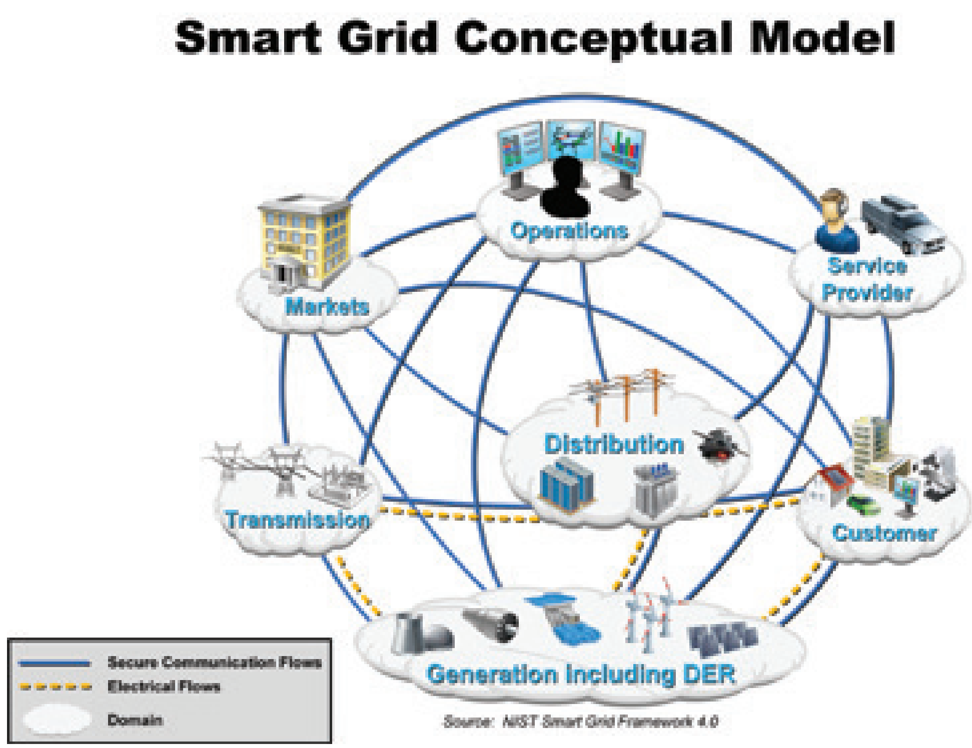

Figure 1 — The updated NIST Smart Grid Conceptual Model.

What is interoperability, and why does it matter?

Interoperability is the capability of two or more systems or applications to securely and effectively exchange and readily use information. There are, of course, stipulations to that statement, such as the information exchange must be timely and occur with little or no inconvenience to the user, but the fundamental point is simple: Interoperability enables the exchange of actionable information between equipment and systems and operators.

Interoperability is in fact a prerequisite for managing large numbers of diverse equipment — especially in aging infrastructures where new equipment must seamlessly integrate with decades-old systems that continue to provide useful, albeit potentially limited, function. The importance of interoperability in power systems gains urgency every day as the number of new technologies deployed across the system grows and capabilities increase substantially over the legacy equipment and systems with which they must integrate. While it is certainly possible for every new device to perfectly emulate the functions of an older piece of equipment that it replaces, the opportunities new technology creates — from automatic reclosers, to smart meters, to asynchronous generation and demand response — require harnessing and coordinating the sensing and control capabilities that emerge with each round of technical innovation.

It is through the coordination and aggregation of small capabilities that we can gain new function and maximize efficiency throughout the grid. For example, consider the thermostat. The purpose of a thermostat is to control the temperature in a room by actuating a heating or air conditioning system in response to measured temperature changes. That's it. It is specific in what it measures and how it works.

Now, consider a communication-enabled smart thermostat that is interoperable with other systems. That thermostat can be used to help manage distribution system congestion, thereby preventing circuit overload and improving system resilience. Managing that peak demand could also allow utilities to avoid spending precious capital on upgrading wires and grid systems to serve growing demand. Or perhaps that thermostat can be used to balance variable-generation renewables and clean our environment by timing its "on" cycles for when carbon-free power is available. Or perhaps, that thermostat can decrease a customer's heating and cooling costs by pre-conditioning a home or office to avoid peak rates.

Beyond the relatively simple capabilities of thermostats and other demand-response devices, the increasing availability of DERs that both generate and store power will transform grid-edge services. Opportunities for customers to provide and be compensated for these services will expand dramatically as adoption of behind-the-meter solar photovoltaics, electric vehicles and other highly capable systems become more widespread.

All of these capabilities — and the value they bring to different stakeholders — are enabled through interoperability. Conceptually, the most important thing to understand is that interoperability is a tool for unlocking new value across the power system. That value can come from improved operations and efficiencies, avoided costs due to decreased outages, or integration of new resources and economic opportunities into energy and grid services markets.

Why is now an important time to publish the fourth Smart Grid Framework?

We are at an incredibly interesting time in the technological arc of the grid. Electric utilities and their customers are both connecting large numbers of small-scale and controllable devices to the power system. The rapid growth, diversity and capability of these grid-connected devices add to the complexity of managing the system and demand a greater focus on interoperability. This explosion of technology diversity is occurring alongside the emergence of software-defined platforms for grid services and therefore amplifies the importance of interoperability for the safe, efficient and resilient operation of our diverse power systems.

The move toward connecting large numbers of smaller-sized equipment in the distribution system is just the next step in a decades-long trend exhibited by the bulk power system. Data from the U.S. Energy Information Administration (EIA) [2] shows that the typical sizes of grid-connected generators have fallen dramatically over the past 20 years, breaking sharply with the previous 100-year trend of increasing generator size. →

Comparing generator additions to the bulk power system over the final 40 years of the 20th century with the first 20 years of this century (see **Figure 2**) illustrates some important trends: First, new generation capacity is being installed roughly twice as fast today as it was in the recent past; and second, the size of each new generator has shifted dramatically smaller. While most new generations built from 1960-1999 relied on generators larger than 500 MW, more than two-thirds of generations built this century is based on sub-200 MW generator technology.

The trends seen in this data are the result of decades-long dynamics that have driven power sector investment towards smaller-scale devices while simultaneously accelerating construction of new generating capacity. Stimulated by regulatory and technological changes that have altered the fundamental calculus of infrastructure finance [3], the combination of individually smaller generators with larger overall capacity additions yields substantial growth in the number of devices that modern power systems must accommodate. For example, in 1970 there were about 4,500 generators connected throughout the entire U.S. electric grid, with just over 200 additional new generators built that year. Contrast that to the more than 80,000 generators connected to our bulk power system today, with more than 4,500 new generators built each year. The management and coordination of all these assets into the operations, economics and security of our power system demands high levels of interoperability.

And yet, the fundamentals that drive investment towards smaller and more numerous bulk generators are even more pronounced in a distribution system undergoing perhaps even more dramatic changes. Where generators once had to be as large as possible to maximize the physical efficiencies of conventional thermal cycles, new technologies from combined cycle to power electronics-driven asynchronous generation can achieve even higher efficiencies at much smaller scales. Where merchant operating rules and system variability increase financial risk for new gigawatt-scale generators, customer-sited distributed energy resources (DERs) have become increasingly economic as technology costs decline and new regulations like FERC Order 2222 [4] expand market access. And where early utility business models depended on the large-scale aggregation of customer loads to manage uncertainty in the system [5], emerging business models are built around understanding and addressing the energy needs of individual customers [6].

All of this creates an environment that is primed to intensely expand the number of DERs connected to the system as well as the roles these resources will play in the new grid. Indeed, this transformation is already well underway. Since 2015, utilities across the country have seen dramatic growth in the number and capacity of customer-sited DERs connected to their systems [7] and industry forecasts are for the combination of distributed generation, demand response and electric vehicles to transform grid-edge services over the next five years [8].

All of these trends point to the need for interoperability. From coordination of a generator fleet that will soon surpass 100,000 individual turbines and inverters to the integration of millions of DERs and other devices into grid-edge operations, the need to exchange and use information in our power system has never been greater.

NIST examined the relationship of earlier Smart Grid Frameworks to these changing conditions and evolving expectations for power grids, and it was clear that a major update was required. This revision was structured to examine the burgeoning innovation and informational needs of emerging grid architectures and provide readers with models they can use to understand associated interoperability strategies, requirements and standards. Considerations of system operations, economics and cybersecurity across four representative architectures provide context for the interoperability-enhancing strategies provided.

