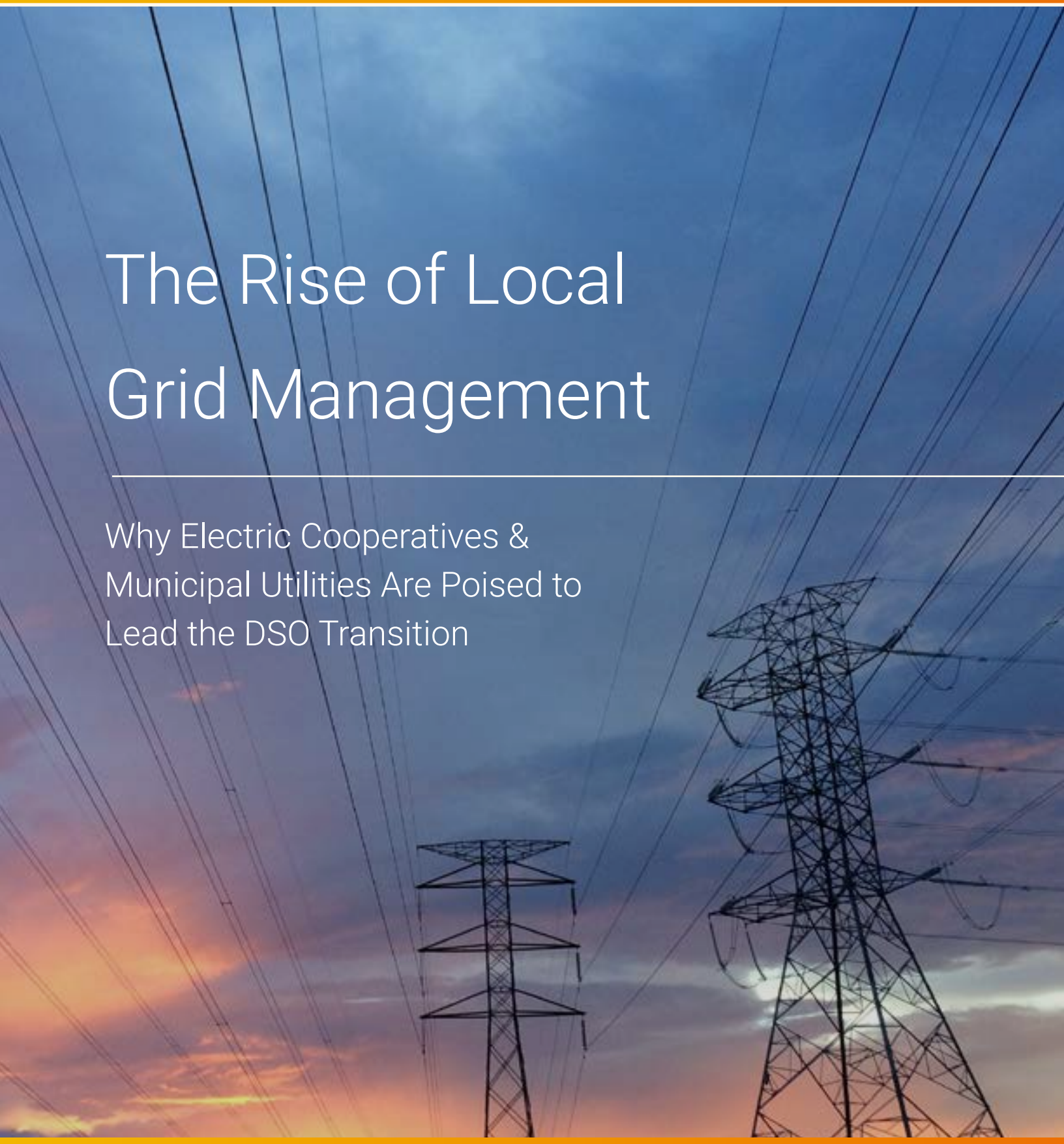
CAMUS
Zero Carbon Grid Orchestration

DSO OF
THE FUTURE

The Rise of Local Grid Management

Why Electric Cooperatives & Municipal Utilities Are Poised to Lead the DSO Transition



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Introduction

The need for immediate and coordinated climate action is clear and compelling. Instead of debating whether to address climate change, the most pressing question is quickly becoming how fast can society decarbonize?

