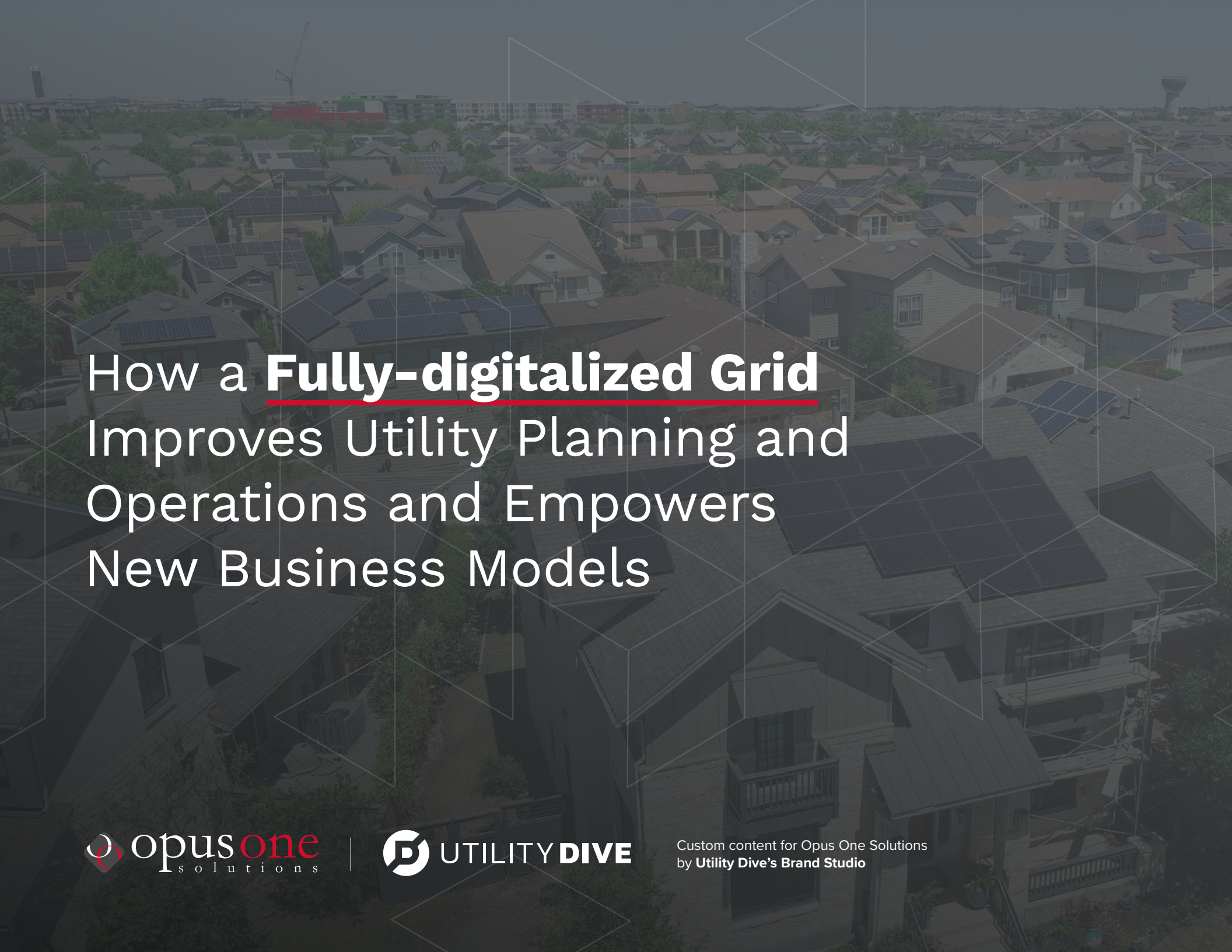

How a **Fully-digitalized Grid** Improves Utility Planning and Operations and Empowers New Business Models

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Before Josh Wong became CEO of Opus One Solutions Energy Corporation, he held a variety of positions at Toronto Hydro-Electric System Ltd., the electric utility that serves Canada's largest city. Wong's time at Toronto Hydro gave him an up-close view of the challenges utilities face today and a clear understanding that many of the traditional tools and approaches the industry has relied on are inadequate in the face of unprecedented, rapid change.

"I think the world is transforming faster than we ever imagined," said Wong, who leads the software engineering company that was founded in 2011, around the same time that many of the challenges and opportunities of an evolving energy system were taking shape. Today, Opus One helps utilities around the world get the visibility and insights they need to effectively manage, control and optimize the distribution system with increasing penetration and optionality around distributed energy resources (DERs).