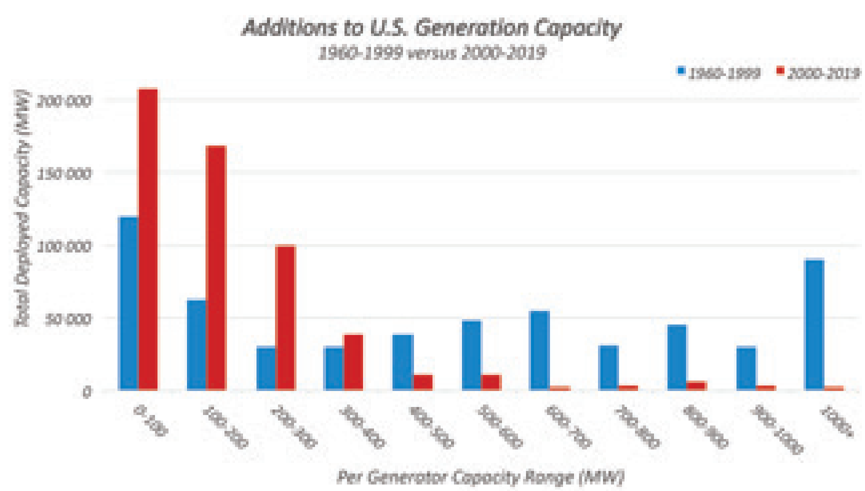

Figure 2 — Additions to U.S. bulk generating capacity, 1960-1999 versus 2000-2019.

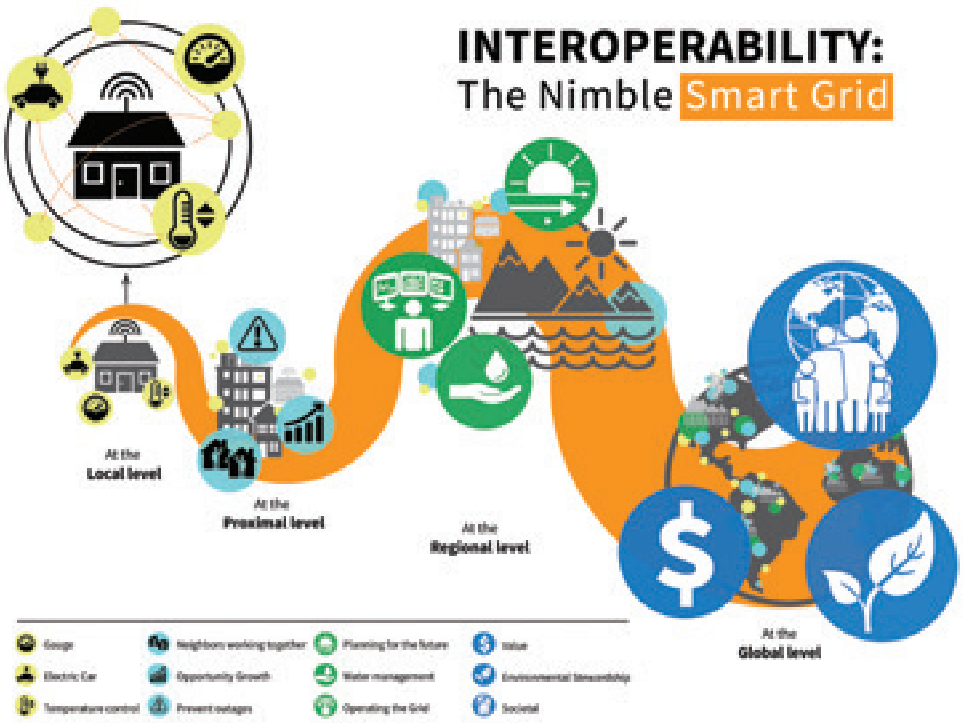

Figure 3 — Interoperability across scales.

Who benefits the most from an interoperable grid?

In short, everybody benefits from improved interoperability because the benefits of interoperability are not a zero-sum game. Interoperability is foundational to ensuring that diverse, distributed and decentralized stakeholders realize the smart grid's benefits. From reducing the cost of integrating new equipment into utility systems [9] to aggregating distributed resources for accessing wholesale markets [10] or providing novel grid services [11], interoperability should be viewed as the mechanism through which maximum function and value can be derived across the full spectrum of grid equipment and interactions.

Consider again the example of a communications-enabled thermostat and the range of impacts it can have on the grid. While each of those impacts is based upon the same fundamental action of turning an HVAC on or off, the value of that action is derived from the scale and purpose behind how — and with what other devices — that thermostat's activity is coordinated. For example, if the goal is managing congestion or other operational constraints on a local distribution feeder, the context for thermostat actuation must derive at least in part from information about the relationship between current energy demand and the physical limits of the local infrastructure [12]. Conversely, optimizing thermostat controls to reduce greenhouse gas emissions instead of feeder congestion is possible, but doing so involves utilizing different information models and establishing interoperability with a different set of actors [13].

The ability of a simple device like a thermostat to contribute to so many grid functions illustrates the breadth of value propositions enabled by interoperability. Opportunities to create value through coordinated actions will grow as new device capabilities are complemented by the emergence of software-defined platforms for new grid services. As illustrated in **Figure 3**, the range of possible grid services depends on finely tuned coordination across multiple devices, grid domains and geographic footprints.

Interoperability empowers customers, utilities and entrepreneurs to provide cost-effective solutions for some of the most challenging issues in our energy system. The NIST Smart Grid Framework aims to stimulate innovation in grid services by introducing a concept of Interoperability Profiles that formally link system objectives and device function with requirements for information exchange. Clarifying interoperability requirements and capabilities in this way brings value to all stakeholders through the coordinated management of energy technologies to maximize our ability to address challenges from grid resilience, to energy costs, to climate change.

How does improving interoperability address climate change?

The functions of interoperability are primarily about information exchange and physical compatibility between elements of a broader system. Because production of electricity and heat emit more greenhouse gases worldwide than any other economic sector [14], using interoperability →

to coordinate action across the grid introduces new sources of flexibility that fundamentally change the system characteristics.

Power systems must become substantially more flexible to maximize the environmental benefits of renewable and clean energy investments [15], and an interoperable smart grid does that by enabling the communication and information exchange necessary to dynamically adjust operations across the generation, transmission, distribution and customer domains. This flexibility not only helps power systems better utilize new clean energy resources but also maximizes the potential for displacing high-polluting resources in grid operations [16].

Interoperability is also a key enabler of highly distributed grid architectures. Most of the energy used in conventional electricity generation never actually reaches the customer because of physical losses in power generation, transmission and distribution [17-19]. But distributed resources can avoid many of these losses and so can deliver electricity more efficiently to the consumer than power generated at remote installations [20, 21]. Using low-carbon DERs at the customer site amplifies these benefits.

But even if we decarbonize the entire power sector, sustainability targets will still require decarbonizing the transportation, industrial and building sectors through electrification [15]. Doing that will require understanding and managing interdependences and information exchanges between previously distinct systems, and an interoperable smart grid capable of integrating diverse resources and technologies would provide an enabling platform for these interactions.

Do all these new devices and interactions create cybersecurity problems for the grid?

Cybersecurity is a complex issue. The large number of organizations involved with operating the grid, and the increasing number of devices connected to the system, mean that no single organization can guarantee secure operations. But that complexity does not mean that it is impossible to have grid cybersecurity. We can learn a lot from existing cybersecurity practices and guidelines, and secure operations can be achieved through a combination of engineering strategies and cybersecurity risk management and mitigation techniques.

The Smart Grid Interoperability Framework suggests two complementary paths to achieving grid cybersecurity: The first path focuses on securing organizations through a risk management approach built upon the core functions and outcomes of the NIST Cybersecurity Framework [22]. The second path focuses on securing new information exchanges through the application of engineering protections previously described for more traditional interfaces [23].

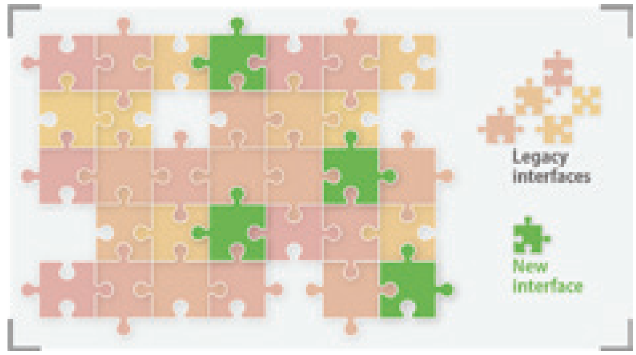

Figure 4 — Understanding cybersecurity strategies for new interfaces.

Both cybersecurity strategies in the Smart Grid Framework rely on extensive prior guidelines and references developed by NIST in collaboration with power systems and cybersecurity experts. This approach of building from existing knowledge carries with it an important lesson for securing the grid — that even as organizations and communications evolve in a modernized grid, the cybersecurity requirements for protecting the system can be derived at least in part from those already in use.