While there is no silver bullet, our electric grid provides a rare opportunity to use existing infrastructure to achieve rapid and large-scale decarbonization. That makes the decarbonization of our power sector essential for our future and ensures that it will be an enormous driver of change for decades to come.

The path to rapid decarbonization must balance competing visions for the future zero carbon grid. We cannot afford to rely solely on massive amounts of utility-scale renewable generation, as the build-up of transmission capacity will take too long, cost too much, and fail to provide resilience to communities under siege. Likewise, strict reliance on distributed resources and microgrids will result in a system that is too expensive and difficult to manage.

So, what are utilities to do?

The best approach is community-centric -- where distribution system operators (DSOs) use local grid management to capture both the cost savings of centralized renewable generation and the locational value of distributed resources.

With a proven record of putting community needs first and an ability to move nimbly towards the future, electric cooperative and municipal utility leaders are best positioned to shepherd the transition to a zero carbon, community-centric, antd DSO-led future.

What would it take for electric cooperatives and municipal utilities to lead this transition?

Contents

1.0

New Challenges for An Old Grid

Let's face it, managing the grid today is far from simple. And it's only getting more complex. Consider four ways in which the grid is rapidly evolving:

Renewable Penetration

Solar and wind, driven by economic advantages over fossil fuel-based generation and ambitious city, state, and national renewable targets, are increasing at a rapid pace. In fact, the IEA projects a 50% rise of global renewable generation from 2019 to 2024, with more than 35 gigawatts (GW) of new rooftop solar to be installed in North America during that time. It is an elephant in the room that cannot be ignored. While the increase in both centralized and distributed renewable generation provides cost and decarbonization benefits, distribution utilities must adapt to balance the variable generation with local loads.

Disasters and Cyber Threats

A warming planet is resulting in a higher frequency and greater intensity of natural disasters across the United States. No region is left unscathed with wildfires, snow storms, hurricanes, tornadoes, and flooding wreaking havoc in communities throughout the country. Some utilities are implementing preventative measures to mitigate or curtail the worst impacts. In October 2019 alone, 2.6 million residents in California lost power due to public safety power shutoffs in response to wildfires.

On top of natural disaster prevention and response, cyberattacks are targeting electricity supply. The 13-fold increase in vulnerability advisories issued by the Department of Homeland Security between 2010 and 2018 for industrial control systems demonstrates this growing challenge. Whether mother nature or bad actors, our changing world is putting greater stress on the ability of local grid operators to adapt to large-scale changes and threats to our electric power systems.

Electric Vehicle (EV) Adoption

The EV sector, meanwhile, is poised for tremendous growth, and with that growth comes a challenge for utilities: an emerging asset class that acts as disaggregated, disorganized high-power loads. If these new loads are unplanned or unchecked, they can create large-scale increases in local peak demand -- and the need to spend millions to adapt. In states like California, agencies are assembling multilateral public-private vehicle-grid integration working groups to prepare for this future.

Building Electrification

In cities across the country, local governments are forcing a shift away from thermal-based HVAC, water heating, and building management to electric options. This transition is largely driven by decarbonization targets in the built environment, with roughly 40% of U.S. CO2 emissions coming from residential and commercial buildings.

In fact, a growing number of cities are banning natural gas supply in new homes and buildings. This leads to increased adoption of electric assets such as heat pumps and related building systems that, similar to electric vehicles, are distributed assets able to be utilized by local utilities.

How can cooperative and municipal utility leaders prepare for and manage these changes?

As a leader of an electric cooperative or municipal utility, how can you safely and efficiently manage your grid while so much of it is changing? A common assertion among those in the energy industry is that co-ops and munis should look to investor-owned utilities for guidance. But are IOUs truly the best positioned to lead? The fundamental shift underlying each of these changes is to a community-centric grid. And who knows their communities better than co-ops and munis?