The massive and ongoing influx of DERs – including solar, battery storage and electric vehicles connected at the edge of the grid – is perhaps the most obvious manifestation of an accelerating transition from an energy system dominated by large power plants sending electrons in one direction to a far cleaner, more decentralized system characterized by bi-directional power flows.

A changing landscape requires new tools

The forces driving this transition are many, though the most important drivers for utilities are customer empowerment and the increasing demand for DERs. Contributing to that are public policy supporting clean energy to address climate change; deregulation that injects competition into markets that were once monopolies; as well as technology advancements. This powerful combination of forces is motivating utilities to reconsider how they do virtually everything, from planning and operations to proactively engaging customers. The backdrop to all this change, of course, is the fixed fundamental mission of electric utilities to deliver safe, affordable and reliable electricity.

While the energy transition is sprawling in its scope, a few statistics highlight just how transformative the emergence of DERs already is – and how much more they will continue to alter the energy system in the future.

For example, the Solar Energy Industries Association (SEIA) reported that the cumulative installed solar PV capacity in the U.S. at the end of 2018 was 62.4 gigawatts, a staggering 75 times the amount of PV that

The five “D’s” propelling energy transition:

Digitalization
Decentralization
Decarbonization
Deregulation
Democratization

was installed at the end of 2008. A significant portion of that PV is connected to the distribution grid. Globally, Bloomberg New Energy Finance (BNEF) reports that 2018 saw nearly 110 gigawatts of solar installations, with 2019 looking to reach as high as 140 gigawatts.

A similar story can be told about energy storage and electric vehicles (EVs). The International Energy Agency (IEA) projects the number of EVs globally will grow from 3.1 million in 2017 to 125 million by 2030. BNEF projects that the global market for storage will double six times by 2030, propelled both by demand for EVs, public policy and technology advancements.

Although the changes taking place are wide-ranging and often challenging to utilities, they also represent significant opportunities to become more efficient, reliable, sustainable and customer-focused. It has often been said that the forces propelling the energy transition can best be represented by the five “D’s”: digitalization, decentralization, decarbonization, deregulation and democratization. Individually, these are all essential trends reshaping how utilities operate, plan and interact with customers.

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Empowering utilities through digitalization

It's crucial to realize that only one of the so-called "D's" is fundamental to the success of all the others. "Digitalization enables all five D's," said Wong. "If we build a software layer on top of hardware, we essentially increase the pace of innovation driven by policy, environment, and customer needs. Digitalization becomes key to unlock modernization and evolution, achieving efficiency and cost savings, from a power system that has been planned and operated in a very analog fashion."