The idea that cybersecurity protections for new interfaces can be informed by the protections already in use for similar conditions is illustrated by the cartoon in **Figure 4**. The concept is pretty simple — just as new pieces can be fit into an existing puzzle, new devices can be securely integrated into the grid by adopting existing protection strategies from interfaces with similar characteristics. In short, the cybersecurity wheel doesn't need to be reinvented for each new device.

Some final thoughts

The electric grid has never been static. It is an always-changing system operating in a dynamic environment governed by the intersection of technology, policy, economics, and innovation. Today, the ability to innovate derives as much from the opportunities created by improved interoperability as from the individual technologies we often think of. The NIST Smart Grid Interoperability Framework helps us think about the complex technical interactions that are already changing the way we operate, make money from and secure our electric grid, while providing a roadmap for how to advance and leverage interoperability to maximize the benefits this transition will bring to all of us.

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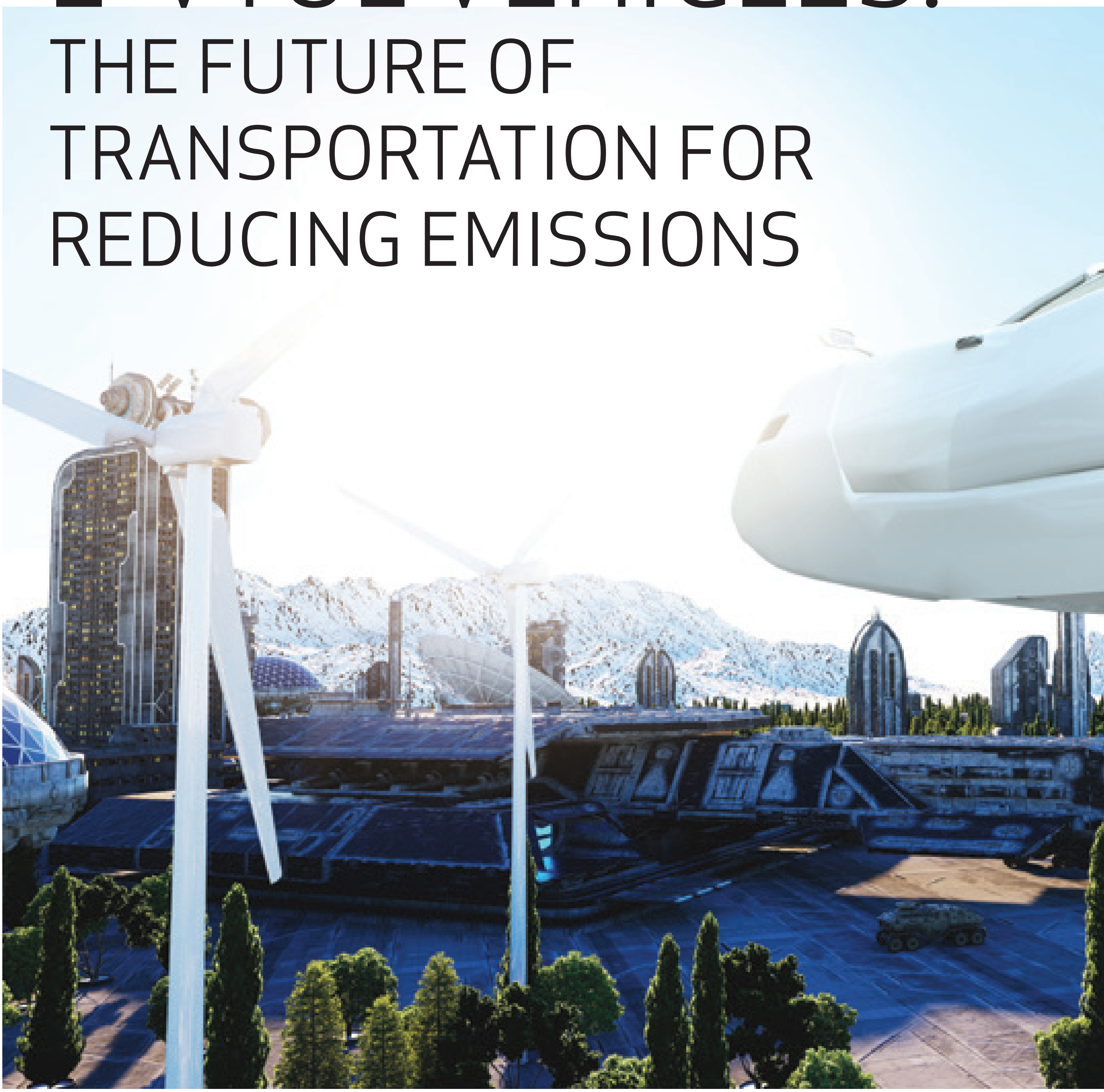
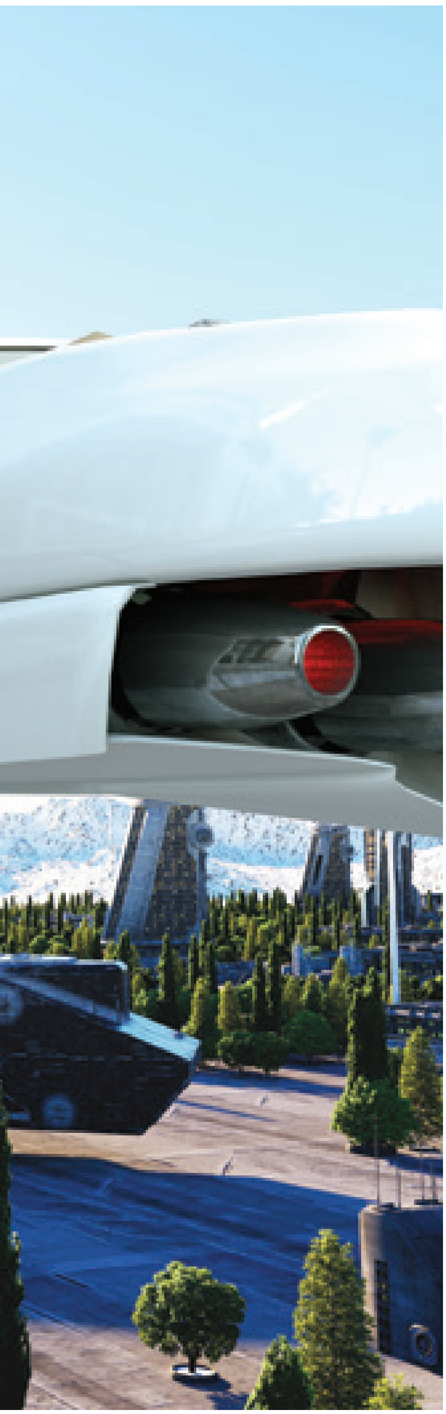
GREEN OVATIONS

FLYING CARS AND E-VTOL VEHICLES:

THE FUTURE OF TRANSPORTATION FOR REDUCING EMISSIONS





KAUSHIK RAJASHEKARA

The advancement of flying cars and eVTOL (electric vertical takeoff and landing) vehicles is reshaping the future of transportation. In addition to helping us reach our destinations more quickly and cut road traffic congestion, flying cars and eVTOL vehicles could help dramatically reduce the overall greenhouse gas (GHG) emissions from transportation globally.

Several companies call the vehicles they are developing "flying cars," but these vehicles do not travel on roads like regular cars. In this article, the term "flying car" is used only for a vehicle that travels like a car on the road and flies like an airplane or helicopter in the sky. The Aeromobil, PAL-V (Personal Air and Land Vehicle) and Terrafugia Transition and TF-X concept vehicles are good examples of flying cars [1], though not all of them have VTOL capability at this time. In 2016, only about half a dozen companies were developing flying cars and eVTOL vehicles; now more than 250 companies worldwide are working on them.

Since many of the proposed eVTOL aircraft will be run purely on batteries, like electric cars, they will be cleaner and quieter. If they are charged using renewable energy sources, it will help humanity progress toward the goals of achieving zero emissions and keeping global temperature rise below 1.5 degrees Celsius by 2100. It is reported that comparing VTOLs that are fully loaded with three passengers to ground-based cars with an average occupancy of 1.54, VTOL GHG emissions per passenger-kilometer are 52 percent lower than internal combustion engine vehicles (ICEVs) and 6 percent lower than pure electric vehicles (EVs) [2]. →

Flying cars and eVTOL vehicles also could change the way cities are developed, with infrastructure development around building roads and bridges minimized and several trees saved from being cut. In these ways, ongoing development of flying cars and eVTOL could help to improve the environment [1]. Furthermore, fewer airports would need to be built, thus reducing air traffic-control problems. And new classes of industries for components would emerge — electrical, mechanical, electronics, signals, controls and communications — and many other related disciplines would take shape.

