TGO Alliance

Orchestrating the Grid to Deliver the Energy Transition

Advancing Total Grid Orchestration for a Resilient Energy Future

TGOAlliance.org

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As the energy landscape continues to evolve, there is increasing need for significant investment over the next few years to enable significant load growth, upgrade aging infrastructure, and support emergent technologies. It's becoming progressively clear that a new approach is required to manage the complex grid of the future. Total Grid Orchestration (TGO) represents a major step forward in this evolution, providing a comprehensive framework for optimizing energy generation, storage, and distribution in real-time.

In this report, we outline the challenges facing the energy and utilities industry and opportunities to advance Total Grid Orchestration capabilities which the TGO Alliance convenes to address.

Energy Transition at a Crossroads

The global energy transition is at a pivotal juncture, characterized by escalating costs, increasing complexity, and significant technological hurdles. This transition is further exacerbated by surging energy demand driven by AI advancements, widespread electrification, modern industrial manufacturing, and the increasing adoption of distributed energy resources (DERs). These DERs include utility-owned battery energy storage systems (BESS) and customer-owned assets such as electric vehicles (EV) and rooftop solar. Additionally, the growing frequency of extreme weather events confronts the most vulnerable parts of the system calling for enhanced resiliency and storm-hardening. Utilities are now under immense pressure to maintain reliability and affordability amidst these evolving challenges while fostering customer enablement.

Historically, utilities have independently operated the electric grid across generation, transmission, and distribution, leading to compartmentalized investment planning and siloed operational structures. This has resulted in segregated investment strategies and uncoordinated operating philosophies aimed at resolving localized constraints at each level, rather than through integrated planning and collaborative operations. However, as the grid evolves with growing load and DER adoption rates, traditional methods of grid management have become less efficient based on the complexity of resources available. These inefficiencies are exposed as regulatory and rate payer expectations intensify. Addressing these challenges won't be easy, which is why Utilities must adopt a holistic perspective on investments and operations that prioritizes:

1. Expansion of behind-the-meter (BTM) clean energy resources and storage.
2. Direct investment in grid modernization and expansion projects to enable a more flexible and dynamic system of systems.
3. Deployment of solutions to orchestrate and optimize supply with demand across entire grid value chain.

The energy transition transcends state-level and federal policy uncertainty as the patterns of investment, economic development, and outage restoration costs all point toward a Bulk Power System (BPS) tipping point.[1] These trends are exacerbated by increased frequency of extreme weather events and our reliance on safe, fair, and affordable energy.

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[1] Virtual power plants 2025 update (January 2025), Pathways to Commercial Liftoff: Virtual Power Plants 2025 Update, U.S. Department of Energy.







Evolution of Grid Modernization

The evolution of grid modernization is crucial to addressing the risks posed by the proliferation of distributed generation and dynamic grid management practices. As the energy landscape shifts towards more decentralized and energy-limited sources, the traditional electric system must adapt to accommodate these changes. In addition to increasing generation uncertainty, utilities must also contend with aging infrastructure, congestion, extreme weather events, and the cybersecurity threats of a complex and increasingly digital system. Grid Modernization programs often aim to improve resiliency, reliability, security, and affordability through a more flexible and intelligent grid; One that can support the shifting demand and supply in real time. In 2023, all 50 states plus DC and Puerto Rico took policy and deployment actions related to grid modernization, utility business model and rate reform, energy storage, microgrids, and demand response.[2] Grid Modernization's strong value proposition with investments tied to prioritized use cases remains crucial to building robust capital plans and to obtaining regulatory approval.