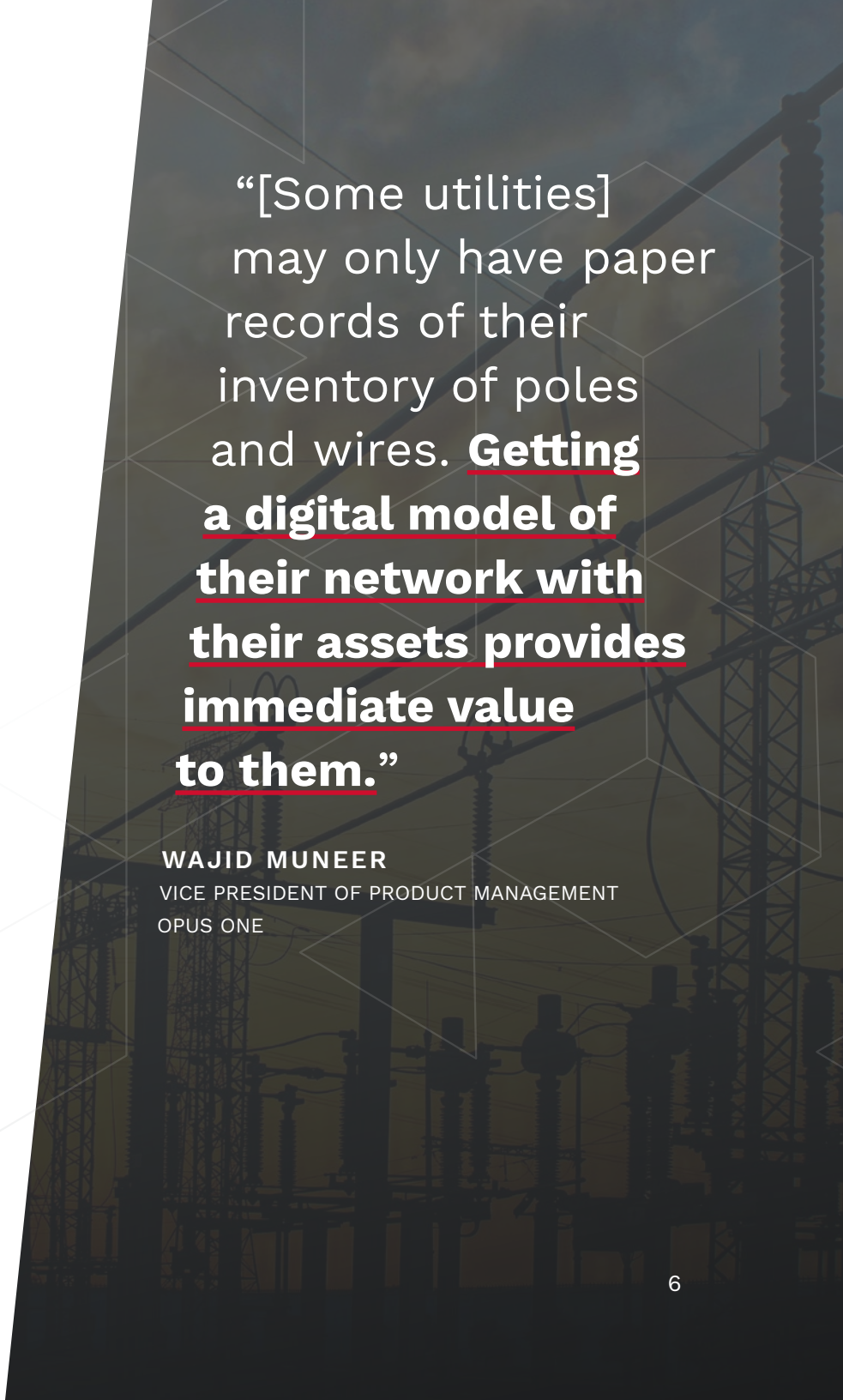
A growing body of both research and, more importantly, utility investments underline the importance of digitalization. A report from the consulting firm McKinsey & Company found that utilities implementing digital technologies could reduce operating expenses by up to 25%. McKinsey also found that digital technologies could improve performance in areas ranging from safety and reliability to customer satisfaction and regulatory compliance by between 20 and 40%. This promise is translating into utility spending. For example, the market research firm Research and Markets projects that utility spending on Internet of Things (IoT) technology will reach $12 billion by 2020, up from $5 billion in 2015.

Still, this march towards digitalization is uneven, with differences between many (though certainly not all) small rural cooperatives and municipal utilities, as well

as more substantial investor-owned utilities (IOUs). “Some utilities are still in early stages of building a good understanding of what is happening on their network and may only have paper records of their inventory of poles and wires. Getting a digital model of their network with their assets provides immediate value to them. Traditionally, creating accurate digital network models has been a big challenge,” said Wajid Muneer, Vice President of Product Management at Opus One.

Other utilities are proactively working to meet the increasing demand their customers have for choice and empowerment through more DER options. At the same time, many utilities are driven internally to achieve grid modernization that achieves improved reliability and quality and reduces costs.

All of this translates into targeting significant resources to implement digital tools. This is a rational business response. As more DERs are installed, the need for digitalization to improve the visibility of grid-edge technologies, develop new business models, and monitor and operate existing infrastructure becomes more pressing. This variability in progress towards digitalization is reflected in research by the McKinsey Global Institute, which studied U.S. companies and found utilities significantly lagging behind the digitalization efforts of other industries.



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WAJID MUNEER
VICE PRESIDENT OF PRODUCT MANAGEMENT
OPUS ONE

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How software and digitalization improve planning

There are numerous reasons why utility digitalization progress is so varied. Some utilities may have seen relatively little DER penetration or are still early in their journey towards grid modernization. Other challenges include a lack of resources, in-house knowledge and effective strategies to tap the power of digitalization.

But another big reason is cultural: utilities are structured to be stable and predictable, which translates into an understandably conservative approach. Introducing any new technology or process that could impact the reliable delivery of electricity to customers injects a level of uncertainty.