Defining the space

The difficulties of designing a flying car or eVTOL are more challenging than designing a small airplane or a regular car. Many of the eVTOL concepts are based on distributed electric propulsion (DEP) — using multiple electric motors, each spinning a simple propeller to generate thrust to achieve an efficient, quiet and safe system. The Vertical Flight Society defines five categories of eVTOLs [3]:

- Vectored thrust eVTOLs have a wing for an efficient cruise and use the same propulsion system for both hover and cruise. The Aurora LightningStrike, Joby Aviation S2 and S4 and Lilium Jet are in this category. The S4 consists of six five-bladed propellers powered by separate electric propulsion units, with four located on its wing and the other two on the tail. The four propellers tilt vertically, including its entire motor nacelle, and two of the propellers tilt vertically with a linkage mechanism. The new Lilium Jet uses the distributed propulsion strategy with 36 small electric ducted fans embedded in the wing and forward canard.
- Lift + cruise eVTOLs have a wing for an efficient cruise, like vectored thrust eVTOLs, but they use two different propulsion systems for hover and cruise flight. The Aurora Flight Sciences, Kitty Hawk Cora and Zee Aero Z-P2 eVTOL are in this category.
- Wingless eVTOLs have multirotors with large disk actuator surfaces, making them efficient in hover, but they do not have a wing for an efficient cruise. These vehicles are suited for short-range operations in cities, such as for air taxis, which could fly over traffic jams. Examples of this class are the EHang 184 and the Volocopter 2X.
- Hoverbikes are multirotors that can be flown like a motorbike with the pilot sitting on a saddle or standing.
- eHelos are electrical conventional helicopters.

Most of the recent developments in eVTOL are focused on the vectored thrust, lift + cruise and wingless types.

Unique design requirements

The design requirements of a ground vehicle are so different from those of an airplane that the task of trying to combine the two sets of requirements in a single flying-car system presents many challenges. For example, the transition of flying cars from airplane to ground mode and vice versa must be seamless for smooth operation. Also, to reduce the total weight of the system, combining the propulsion system for both road and air travel could be a major challenge because of the different requirements.

There are other major challenges:

- Sources of primary energy to achieve highest power and energy density, given the substantial power requirements during vertical takeoff, landing and cruise with opposing wind direction;
- Optimum propulsion architectures for a given vehicle considering the different load profile for the traction versus flight, as well as aerodynamic issues for flying cars with both road-drive and flight requirements;
- Controlling algorithms for stable operation throughout the flight, combined with propulsion controllers and fast response motor control systems to manage stability during flight;
- Determination of the right altitude level for a given flight profile under changing circumstances and weather conditions, as well as accounting for effect due to extreme weather conditions;
- Signal, communication, safety and reliability issues;
- Meeting all of the regulatory requirements, which can be quite distinct for road and air travel.

In addition, adequate air traffic control is necessary for handling hundreds or thousands of airborne vehicles. And, to keep these vehicles safe, they must be autonomous and offer many other advanced technologies, such as auto cruise control, pilot/passengers auto eject, extremely reliable 3D vision, etc.

Onboard power

The main considerations in the selection of a battery are power density, energy density, weight, volume, cycle life, operating temperature range, safety, material recycling, maintenance and cost. Satisfying both the power and energy requirements with a low battery weight is essential for eVTOL vehicles to be power and energy efficient. A battery-management system is necessary to balance the state of charge of individual cells and modules, and thermal management is important to achieve high cycle life and long life. Presently, the best lithium-ion batteries provide energy density of about 200 Wh/kg to 250 wh/kg. These batteries are sufficient for flying cars for road operation and short-range eVTOL operation with one or two passengers.

Several companies are working on other technologies that can provide higher energy density and power density than the present lithium-ion batteries. A few companies are working on lithium-sulfur (Li-S) battery technology. OXIS Energy, for example, has already achieved 450wh/kg at cell level and expects to achieve 600wh/kg by 2025 (www.oxisenergy.com).

Another emerging technology is the solid-state battery, in which the liquid electrolyte in lithium-ion batteries is replaced with a solid electrolyte. This type of battery is reported to be safer, offer long cycle life and have a faster recharge time. A glass solid-state battery can have three times higher energy density than lithium-ion. But these batteries are still in the research stage at cell level, and several issues related to technological challenges and manufacturing have to be resolved. QuantumScape, Solid Power and a few other companies are working on this type of technology.

An additional battery technology could be lithium air, which has theoretically five to 10 times the energy of lithium-ion batteries of the same weight. But the rechargeable lithium-air batteries would probably not be commercially available for several years because of technological challenges and recharging issues.

The proton exchange membrane (PEM) fuel cell has significant potential to provide the required power for both flying cars and also for eVTOL-only vehicles. The major issue is related to the supply of hydrogen and maintaining the entire system in a safe environment inside the vehicle. Intelligent Energy and several other fuel-cell manufacturers are working to exceed the U.S. Department of Energy (DoE) technical target of 2kW/kg for fuel cell stack. With the advancement of hydrogen storage and fuel cell stack technologies, hydrogen fuel cells would play a key role in the decarbonization strategy for aviation, as they can power aircraft efficiently.

Electric machines

The selection, technology, power density and thermal management of the electric motor are all very important for achieving high efficiency for eVTOL and flying cars. The number of motors being used depends on the aircraft design. For example, 18 brushless DC motors driving fixed-pitch propellers arrayed on a lattice ring powered the Volocopter VC200 air taxi during demonstrations. Thirty-six motors turning fans in a ducted wing and canard powered the electric Lilium Jet that was recently flown. But the flying cars with eVTOL capability have entirely different configurations, with one or two motors for ground propulsion and a separate tilt rotor or lift fan for takeoff and landing. If it is a tilt rotor system, the same also can be used for forward propulsion during the flight. The motors required for ground propulsion and eVTOL have different requirements in a few aspects. Although both need high-torque-density motors, an eVTOL system prefers a motor of high torque but relatively low revolutions per minute (RPM) in a direct drive to reduce propeller tip speed and mitigate noise without the need for a gearbox.

In eVTOL vehicles, permanent magnet (PM) machines are being increasingly used because of their high efficiency and power density. As an example, the lift fan in XV-24A LightningStrike uses PM motors with composite stators and embedded electromagnetic conductors to achieve the best power-to-weight ratio. The Lilium Jet also uses the PM synchronous motors with sinusoidal back electromotive force (EMF). Most of these PM motors are sinusoidal back EMF synchronous motors that would provide smooth torque operation.

Although the induction motor is rugged and well advanced in technology, it has very sluggish transient response. As a result, it takes longer for the motor to react, particularly for multi-rotor machines and when the rotor is used for controlling flight dynamics. Also, the efficiency and power density are not as high as that of PM machines.

The switched reluctance machines are extremely noisy during operation, have higher torque pulsations, lower efficiency, larger size and higher weight than PM machines. Synchronous reluctance motors have poor power factor and relatively poorer performance compared to PM machines.

The PM machine will continue to be the right choice for a long time to come, particularly for flying cars and for eVTOL-only vehicles. Monitoring the conditions of the electric machine is very important for detecting any impending failures such as bearing, rotor and stator faults, as well as to ensure that high reliability standards are met for the aircraft. →

Power electronics and motor control

Power electronics is an enabling technology for the development of flying cars and eVTOL systems, as it has been for electric vehicles. The selection of power semiconductor devices, converters/inverters, control and switching strategies, packaging of the individual units, thermal management and system integration are very important for the development of efficient and high-performance vehicles.

Wide band gap (WBG) devices such as silicon carbide (SiC) devices with inherent radiation resistance, high-temperature operating capacity, high voltage and power handling capability, high power efficiency and flexibility make them best suited for eVTOL systems. The wider band gap, larger critical electric field and higher thermal conductivity enable SiC devices to operate at higher temperatures and higher voltages. This offers higher power density and higher current density than pure silicon devices, enabling high-power density converters to be achieved.

Another WBG device, the gallium nitride (GaN) device, is projected to have significantly higher performance over silicon-based devices due to its excellent material properties, such as high electron mobility, high breakdown field and high electron velocity. However, GaN devices are still not ready for the high power level required in eVTOL systems.

In addition to power devices, high performance control methodologies such as direct torque and flux control or field orientation control are essential for controlling the motor using the inverter for stable and high-efficiency operation.

As in electric vehicles, the trend for eVTOL systems is to integrate the motor and inverter as one unit to achieve higher power density, ease of thermal management, reduction of cable lengths (and, in turn, reduction in susceptibility to electromagnetic interference) and ease of maintenance. For example, H3X (https://www.h3x.tech/) is developing an integrated, geared, high-speed electric motor with SiC inverter system-HPDM-250. H3X says it provides 13 kW/kg continuous, exceeding the Advanced Research Projects Agency-Energy (ARPA-E) requirement of 12 kW/kg in the recently awarded ASCEND program for electric aircraft applications. Rolls-Royce has developed an integrated electric motor drive (RRP200D) with 200kW output with torque-to-weight ratio of about 30 Nm per kilogram (https://www.rolls-royce.com/innovation/propulsion/air-taxis.asp). NASA has also funded and demonstrated larger and higher power density motors.