The most successful leaders during any industry transformation identify opportunities within a set of challenges. Case in point: several emerging markets and developing countries have leapfrogged centralized landline telecommunications infrastructure in favor of cell phones, which are used not only for communications but also banking, photos and news.

As the grid becomes more distributed, the true opportunity at hand is to leverage this transition and harness local resources to drive a more reliable, adaptable and efficient grid.

So, what would a leapfrog look like for electric co-ops and municipal utilities?

2.0

Our Vision for the DSO of the Future

Imagine the Future

The year is 2040. What does the grid look like? How does it operate? How much wind, solar, and battery storage is interconnected? How many vehicles and buildings are now fully electric? Close your eyes and take a moment to truly visualize this. If existing renewable energy and electric vehicle adoption targets are realized, penetration rates will be very, very high.

Open your eyes. What did you see? The Jetsons? Mad Max?

More likely, you envisioned something in the middle: a more modernized, decarbonized, and flexible version of today's grid. A climate, society, and resource mix that have changed, but an electrical infrastructure that has smartly evolved and adapted. A system that is still focused on safely and efficiently balancing demand for and supply of electricity, but with a very different set of tools to do it better. This is the future that we envision, too.

A Community-Centric Approach

Our vision revolves around the concept that the grid of the future is community-centric and led by a Distribution System Operator (DSO). What would an operations manager from a traditional distribution utility notice about this DSO-led grid?

Almost immediately, they would recognize a shift toward balancing supply and demand at a local level rather than relying on centralized power that is distributed downstream. The utility, now functioning as a DSO, orchestrates distributed, local generation and flexible load to optimize for the goals of the system. All resources, centralized and distributed, are treated as tools for balancing, rather than parts of a problem to be solved.

The grid is strong yet flexible, with layered subsystems supporting one another and adapting to the planned and unplanned. Utilities, large and small, have the hardware and software to effectively monitor, forecast, and orchestrate the grid.

Our grid operator observes how renewable generation, electric vehicles, and electrified building loads are resources that help keep the grid in balance -- while serving community needs. This is a system where clean energy is generated, stored, and intelligently managed to be used when and where it's needed; a future made possible, in part, by the rise of the DSO. This is the DSO of the future.

This vision is achievable. But how do we get there? And where do we start?

3.0

Local Balancing of All Resources

Monitor, Forecast, and Orchestrate

The shift to this community-centric DSO model relies upon utilities taking steps to better monitor, forecast, and orchestrate the myriad resources connected to the grid.

Step 1: Grid Visibility

The foundation of this future DSO model starts with system-wide asset visibility. You cannot control what you cannot see.

In a centralized system with relatively few large assets, it is possible to directly observe and predict the behavior of each asset. But in a system with thousands or millions of assets, operators need tools to aggregate vast amounts of information and provide actionable insight at the system level.

This is a fundamentally different approach -- stemming from Google's design philosophy of reliable software on unreliable hardware -- that leverages the law of large numbers to manage reliability as a property of the system, rather than its components.

This approach enables utility leaders to better understand the effects that aggregate changes—like the surplus midday export from rooftop solar systems or the evening load ramp from electric vehicles—are likely to have on local grid balancing.

The first step for any utility to progress towards a community-centric DSO model is to add visibility to current operations -- represented as the outermost ring in the DSO Capabilities Circle (see page 10).

This visibility must extend across the existing network and be prepared to integrate future participants, assets and programs.

Step 2: Forecasting

In addition to monitoring real-time and historical data for grid-connected resources, forecasting supports utilities' efforts to reliably serve communities.

Forecasting has traditionally consisted of long-term projection of changes in load. These forecasts, developed by system planners, continue to inform infrastructure investments and energy procurement on a timeline of months and years.