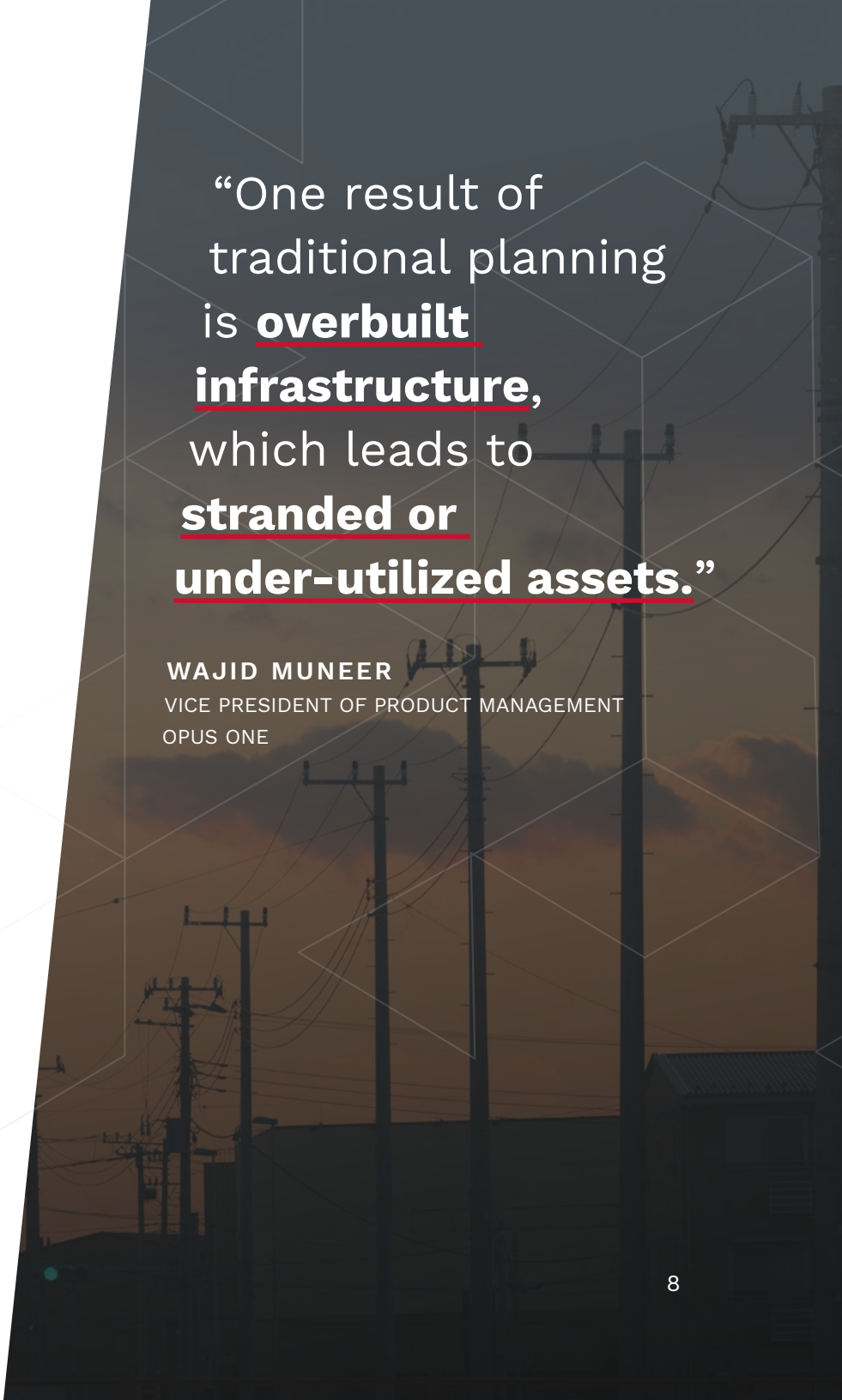
That natural conservatism – paired with a comfort level with the status quo – helps explain why the initial wave of digitalization efforts took the form of pilot projects, though that phase is coming to a close. “Pilot projects around specific equipment like batteries, microgrids, EVs, sensors and controllers are slowing down,” said Wong. “Now utilities are thinking about what they are going to do with grid-edge technologies and digitalizing the grid to fully exploit them, towards a sustainable and growing operating, business and customer model.”