Other issues

For practical and large-scale deployment, flying cars and eVTOL-only vehicles have to be intelligent, connected and autonomous. To achieve this, the communications and control aspects of these vehicles must be addressed. The most important consideration is safety; rapid-inflating parachutes, airbags, energy-absorbing seats and related features must be incorporated. Noise considerations also must be addressed for operation in urban areas. The altitude of operation also plays an important role, and the vehicles may have to be aligned in invisible lanes. Other issues such as stability, aerodynamic propulsion issues, airworthiness, flight testing, certification and economics also demand attention.

The future of transportation

eVTOL vehicles will revolutionize the future of transportation. These aircraft are emission-free, safe, fast, very low noise, and they could be designed for adaptability to different weather conditions. As battery technology improves, eVTOL vehicles such as air taxis will become more sustainable and fly for longer ranges and at higher speeds.

Although in recent years more emphasis has been applied to eVTOL-only vehicles, there is a parallel effort to develop flying cars that can go on the road and in the sky. As the technologies and infrastructure advance, there could be a possibility that flying cars — like Aeromobile, PAL-V, ASKA, Terrafugia TF-X — will be the future of all personal transportation. At present, these are purely IC engine-based or hybrid vehicles. In the future, these could also be converted to pure electric operation with eVTOL capability.

The charging infrastructure is also important for these vehicles to be realistic. Several companies are working to develop an extensive charging infrastructure based on renewable energy sources, which could lead to significant emission reductions from road and air transportation.

For long-distance operation, small airplanes that can carry about 10 to 15 passengers with hybrid propulsion and VTOL capability could be the future. These aircraft could use smaller airports that are closer to a set of residential neighborhoods for their operation.

Continuing research and development by industry, academia and government worldwide will further advance the technology of eVTOL vehicles, making them more viable with longer ranges and higher performance, safety, reliability and lower cost. The advancement of these vehicles is crucial for helping to keep global temperature rise within 1.5 degrees Celsius by 2100 and reducing the effects of global warming.

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KEEPING THE LIGHTS ON: HOW SERVICE INNOVATION IS FUELING THE POST-COVID RECOVERY

SARA CERRUTI

Traditionally, players in the energy space have responded to periods of market volatility by cutting CapEx spending on aging assets and infrastructure, reducing headcount and postponing or cutting OpEx spending on maintenance activities. To a large extent, the response to the COVID crisis was no different in this respect.

But cutting costs can be done only so many times before the reliability of assets, the integrity of the infrastructure and the safety of employees and customers are put at risk by accidents or outages that may also have legal or regulatory implications. Additionally, the COVID crisis added so many other complicating factors that energy players and their service providers were not able to respond exclusively by leveraging the playbook that had seen them through previous crises:

- Much of the available overhead was already cut during the 2008 and 2014 crises, so energy operators were challenged to find new ways of driving efficiency during the market instability
- COVID-induced lockdowns impeded technicians from being deployed to customer sites to maintain assets
- Supply chain interruptions impacted the availability of parts and equipment needed to maintain assets and infrastructure
- New revenue streams with accelerated time to value were needed to survive the COVID-induced market volatility

The crisis challenged operators and service providers alike to find ways of stabilizing operations and keeping assets up and running. But it also acted as a catalyst that has accelerated innovation and transformation while at the same time generating ideas that have supported optimizing costs and driving efficiency in existing processes.

What are some of the ways that energy industry players have leveraged innovation to survive the pandemic and build resiliency for the future?

1. Keep assets running with remote technical support

During the height of the COVID crisis, we heard many stories of companies that put in place or expanded upon existing remote technical support operations. Technical teams used historical asset data combined with live data from sensors where available, or communication with onsite customer teams for assets not monitored remotely, to maximize their ability to remotely troubleshoot assets. →


ENERGY
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The success rate of remote troubleshooting efforts has convinced both service providers and customers that continued investment in technical support teams and technology can help contain field deployment costs while reducing downtime and driving a new level of service and responsiveness for customers. Before COVID, many customers expressed reluctance to try remote troubleshooting: Calling a technician to the site was perceived to be the fastest way to resolve issues. The crisis demonstrated to customers that remote troubleshooting is a viable and more cost-effective alternative to a field call, and they are now much more likely to accept engaging with vendors through remote interaction.

2. Support stable operations with accurate, actionable data

One of the primary distinctions between organizations that thrived and those that struggled during the COVID crisis was access to accurate and actionable data on everything from operations to customers to assets. One energy company recently shared an example of this: During the COVID crisis, they were able to cross reference installed asset history data with “as maintained” bill of materials data to predict which parts of their customers’ assets were most likely to fail. With this information, along with on-hand inventory data, they were able to locate available inventory and bypass supply chain interruptions by proactively staging parts close to the customer sites where they were most likely to be needed, thus keeping their customers’ assets operational throughout the crisis.

> **The number one lesson learned from the pandemic is how unprepared players in all industries were to deal with a global calamity of COVID’s magnitude.**

Most organizations already have access to various forms of data that can be used to support critical business processes. However, many say they are overwhelmed by volumes of data in varying formats and struggle to find ways of turning this data into meaningful, actionable information. I recently heard a business leader interviewed who cautioned that businesses that try to analyze too many variables often lose sight of the truly vital ones: Organizations that were able to harness the power of data and technology were successful because they understood that the outcome of their analytics efforts needed to drive action. They focused first on identifying the issue they were trying to solve, and then on identifying, collecting and analyzing the data needed to solve it. In this way, they were able to tackle one issue with one analytic, solve it, then move on to the next.

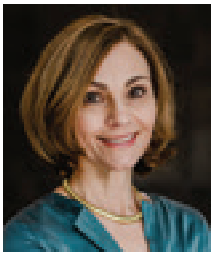
3. Define new service models using data and technology

For the energy industry, repairing and maintaining assets in remote locations is difficult under the best of circumstances. During COVID lockdowns, the added logistical complexity of getting resources into the field quickly and safely made it nearly impossible to execute emergency repairs within reasonable timeframes. Those that had assets that were monitored remotely fared a little better than their counterparts without connected assets. But for the most part, energy players are still not consistently able to leverage data from connected assets to be proactive in their maintenance approach. As one service leader recently told me, "We still can't figure out how to use our asset data to accurately predict when our assets will fail, much fewer leverage data to design the next generation of products so they won't fail to begin with!"

For many in the energy space, the COVID crisis brought home an important lesson: Future products will need to be designed to drive outcomes. They will need connectivity built in, they will need the upgrade process for both hardware and software to be agile, and they will need components and parts that can be identified and replaced quickly. Service companies that want to shift to an outcome-based service model will need to learn how to harness the power of data to build the historical evidence that will allow them to analyze how, why and when assets fail. From this information, they will need to formulate a maintenance strategy that ensures the future availability and reliability of assets. Only by implementing a shift from reactive service models to outcome-based service models will players be able to control operating costs while at the same time delivering on customers' evolving expectations of uptime and reliability of assets.

The number one lesson learned from the pandemic is how unprepared players in all industries were to deal with a global calamity of COVID's magnitude. However, the crisis also provided a unique opportunity for companies to build resiliency through innovation. Some companies learned to harness the power of data to enhance process efficiency and ensure business continuity. Others were able to lay the foundations for new service models that will ultimately strengthen ties with their customers.

One thing is clear, in the post-COVID world, the ability to innovate will become a competitive differentiator that will determine who succeeds and who is left behind. The companies that started the innovation journey during the height of the crisis and can leverage their experience to put in place a post-COVID roadmap will be more resilient and better positioned to tackle the business challenges that lie ahead.



ABOUT THE AUTHOR:

Sara Cerruti is a senior director of Global Customer Transformation at ServiceMax. She has more than 20 years of experience in driving business process optimization and digital transformation initiatives in industrial businesses including Oil & Gas and Power. Cerruti combines Lean Six Sigma transactional and shop floor experience with business process transformation expertise to help customers achieve results by effectively leveraging technology to drive productivity and growth opportunities.

PLUG AND PLAY SOLAR IS THE KEY TO GIVING SOFT COST REDUCTIONS A JOLT

COLIN MATTOX

The cost declines in solar over the past decade have been nothing short of extraordinary. Just 10 years ago, the cost per watt for a standard rooftop panel was about 12x more expensive, carbon footprints were for the environmentally active fringe, and financing was still pretty tricky to come by. Innovations that helped overcome cost, perception and access barriers like these have set the stage for massive growth in residential solar in the coming decade.

Despite these and other critical advancements, solar's soft costs (AKA "everything else") have stayed stubbornly high.