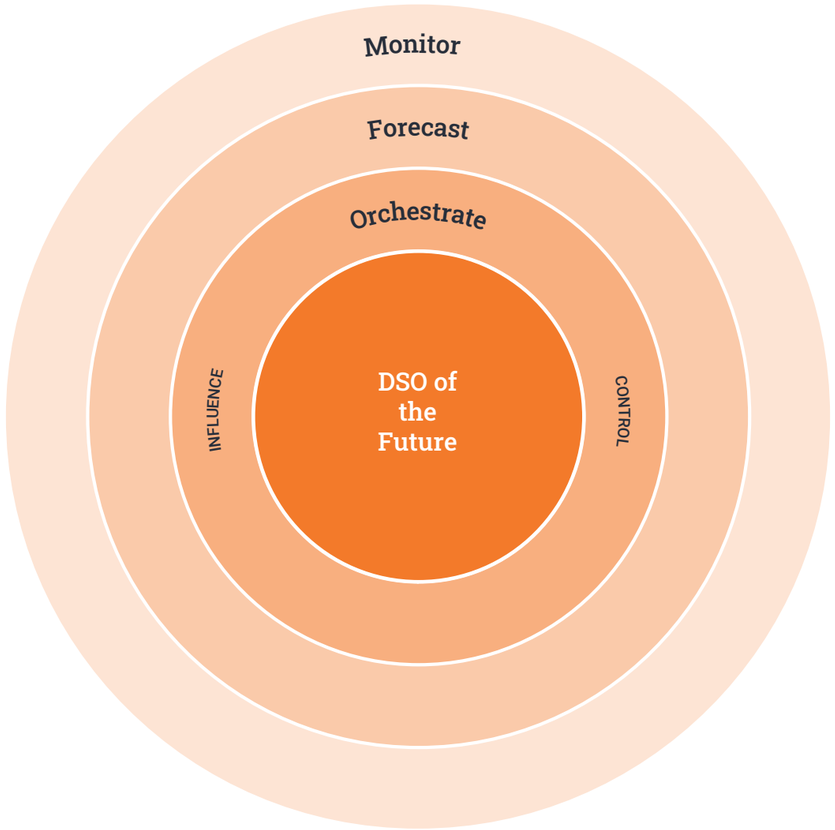
More recently, forecasting of distributed energy resource adoption, especially distributed generation such as rooftop PV, have helped utilities fine tune their estimates for local demand on a shorter timeframe of hours and days.

As more distributed resources connect to the grid, the role of forecasting local load and distributed generation on the order of minutes and hours will become increasingly important.

Rather than adjusting forecasts on the margins, changes in DER behavior will cause large-scale adjustments. Better tools, including predictive algorithms for consumer behavior and distributed generation, can lay the foundation for utilities to better manage an increasingly distributed system.

This is the second ring of the DSO Capabilities Circle. As a utility enhances its ability to monitor and forecast local grid conditions, it can begin to better inform real-time grid operations.

DSO Capabilities Circle



Step 3: Market-based Orchestration

Traditionally, operators have treated load as relatively uncontrollable -- with the exception of a small number of demand response resources -- and centralized generation as the primary tool for balancing.
The shift to a more distributed system brings with it the need for grid operators to gain more fine-tuned control over local balancing.

How can operators achieve this?

Expand the grid operator toolkit to include the full spectrum of grid-connected devices: from utility-owned and managed to customer-owned and controlled.

Orchestration is a concept that encompasses everything from a utility's real-time direct control of equipment like tap-changing transformers and switchgear to the use of financial incentives to proactively influence consumer's behavior, such as delaying EV charging.

The goal of orchestration is to take a comprehensive view of local supply and demand options -- for both energy and grid support services -- and identify the optimal balance, dynamically.

The spectrum of resources available to market-based orchestrators can be divided into two categories: control and influence.

Control

Even in a market-based environment, there are elements that utilities will want to, and should, control. These include both centralized and distributed equipment that can help manage grid state, including traditional distribution equipment like reclosers and capacitor banks, as well as utility-owned distributed energy resources - such as substation-located battery storage -- and even customer-owned DERs that have opted in to direct control schemes

Utilities have relied upon direct control as a primary tool for local balancing for more than a century -- with the inclusion of DERs and emergence of Distribution Automation technologies as recent additions to the utility toolkit.