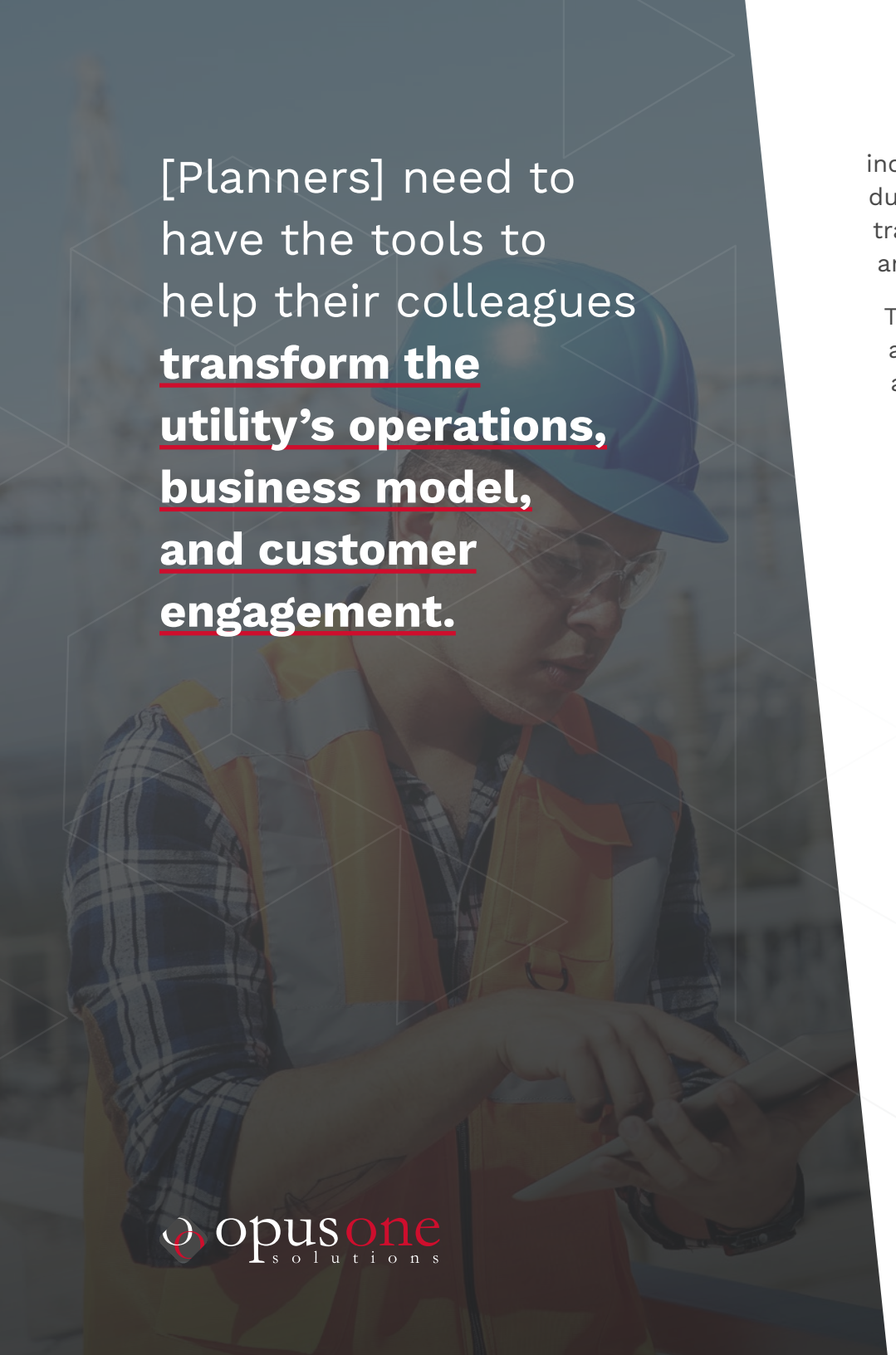
The move away from experimentation to more widespread implementation can be seen in the critical realm of distribution system planning, an area where

digitalization and sophisticated software can deliver significant value, particularly in comparison to traditional approaches. Historically, planners have analyzed distribution feeders under future worst-case scenarios of load growth to identify necessary infrastructure upgrades. In particular, planners have sought to assure system reliability by pinpointing upgrades that can handle peak demand.

While this approach was adequate when power flows were in just one direction, it was not the most efficient process. “One result of traditional planning is overbuilt infrastructure, which leads to stranded or under-utilized assets. When you build something to meet the needs of 10 years from now, it will inevitably be inefficient and require investing a lot more money than necessary,” said Muneer. “Our value proposition is that you don’t have to overbuild the network, instead you can evaluate and utilize distributed energy resources and distribution automation devices to maintain the same, and perhaps even improve, the level of reliability and power quality at an overall lower cost.”

But those options are nearly impossible to uncover and adequately analyze when planners utilize traditional manually intensive tools. For starters,





[Planners] need to have the tools to help their colleagues **transform the utility's operations, business model, and customer engagement.**

increasing the probability of bi-directional power flows due to DER integration represents more scenarios than traditional planning tools can accommodate in a reasonable amount of time.

The use of traditional planning tools and processes are also limited in their ability to account for both economic and technical considerations and don't account for the increasingly integrated nature of the power system. "I used to be a planner and we would do all of the technical analyses first. And then we would run a few economic cases and come up with a business case to find the project with the highest NPV (net present value)," said Wong. "Today, planning needs to be integrated across the technical and economic factors and reflect things like running non-wires solutions and battery dispatch that responds to market rules. All of those are technical and economic analysis that should be run together and take into account impacts from DERs to distribution to the bulk power system."