As anyone in the industry knows, that's because soft costs have proven to be more difficult to cut at that same rate — in part because the industry is not fully in control. Soft costs — such as customer acquisition, installation, permitting and inspection — now represent more than 60 percent of solar photovoltaic system costs, according to the U.S. Department of Energy.

One key to getting solar soft costs down is to simplify and standardize installation.

Right now, the technical act of connecting a home's rooftop solar to the grid remains surprisingly difficult — it is overly customized. Customization leads to time-consuming and complicated jobs. While other aspects of installation have improved and evolved, grid connection has stayed essentially the same. That complication is expensive.

Instead of the current system, imagine if connecting solar to the grid was as easy as plugging your new coffee maker into the outlet on your wall. What if we could make solar grid connections take the same amount of time and work? →

> **"Innovations that helped overcome cost, perception, and access barriers like these have set the stage for massive growth in residential solar in the coming decade."**

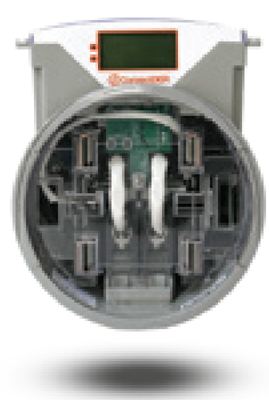
Con Edison employees receive training on meter collar installation.

Plugging your coffee maker in is easy because it's standardized and doesn't require any special training, If plugging in your coffee maker required specialized electrical work it would raise the cost by 100X or more. But it's not difficult — you remove it from the box and plug it in, and a couple of minutes later, you have coffee. You don't need to hire an electrician for installation or get a permit — all those things happen behind the plug.

We need to get rooftop solar — and all distributed energy resources — as close to appliance installation as possible.

What happens now in the United States? How do we (typically) connect rooftop solar to the grid?

First, the actual electrical work. The sides or back of many solar homes have a veritable maze of PVC pipe, wiring and junction boxes. All of those extra connections and wiring equals work, time, money and diminished safety. Complicated connections add hours to an installation — and when you start working at the scale that we expect in the next decade — that can mean millions upon millions of dollars in waste and unnecessary customization. They also make permitting more difficult and time-consuming.



> That's straightforward savings, but the real impact could come in the form of streamlined permitting.

We have the technology to change this, and it should start with standardization. When you buy your coffee maker, it comes with a plug, and that plug fits into your wall socket. It's plug and play. We have the technology to make plugging rooftop solar into the grid nearly as easy as plugging in that new coffee maker.

That starts with standardizing the connection to the grid. By standardizing the connection, we'll shrink installation times. For example, utilities that have used our meter collar — a single, UL listed device that has been tried and tested in programs and pilots across the country — have saved up to several thousand per installation.

Using a meter collar means that solar installers simply detach the home's meter, hook up a meter collar, replace the meter and then plug the inverter's power directly into the meter collar. The interconnection leaves the homeowner offline for a mere five minutes instead of several hours for a traditional install.

That's straightforward savings, but the real impact could come in the form of streamlined permitting. Can you imagine if, rather than a custom application, every solar installation had a standardized grid interconnection? Appliance connections have standards that are set, permitted and approved centrally. Standardization lowers costs, speeds installation and expands access — all things we need and want from solar.

Plug and play solar will transform the installation and permitting process and give soft cost reductions the jolt they need.

ABOUT THE AUTHOR:

Colin Mattox is head of product marketing at ConnectDER, where he leads efforts on content creation, overall messaging, campaign planning and budget management.

POWER LINE SURVEYS GET MORE PRECISE

ENHANCING LARGE-SCALE MAPPING IN THE WIDE-OPEN PLAINS

JOHN STENMARK

Kevin Kenna has lots of experience with Global Navigation Satellite System (GNSS) and major projects for utilities, government agencies and large area mapping. He's used Global Positioning Systems (GPS) and GNSS for more than two decades and estimates that he has worked on mapping/surveying more than 20,000 miles of power lines; a project of 10,000 square miles is not unusual for him.

Kenna's current work with Merrick & Company, a Colorado-based engineering, architecture, surveying and geospatial firm, involves establishing ground control for a series of aerial lidar mapping projects in Nebraska. He's establishing checkpoints that are used to determine and correct any vertical bias in the airborne measurements.

Creating accurate maps over large areas draws on an array of sensing technologies including digital imaging and lidar. To ensure accurate georeferencing of the sensors, Kenna uses GNSS to provide precise positioning data. When working on projects covering large areas, real-time GNSS can be limited, so Kenna's firm, switched to satellite-based precise positioning services.

"To ensure accurate georeferencing of the sensors, Kenna uses GNSS to provide precise positioning data."

For the most part, the work requires high accuracy in the vertical component — one of the most challenging aspects for GNSS surveyors. And it often takes place in areas where conventional RTK is impractical and VRS is not available.

Before putting RTX into practice, they conducted extensive tests to confirm that the solution could perform reliable results. To test for accuracy and high productivity, they chose a Sunnyvale-based technology company's RTX correction services. →

A GNSS receiver uses RTX to produce precise position data. RTX enabled efficient real-time measurement without need for base stations or cellular connections.

On a recent project covering 8,000 square miles in northeast Nebraska, Kenna captured roughly 350 points for aerial lidar. Quality control terms of the contract required 50 percent of the points to be measured twice, with the two measurements agreeing to within 5 cm vertically.

Working alone, Kenna completed the field work in roughly three weeks. The work included additional points to improve redundancy in the checkpoints as well as ties into NGS control three times in each county, with a minimum of five minutes of data at each occupation. Kenna used a GNSS receiver with a controller running off-the-shelf surveying software. The receiver collects the RTX correction data directly from communications satellites and produces real-time positions accurate to 2cm horizontal and 5cm vertical. The software monitors each observation and displays information that enables Kenna to assess the accuracy at every point. At the end of each day in the field, he compiled the measurements in office software and produced results in the coordinate system specified by the client.

Simplified logistics for aerial surveys

Aerial mapping has for years required terrestrial base stations to serve as reference points for measurements to establish ground control points as well as base stations for precise GNSS positioning of the airborne sensors produced via post-processed kinematic (PPK) techniques. The approach required base stations to be not more than 20 miles apart. The switch to RTX removed those constraints and provided a significant increase in flexibility.

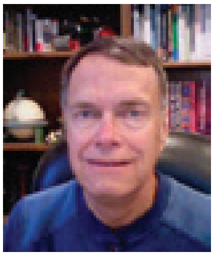
Merrick uses integrated GNSS and inertial measurement systems connected to lidar sensors in its fixed-wing and helicopter surveys. Merrick processes the data in RTX post processing software and uses the results to produce high accuracy maps and terrain models.

GNSS receiver uses RTX to produce precise position data. RTX enabled efficient real-time measurement without need for base stations or cellular connections.

Far removed from the Nebraska plains, Kenna uses RTX for a real-time survey in the Colorado mountains. Satellite-delivered correction data ensures accurate results anywhere on Earth.

Merrick's Director of Operations and Technology Matt Bethel sees two improvements resulting from RTX: "Historically on larger projects, we would target what we felt to be the portion of a block with the best flying weather for a given day and set bases up there. If the weather changed and affected visibility from the air then we would be forced to stop flying for the day. It's really nice to have the flexibility to move freely around projects without concern about base stations and CORS locations. Secondly, the plots show us that the lidar data is as good as, or maybe slightly better than, previous methods of single-base GNSS. Therefore, we didn't sacrifice any accuracy while gaining the ability to move freely around large projects and save time that was historically spent setting up bases."

RTX also eliminates the need for fixed base stations or ties to terrestrial GNSS networks, which often require access to cellular communications. This gives Bethel and Kenna flexibility in planning and executing their projects while maintaining confidence that their results will meet even stringent accuracy requirements. "Not needing to set up base stations in the morning and go back and pick up at the end of the day is a huge advantage from the way it used to be," Kenna said. "Now, as technology advances, things become more efficient and we get a lot more production."



ABOUT THE AUTHOR:

John Stenmark is a writer and consultant working in the geospatial, AEC and associated industries. A professional surveyor, he has more than 25 years of experience in applying advanced technology to surveying and related disciplines.

MONETIZING RENEWABLES' MANAGEMENT WITH IOT INTELLIGENCE

MICHAEL SKURLA

Reliable, clean electricity generated by utility-scale solar is one of the fastest routes to reducing our carbon emissions and securing our clean energy future. In fact, the U.S. Energy Information Administration reported renewable energy resources were the fastest-growing source of electricity generation in the U.S. for the last two years.

There are more than 37,000 megawatts (MW) of utility-scale solar projects currently operating — and another 112,000 MW under development. When paired with energy storage, utility-scale solar provides backup power to meet the needs for energy ramps. As utility-scale solar gains market acceptance, wide-scale adoption of storage has paved the way for increased solar deployments.