For example, voltage control is often cited as a top priority for distribution system operators with more unmonitored behind-the-meter solar. If unmanaged, behind-the-meter solar can push localized distribution system voltages higher during midday. Another example is the rise of electric vehicles, especially electrified fleets by third-party logistics operators and transit agencies. Unlike behind-the-meter generation, these added loads can have the opposite effect of lowering voltage during times of mass fleet charging - doubly impacted as EV charging speeds increase over time.

Influence

A utility can also influence consumers' behavior by incentivizing active load shifting or shedding, achieved in limited amounts today through demand response programs. In addition, for consumers with distributed generation, utilities can passively influence the timing of consumption, as is currently achieved through rate design and storage incentive programs. These approaches expand the resources available to grid operators to include distributed resources that are infrequently utilized for grid management today.

This mix of centralized and decentralized control allows all actors in a complex environment to act in their own best interest, while supporting the grid at large -- similar to the current structure for managing transmission system operations. A utility that is able to effectively use market-based orchestration, represented by the third ring on the DSO Capabilities Circle, will be well prepared to act as an effective Distribution System Operator.

Goal: Customer and Utility Grid Harmony

The transition to a community-centric DSO model represents a shift from full reliance on top-down, centralized control to incorporating a greater degree of local balancing.

This rebalancing is akin to shifting from an orchestra that plays a specific piece of sheet music to a jazz ensemble, able to flow, adapt and delight the audience. Both orchestras and jazz ensembles play beautiful music, but one strives for perfection dictated by a predetermined plan while the other is infinitely adaptable and able to harness the strengths of individual members.

Both approaches deliver results, but which is better suited to serve your community members' needs?

The future DSO will be a jazz ensemble. The paradigm shift enabling the rise of local grid management involves applying market fundamentals to directly control some assets while influencing others. With this approach, the increase in distributed resources and greater variance in customer behavior becomes a strength to be harnessed rather than a challenge to be addressed. Ultimately, new business models will emerge to provide this flexibility -- benefiting energy consumers, resource owners, and system operators.

4.0

The Path to a DSO-led Future

The community-centric DSO model provides an opportunity to better serve the diverse needs of electricity consumers – and electric cooperatives and municipal utilities are well-prepared to lead the way.

The Unique Position of Electric Co-ops and Municipal Utilities

The need to realign utility profit motives from a rate base model to performance-based incentives is often considered the largest policy-related obstacle for the DSO transition. However, non-profit utilities -- like yours -- are unburdened by the requirement to prioritize investors. As a result, you have a significant advantage over your investor-owned counterparts -- as you can focus, instead, on maximizing system-wide benefits and community interests.

However, compared to investor-owned utilities, electric cooperatives and municipal utilities are typically more cost-conscious and often more resource constrained. Instead of piloting a wide array of innovative technologies, organizations like yours must be thoughtful and focused in where and how you innovate. As a result, co-op and muni leaders search for tools that can empower organizations to accomplish more with limited resources.

The (Unfulfilled) Promise of Software

Software has long promised to help grid operators achieve more with less. And while many tools have proven well-designed for a centralized system, co-ops and munis' existing software solutions will not prepare them to act as Distribution System Operators.

Why? DSOs need software that is flexible, affordable, and built to manage hundreds to millions of distributed resources. Existing grid management software fails to meet those needs -- limited by being proprietary, on-premises, and inefficiently integrated.

The hardware that we need to rapidly decarbonize the power sector already exists: from solar photovoltaics to wind turbines and battery energy storage to electric vehicles - all with economics that pencil.

The opportunity now is to scale our use of these technologies with thoughtful and intelligent management. Hardware has done its job to reach techno-economic parity, it's now time for software to step in and take the baton.

Fortunately, a different approach to grid management software, informed by the evolution of distributed computing, offers to bridge the gap left by existing software tools and prepare utilities for the future of local grid management.

5.0

The Power of an Open Source Approach

Why Open Source?