Planning has also become an increasingly strategic function for utilities. To execute on a utility's strategy - whether it's the overall corporate strategy or customer demands, changing business models, policies and regulations - requires data. Planners are at the center of all of this and need to have the tools to help their colleagues transform the utility's operations, business model, and customer engagement.

Integrated planning empowered by software

A move towards integrated planning that simultaneously addresses DER, distribution, and bulk power impacts is becoming the norm in places like Hawaii, New York and California, where DERs have been installed at the quickest pace.

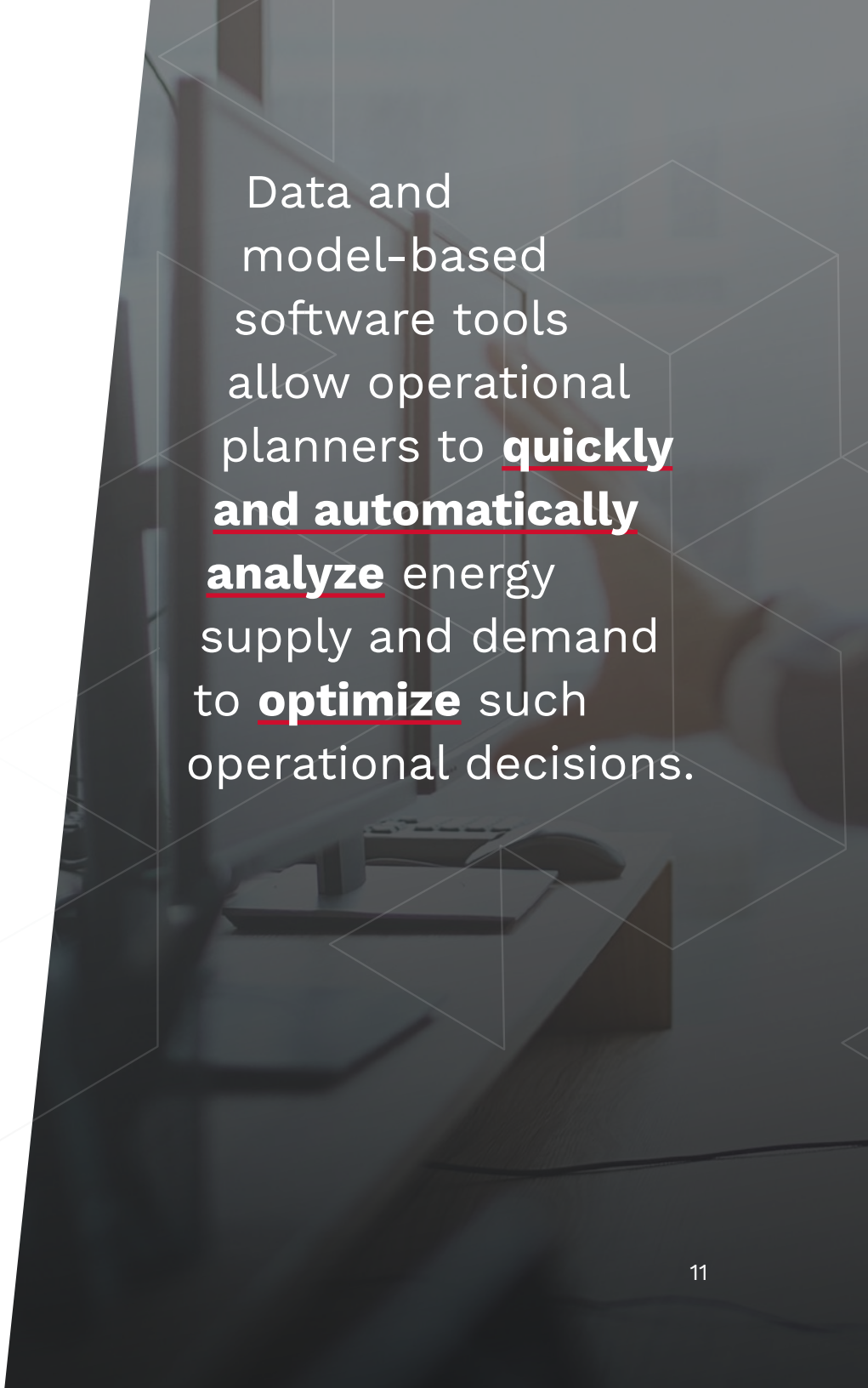
“When we talk about integrated planning, we talk about it across multiple vectors, all being enabled by software. One is integrating between what is grid and what is grid edge,” said Wong. “When the edge becomes a primary driver of change, it challenges traditional planning tools. They can handle one solar system or one battery, but for me to run a large set of scenarios on a thousand solar + storage systems and across different feeder configurations, you will see how time, labor and computationally intensive this process becomes.”