While managing and integrating solar panels across vast solar farm infrastructure is essential, it requires a power grid that can adapt and efficiently maintain load balance. For solar operations to scale effectively while serving larger numbers of consumer end-users, there's a need for scalable operations and management solutions that utility managers can depend on for business insight and intelligence. →

IoT platforms keep energy pulse alive

In our connected, 24x7 world, energy production has become front and center for enabling all of our activities. Our digitized world can no longer rely on manual operations and management of energy/utility-scale infrastructure with engineers walking the facilities and plants. Automated, real-time operations systems are now the norm and allow operators and engineers to tap into cloud-based management systems to expedite the detection and mediation of risks before they turn into major disasters.

With solar plant expansion, both in size and complexity, turnkey monitoring portals for utility-scale solar installations are essential. Across these solar farms, each solar panel generates DC energy that is fed into a combiner (combining output from several solar strings), then sends the power into an inverter, converting it into AC. Equipment failure at any stage can hinder electrification if operators don't receive alerts on potential problems.

IoT-enabled platforms have become the most cost-effective solutions to aggregate, organize and harness insightful intelligence from the grid edge. With IoT sensors attached to each solar panel, cloud-based IoT platforms provide grid managers with real-time, actionable analytics and end-to-end management systems. From asset management, production insights, customized reporting and alerting, coupled with digital operations and maintenance services, IoT platforms collect, analyze and share sensor data, obtained from every single connected solar panel and piece of equipment. This "solar energy digital supply chain" connected by the IoT network, leverages wired/wireless sensors to meet the specific needs of the solar sites.

This means operators have a digital twin of their entire portfolio of assets providing real-time state awareness as well as full control over the management and security of their geographically distributed infrastructure — whether monitoring one site, or hundreds of thousands of sites across a region. Real-time and historical analytics enabled by an IoT platform, allow unparalleled monitoring and management of solar installations on scale. Operators can easily create a multi-display operations center dashboard to gain remote access to:

- Manage equipment - drilling down into all equipment capabilities and sensors — including inverters, weather instruments, conditioners, easily perform on-demand or scheduled reboots and software updates and more.
- Meteorological measurements — monitor solar irradiation, back of module temp, wind speed, rain and ambient temperature.
- Production monitoring — with simple, historical representation of actual solar generation vs expected, allows for analysis of key performance indicators.
- Real-time faults and alerts — data is scanned in real time for any values exceeding normal operating thresholds triggering an automated alert.
- Measurement of individual devices — including substations, storage, grid metering, transformers and more.
- Forecast of energy productions — integrating weather forecast data can easily make adjustments to increase generation as needed.

In our digitized world, IoT and IoT-enabled technology advances are allowing energy leaders to better manage smart grids by relying on scalable technologies that provide automated actionable intelligence in real-time for our always-on needs.

The aggregated data can be encrypted and securely transmitted or shared with utility companies, via cell connection to avoid hindrances in the event of inclement weather. Utility companies, updated on the conditions of their PV sites, are notified via alerts on solar site problems — from panel temperatures, to wind effects, to ambient temperatures due to weather conditions affecting the panels and more.

IoT utility-scale solar farms are the future

Considering the IoT platform as a single source of truth, utility-scale solar infrastructure operators gain full insight into their solar panel-derived generation and the load connected to smart buildings and homes. Armed with this holistic view into the vast amounts of data generated from each solar panel, across vast solar farms, operators have, at their fingertips, valuable insight into the working of their solar infrastructure that's never been possible before.

As automated alerts are flagged and dispatched to specified stakeholders and crew, data is harnessed for actionable insights for remote troubleshooting. Managers have full control of their geographically distributed smart metering infrastructure from a central command station. They can remotely manage and operate every aspect of their business — eliminating costly and time-consuming walk-throughs, truck rolls and on-site staff presence.

The remote monitoring and analytics capabilities of the IoT platforms are invaluable for the electrification of our smart cities, buildings and homes. The remote management of solar assets and networked systems from an operations center allows engineers to troubleshoot and remotely diagnose and resolve problems before dispatching field technicians to the site.

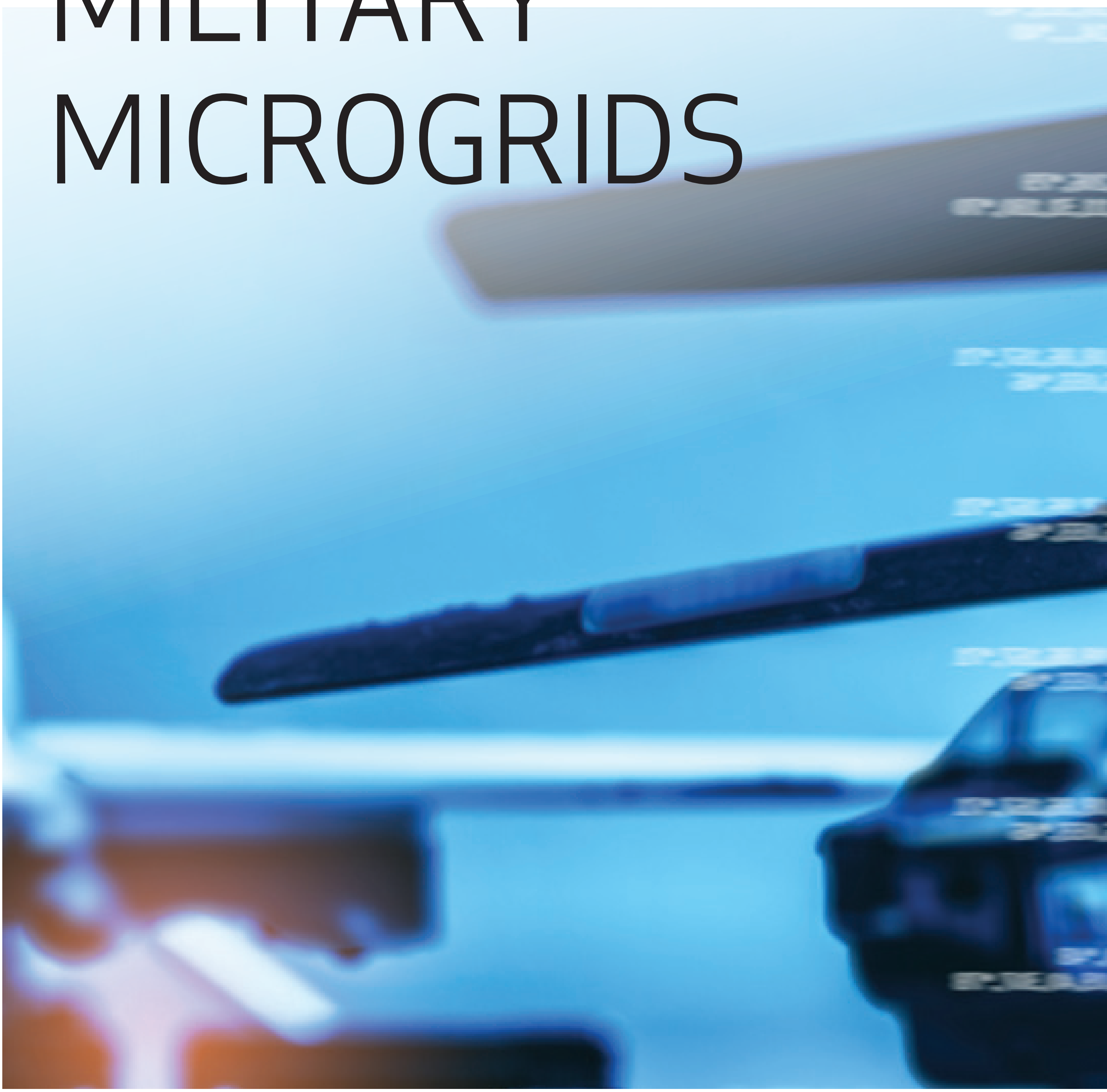
In our digitized world, IoT and IoT-enabled technology advances are allowing energy leaders to better manage smart grids by relying on scalable technologies that provide automated actionable intelligence in real-time for our always-on needs. With our heavy reliance on distributed energy sources and renewable energy supplements, the utility-scale solar industry has fully embraced IoT technologies for better control of our continued struggle against climate change and as we strive to lower our carbon footprint.

ABOUT THE AUTHOR:

Michael C. Skurla is the chief product officer of Radix IoT — offering limitless monitoring and management rooted in intelligence. He has over two decades' experience in control automation and IoT product design with Fortune 500 companies. He is a contributing member of CABA, ASHRAE, IES Education and USGBC and a frequent lecturer on the evolving use of analytics and emerging IT technologies to foster efficiency within commercial facility design.

SECURITY SESSIONS

ADVANCING MILITARY MICROGRIDS



STEPHANIE PINE

Federal power systems support critical infrastructure and missions at the forefront of national defense operations. With the weight of national security on the line, truly resilient power is essential for these federal entities. Unfortunately, the main power grid can't guarantee resilient power for these locations 100 percent of the time.