Open source software offers a transformational change from proprietary and closed grid management tools. Utilities with in house development capabilities can flexibly and cost effectively extend the capabilities of the platform or add key customizations. Increased transparency means you always understand how your data is being used and how conclusions are being derived.

This approach enables greater data aggregation from diverse sources, visualization crafting, and tool integration by ecosystem partners -- much better than by relying on a single developer to build these capabilities into a proprietary, on-premises solution.

Open source development also enables more streamlined integration, faster development, and the freedom and transparency to adopt specific tools when they are needed - not too early, not too late, and within budget.

Why As-a-Service (aaS)?

Software as a Service can deliver the benefits of a cloud-hosted approach to grid managers. These include faster deployment, lower costs, improved scalability and integration, increased reliability, continuous improvements, and greater ease of use.

6.0

A Software Solution for DSOs

Grid Management as a Service

Grid Management as a Service (GMaaS) is an approach to grid management software in which utilities subscribe to cloud-based tools that are hosted by a third-party provider. Much like traditional Software as a Service (SaaS), sales of which increased 15-fold from 2010 to 2020, GMaaS can be supported by an open source ecosystem and offers rapid advancement in software development.

Most importantly, GMaaS offers the potential for electric co-op and municipal utility leaders to affordably procure the tools they need to better manage the grid today while enabling a future as a Distribution System Operator (DSO).

“Zero Trust” Cybersecurity

As digitalization of the grid accelerates, protecting critical infrastructure from attackers is increasingly top-of-mind. Effective cybersecurity is based on a foundation of visibility, access management and rapid mitigation. Grid Management as a Service allows your organization to take advantage of enhanced security services while minimizing risk of exposure through a “Zero Trust” model.

“Zero Trust” cybersecurity relies on authenticating each user or subsystem through multi-channel mechanisms, such as two-factor authentication, and then providing each user with explicit access to a limited set of systems. This is in contrast to a common security approach within many IT environments that can be described informally as “hard crust and squishy center” -- relying upon a hardened network edge, such as a firewall or VPN, while leaving internal services exposed to users inside the security boundary, often without even a password. With GMaaS, grid managers can deploy “Zero Trust” cybersecurity principles to prevent bad actors from compromising the behavior of grid management systems.

Unlocking New Capabilities

GMaaS offers a radically different approach that can unleash the full potential of local resources.

Rapid integration between data sources and tools can enable operations managers to rely on a unified interface for both real-time monitoring and near-term predictive state estimation. The open source foundation allows for DER vendors to design new solutions to work with the software platform from day one with forward compatibility and full flexibility. The presence of robust real-time situational awareness makes it possible to embrace and choose local resources as the preferred tools -- using local energy procurement, retail programs, incentives, or markets as mechanisms for actively engaging community members.

Open source, as-a-service software represents a significant change from the tools that electric co-ops and municipal utilities rely upon today. It is an opportunity -- a welcome and necessary shift that can better prepare grid operators to deliver greater flexibility, resilience, reliability, and economic development as community-centric DSOs.