Software such as Opus One Solutions’ GridOS® allows utilities to move away from traditional planning for absolute worst-case scenarios of peak demand, towards integrated planning across the DERs/distribution and bulk power systems, across technical and economic analyses, and across time domains. “When you bring in solar, EV charging and batteries, those all have time-variable operation. Building a time series approach to scenario planning is key,” said Wong.

Planning and utility operations benefit when it’s possible to utilize a combination of both real-time data and

model-based software tools, in the form of operational planning. A powerful DERMS (distributed energy resources management system) of the sort included in GridOS allows for effective control and dispatch of DERs, essential for reliable grid and DER operations in real time. At the same time, data and model-based software tools allow operational planners to quickly and automatically analyze energy supply and demand to optimize such operational decisions. This strategy provides insights that help utilities address possible areas of constraint, offers guidance on hosting capacity to allow for greater DER penetration and fully takes advantage of the grid's traditional and DER controllable resources.

Already, the utility industry is seeing how improved digitalization unlocks new business models and avenues for better customer engagement. One leading example is transactive energy, which is made possible when utilities leverage techno-economic analyses to apply the value of DERs for planning and operations, taking advantage of an integrated approach that simultaneously emphasizes DERs and existing grid resources — an important win-win for both utilities and DER owners and developers. At a high level, transactive energy refers to the platform marketplace that facilitates decisions and transactions involving the generation, storage, distribution and consumption of power. For instance, transactive energy enables rooftop solar and electric vehicle owners to trade electricity and provide services to the wider grid.