Main power grids have aging infrastructure and are becoming a prime target for physical damage and cyberattacks, which have the potential to shutter the grid and cause unprecedented consequences. Military operations have existing backup generation on-site, but these backups aren't enough to sustain ongoing base operations for days at a time. Existing equipment is often not configured effectively or maintained properly as stand-alone assets, but it does have the potential to be leveraged for energy-security measures in military installations by being integrated into an advanced microgrid.

Many military bases have pursued advanced microgrids to help support their power needs, but Fort Belvoir in Virginia is the first to integrate existing generation sources into the system to reduce capital costs and improve resiliency. As such, it serves as a model for future power systems at mission-critical military bases. →

The Department of Defense's (DoD's) Environmental Security Technology Certification Program (ESTCP) knew maintaining operations in the face of a crisis was crucial for any military operation, and it was determined to demonstrate the viability of implementing advanced, cybersecure microgrids at military operations that use existing on-site generation and infrastructure. For this application, ESTCP was interested in proving a cybersecure microgrid could reduce operating costs for the base while sustaining critical missions, ideally becoming a replicable model for future DoD installations.

Understanding the Fort Belvoir microgrid

To achieve these goals, ESTCP selected a Chicago-based provider of equipment and services for electric power systems to develop an advanced cybersecure microgrid with the capability of seamlessly islanding from the main grid and properly isolating itself in black-start conditions. The base's existing generation assets were a crucial component to the microgrid's design, and the system used the base's existing utility connection.

Building the system around available fixed and mobile generators eliminated the need to bring new, permanent generation into the equation, and it helped expedite the deployment and decrease overhead costs for the system. These existing assets had sufficient generation capabilities to support 13 critical buildings in a subsection of the base in the event the microgrid had to island from the main grid.

Besides integrating existing generation into the microgrid, the system relies on a distributed, cybersecure microgrid control system that provides automated, intelligent decision-making coupled with embedded cybersecurity protection. The control system was the first of its kind to receive an Authorization to Operate from the DoD, verifying it would be effective and secure enough for a federal microgrid. The microgrid control system directs and protects every asset within the microgrid, seamlessly balancing and optimizing the system.

Setting the stage for future deployments

The microgrid deployment culminated in two testing events to verify the system would operate as intended. Following the tests, results proved the microgrid could successfully island from the main power grid without hindering any critical operations at the base. Demonstration of the microgrid also validated that the system could support the base's critical needs for multiple days in the face of an outage on the main grid, and it set the stage for future exploration in military microgrids using existing on-site generation.

Expected to be the first of many similarly designed microgrids, it is important to understand the lessons this project brought to light to simplify future deployments — military or otherwise — and to help ensure microgrids can come online faster.

Lesson: Microgrids need supportive stakeholders

Every microgrid will have a variety of stakeholders: the owner, the developer, the utility etc. Connecting with all stakeholders throughout the project is necessary to understand their expectations of the final system, identify potential roadblocks in the deployment schedule and ensure everyone is satisfied with the end result. It also helps prevent conflict and delays with the deployment. Additionally, finding a champion to actively support and promote the project internally is critical to the effort's success. This champion can help facilitate stakeholder conversation, use their influence to guide progress and deconflict issues as they arise.

Lesson: Integrating existing infrastructure can be challenging

The majority of microgrids will not be completely greenfield installations. Often, a microgrid is being integrated into an existing electrical system, and not all existing electrical infrastructure in its present state is ready to support a microgrid.

Before designing a microgrid around existing equipment, it's important to identify any potential limitations. Within the Fort Belvoir microgrid, the system ultimately benefited from using the preexisting generation and other assets, but adjustments were made to the intended design to integrate everything properly. Key areas of consideration regarding infrastructure include:

- Existing electrical distribution: When integrating existing assets into a new microgrid, some key areas of focus should be the size and status of existing transformers, whether there is imbalance on the system, what existing generation assets exist and where the present utility feeder connection is located in relation to the microgrid site. All of these factors can have a big impact on the microgrid's design.
- Existing generation: Generators are often the backbone of a microgrid. If the new system is planning to integrate an existing generator, be sure to examine its present operational state. Does the generator work properly? Has it been maintained? What can the existing generator controls do? These may seem like simple questions, but understanding the state of existing generation early on can help avoid headaches during the deployment process.
- Physical location: Brownfield microgrids can come with a variety of challenges, including identifying where any new distribution equipment can be safely and effectively placed to support the system. Before designing the system, be sure to review location and growth constraints that could affect the overall size of the microgrid.
- State of the communication network: It's very likely a present network at the microgrid's location is serving existing assets. Will that network be enough to support the communication needs of a microgrid? Typically, the existing network will not have been designed to support a microgrid control system, and updates will need to be made.

> "In our digitized world, IoT and IoT-enabled technology advances are allowing energy leaders to better manage smart grids by relying on scalable technologies that provide automated actionable intelligence in real-time for our always-on needs."

Lesson: Defining operation requirements of the microgrid

After assessing existing infrastructure, it's important to identify the ideal use cases and system applications the microgrid could achieve upon completion. Below is a list of standard use cases and complex use cases. Not every microgrid can meet each of these. Outlining the desired operational requirements early on helps the microgrid integrator identify any design limitations associated with the existing infrastructure being used. In some cases, operational requirements may need adjusting to better match the capabilities of existing infrastructure.

Standard Use Cases

- Grid-tied
- Island
- Transitions
  - o Black start
  - o Intentional island
  - o Island to grid-tied
- DER optimization
- DER monitoring and control

Complex Use Cases

- Storm preparedness
- Islanding with renewables (Green mode)
- Peak-shaving
- Curtailment
- Renewable smoothing
- Frequency regulation
- Power factor correction →

Lesson: Multi-Layered contingency handling

What happens when a generator doesn't start? Or when communications fail? A microgrid system should have multiple layers and contingency-handling tools in place to help the microgrid stay online and operational when the end-user needs it most. Three areas to focus on are: resilient equipment, distributed design and intelligent controls.

No matter the equipment chosen to support the system, consider the physical challenges of the area. Must the equipment maintain operation in extremely cold or extremely hot conditions? Does it need to be submersible and withstand challenges associated with rain or snow? Does the equipment require an uninterrupted power supply to power control equipment in the face of an outage?

Next, look at the system design. The goal should be to eliminate a single point of failure. A distributed control architecture can improve redundancy and resilience in a microgrid. This includes the electrical distribution, generation equipment, network and controls for the system. Consider whether the system would benefit from a fiber-loop network that redundantly connects all the equipment.

Every microgrid deserves an intelligent control system capable of withstanding multiple levels of contingencies. Even the most beautifully designed systems can experience operation challenges, but a robust control system automatically adapts to prioritize operational requirements.

Lesson: Proper cybersecurity considerations

When considering cybersecurity within critical facilities, it's important to recognize the evaluation is really of a system of systems and not just a single piece of equipment. If left unprotected, these systems are vulnerable to attack. The question isn't if there will be an attack, but when. It is estimated that the Department of Defense thwarts 36 million dangerous emails per day [1], clearly illustrating the constant threat to DoD systems.

Cybersecurity is critical for a microgrid system, and it's very easy to get wrong. Complex security protocols can often result in fragile systems, which limits resilience. The more devices, software and communications in place to support cybersecurity, the greater the number of intrusion points.

The best way to provide the security a microgrid and its environment requires is to pursue a proven energy-management system, such as a cybersecure microgrid controller with built-in security. When a control system has multiple layers of defense embedded in its design, it's better equipped to respond appropriately when a threat presents itself.

As microgrids become more prevalent around the world, the industry is able to pursue simplified solutions to meet energy goals thanks to experienced microgrid integrators and owners sharing their best practices for deployment and design. Kicking off a new microgrid effort may seem intimidating and overwhelming, but know that the process doesn't have to start with a blank piece of paper.

Remember, complex solutions aren't always the best choice; there is no reason any microgrid needs to reinvent the wheel. Resources are available from experienced organizations that have been through this before and from microgrid integrators that can help lighten the load when it comes to actually designing and implementing an advanced microgrid.

Reference

[1] https://www.nextgov.com/cybersecurity/2018/01/pentagon-thwarts-36-million-email-breach-attempts-daily/145149/

ABOUT THE AUTHOR:

Stephanie Pine is director of strategic accounts, at S&C Electric Company. Pine has spent the last 10 years in power and energy R&D and microgrids. She has served as the project manager on several deployed military and commercial microgrid projects, as well as on a number of government microgrid research projects. Prior to entering the power and energy space, she worked in higher education, focusing on revenue generation and organizational process and policy development. Pine is a graduate of Oregon State University and holds a Lean Six Sigma black belt.

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