7.0

Looking Ahead

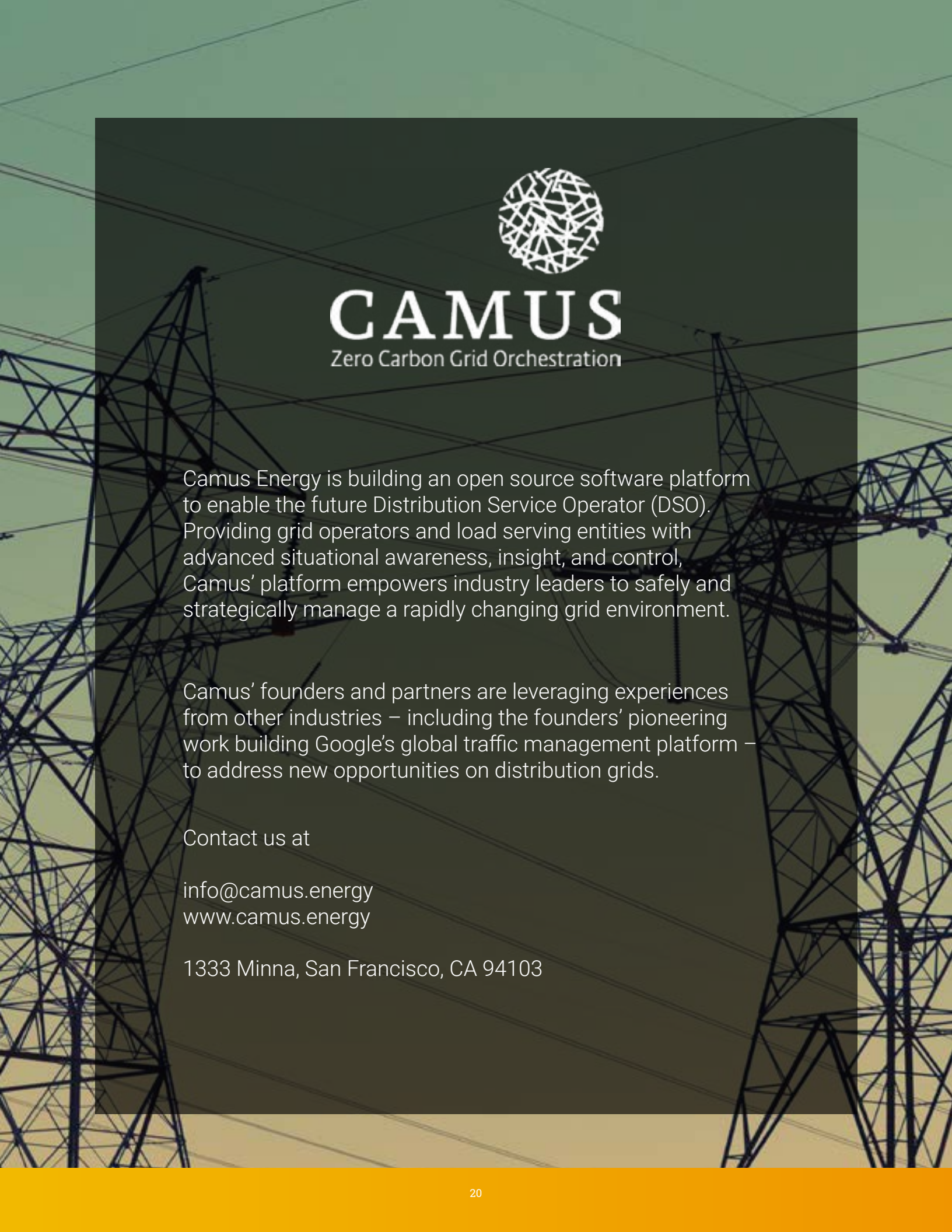
Your community's assets can unlock a grid revolution. Electric cooperatives and municipal utilities are ideally positioned to redefine how electricity is managed and delivered. The rise of local grid management -- led by those organizations who have focused on community needs for a century -- can accelerate the transition to a more distributed and decarbonized future.

To transform, utilities must usher in the era of community-centric Distribution System Operators.

Becoming the DSO of the future can be done without the stress, expense and near impossibility of masterfully controlling every asset. Software can help leverage a distributed systems approach and orchestrate on-demand resources to work for you.

The result will be a cost-effective grid that you can protect, flexibly scale, operate sustainably, and quickly adapt to serve your community members' changing needs -- tomorrow and into the future.

Ready to learn more? Check out the other papers in our series on "The Rise of Local Grid Management".



CAMUS

Zero Carbon Grid Orchestration

Camus Energy is building an open source software platform to enable the future Distribution Service Operator (DSO). Providing grid operators and load serving entities with advanced situational awareness, insight, and control, Camus' platform empowers industry leaders to safely and strategically manage a rapidly changing grid environment.

Camus' founders and partners are leveraging experiences from other industries – including the founders' pioneering work building Google's global traffic management platform – to address new opportunities on distribution grids.

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