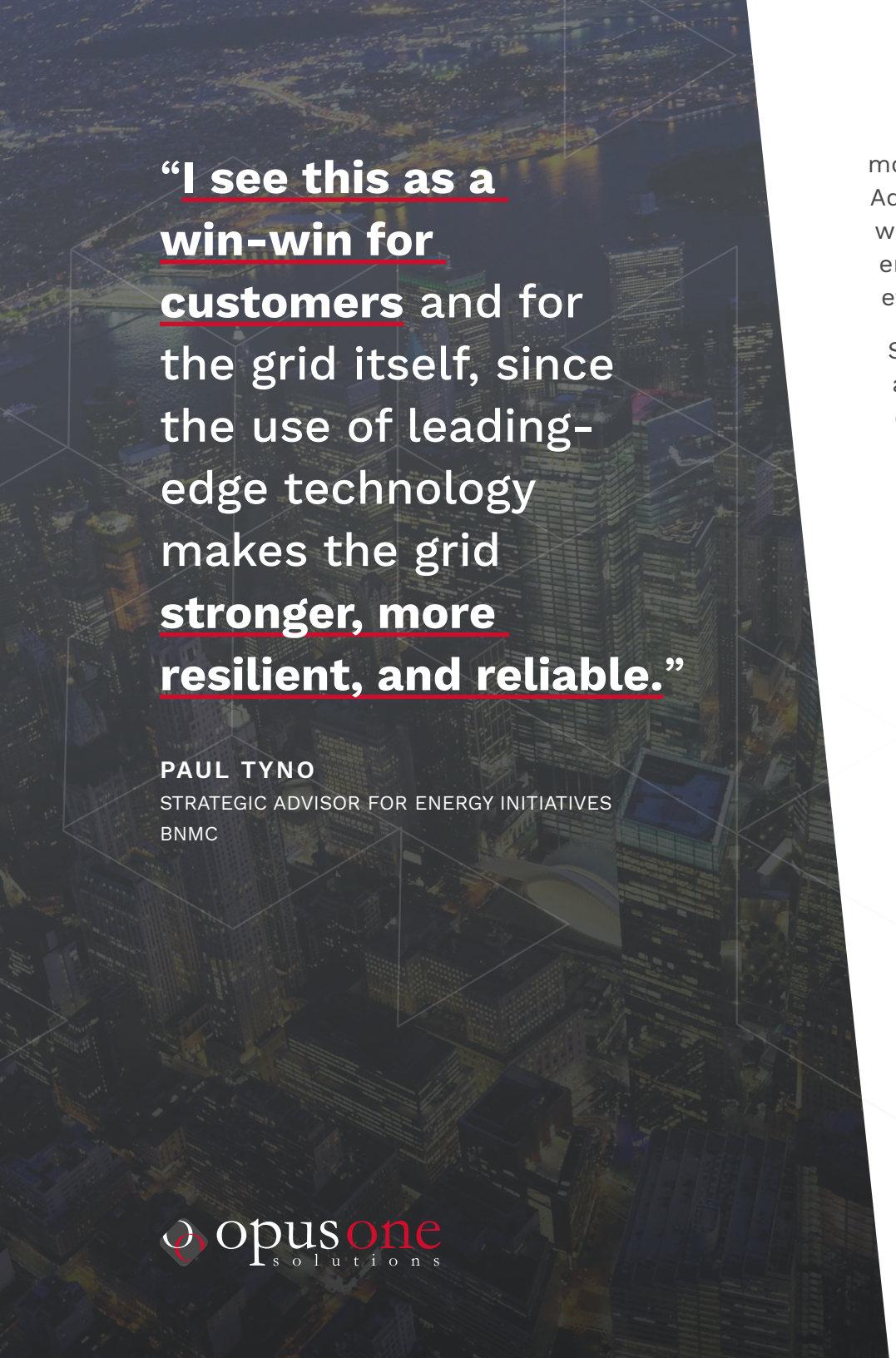


Transactive energy in action

In New York, the utility National Grid worked with Opus One Solutions to develop and deploy North America's first transactive energy marketplace. Responding to New York's Reforming the Energy Vision (REV), which is driving innovation in how utilities and consumers interact, National Grid utilized Opus One's GridOS Transactive Energy Management System (TEMS) to establish a transactive energy marketplace on the Buffalo Niagara Medical Campus. National Grid launched a distributed system platform (DSP) on the campus as a way to create new markets that ensure that local DERs are paid appropriately for the services they provide.

"It allows the outputs of the planning process to be used in day to day operations and evaluation of new business models for the utility," said Muneer. "Our software helps identify the future grid's needs, where, when and how bad the grid congestion will be, and then uses various financial models to quantify those grid needs in monetary terms. Those values are offered to third-party DER participants on the platform, and they can make their own decisions about whether to accept or reject the offers." It's a dynamic marketplace: the system calculates prices on both a day-ahead basis as well as on the same day.

For the Buffalo Niagara Medical Campus (BNMC), the project was a way to demonstrate how DERs can be deployed in a way that benefits everyone. "I see this as a win-win for customers and for the grid itself, since the use of leading-edge technology makes the grid stronger,



> **“I see this as a win-win for customers** and for the grid itself, since the use of leading-edge technology makes the grid **stronger, more resilient, and reliable.”**

PAUL TYNO
STRATEGIC ADVISOR FOR ENERGY INITIATIVES
BNMC

more resilient, and reliable,” said Paul Tyno, Strategic Advisor for Energy Initiatives at BNMC. “This is consistent with our energy focus of providing high quality, continuous energy that defines a global standard for innovation, energy efficiency, and modern energy management.”

Shared benefits were important to National Grid, which also saw the project as a way to shape its future DER deployments. “The demonstration is proving that our strategy for DSP development and market engagement can be viable and beneficial to all parties involved,” said Carlos Nouel, former Vice President, New Energy Solutions for National Grid. “We’ve made a strong commitment to the adoption of distributed energy resources as a benefit to customers, and our experiences in Buffalo will help guide our efforts going forward.”

As the project moves forward, there will be valuable lessons about the benefits a dynamic transactive marketplace can provide to the grid overall. In particular, it may demonstrate the ability of DERs to avoid or delay infrastructure investments as non-wires solutions. “Instead of building a new substation or adding transformers to the line, the utility might be able to maintain reliability and quality of supply without investments in traditional assets, and instead, meet the same needs with DERs,” said Muneer.

Letting data speak

The foundation of these potential benefits is digitalization and data. “Having the tools to collect, analyze and share valuable data opens up so many possibilities,” said Wong. “When you socialize and democratize these advanced analytics, the data will speak for itself no matter whether you’re talking about an investor-owned utility, a muni or coop or an academic institution.”

Because data and analytics are so critical, Opus One has made its planning tool available for free this year. “People can use it as a fully scalable tool and plan with as many DERs on as many circuits as they want. What’s more, it’s a tool for collaborative planning with unlimited users, where the industry can join efforts in planning for the future. So let’s plan the future together.”

Opus One Solutions is a software engineering and solutions company with the vision of a digitalized, decentralized and decarbonized planet. Its intelligent energy networking platform, GridOS®, optimizes complex power flows so that it can deliver real-time energy management and integrated planning to distribution utilities and other managers of distributed energy assets. GridOS is modular, scalable, and integrates seamlessly with existing data systems to unlock greater potential for distributed energy resources, including renewable generation, energy storage, and responsive demand. GridOS also facilitates the management of microgrids — from homes to businesses to communities — for unparalleled grid resiliency and value to the electricity customer.

To learn more about how GridOS can improve grid operations and planning, email their team at info@opusonesolutions.com or visit their website at www.opusonesolutions.com.

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