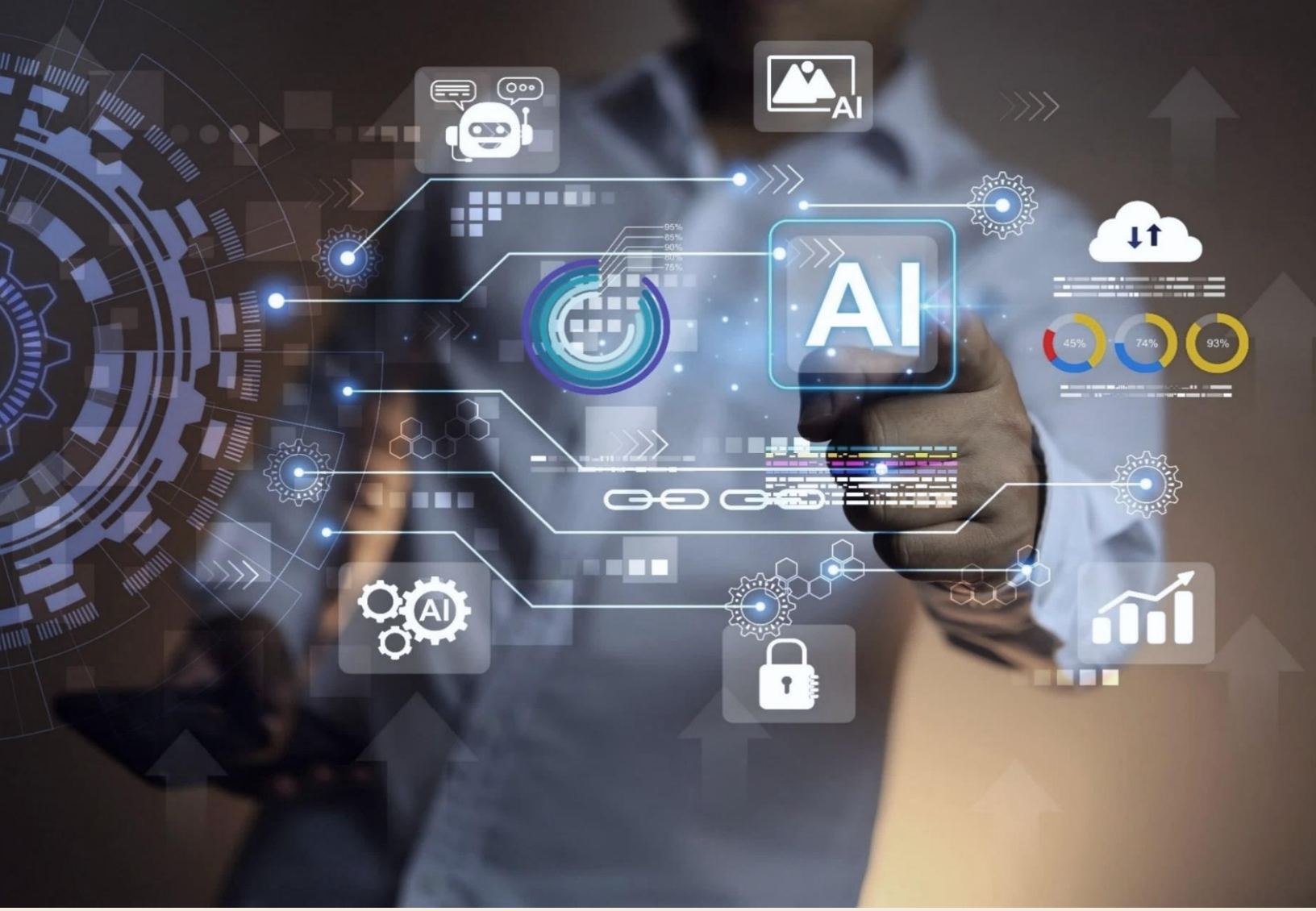
Behind-the-Meter (BTM) Resources play a pivotal role in a utilities ability to manage and optimize the grid as electric vehicles, solar generation, and battery storage take hold. These Distributed Energy Resources (DERs) are fundamentally changing the nature of the energy grid – it's now bi-directional, it's energy limited, and it's hard to predict (or even see). BTM DERs are driving new operational challenges such as voltage control, back feed, protection and control coordination, overloading distribution transformers and conductors, and masked loads. Implementing grid edge solutions that unlock large-scale flexible demand management and DER Management will allow for better integration of these resources into the grid, enabling utilities to manage demand fluctuations more effectively.

To fully harness the value of BTM technologies, **Grid Infrastructure investments** must evolve as well. A modern distribution grid should be capable of easily connecting, dispatching, and controlling diverse energy resources. This requires the deployment of advanced grid automation, segmentation, islanding, and management techniques. These advancements enhance the grid's ability to respond to outages and maintain stability during peak demand periods. For many utilities, this often begins with advancing core capabilities – Advanced Metering Infrastructure (AMI), Distribution Automation (DA/FLISR), Volt-Var Optimization (VVO/IVVM), Advanced Distribution Management Systems (ADMS), Geospatial Information Systems (GIS), and Asset Management Platforms. Building a strong, integrated foundation is critical to long-term success of Grid Modernization objectives.

The role of customers in orchestrating the grid should not be underestimated. While BTM assets can present challenges, they offer an opportunity to be leveraged as grid assets. Customers will play a significant role in the valuation, engagement, and utilization of these assets. A focused effort to understand and harness the value of these assets can transform them into reliable resources that can be rapidly developed.

Digital Grid Enablement harnesses modernized communications and control systems, converting infrastructure investments into critical energy information. Getting the right data (accuracy) into the right system (integrations) for the right person (access and visualization) at the right time (coincident) is no easy task but holds the key to unlocking the benefits of grid investments. Leveraging data effectively requires long-term, strategic planning across business siloes. Maturation of data governance will allow utilities to deploy solutions that visualize, orchestrate, and optimize grid resources are crucial for effective grid management. These technologies enable utilities to enhance energy distribution, reduce operational costs, and improve overall grid performance. The integration of AI and machine learning technologies can further enhance decision-making processes, allowing for real-time adjustments and predictive maintenance.

[2] Autumn Proudlove et al., *50 States of Grid Modernization: Q4 2018 quarterly report & 2018 annual review*, North Carolina Clean Energy Technology Center, February 2019, nccleantech.ncsu.edu.



The Impact of Artificial Intelligence

The energy sector is being transformed by the growing use of artificial intelligence (AI) creating both challenges and opportunities as the industry continues to balance between reliability, affordability, and sustainability goals.

Unprecedented energy consumption associated with AI facilities due to their higher power density, increased cooling demand, continuous utilization, and rapid pace of growth is a major challenge for utilities. As AI scales, utilities will be challenged to meet the surging electricity demand while minimizing environmental impacts and maintaining safe and reliable service.

The growth of AI presents new opportunities for innovative solutions that can help balance the electric grid and integrate more renewable energy sources, such as **flexible demand management**. Hyperscale datacenters that are used for AI research and development provide an ideal platform for TGO to develop and test new strategies for managing energy demand. By enrolling and leveraging any flexibility in datacenter operations, companies can optimize energy use, reduce peak demand, and minimize overall energy consumption, thereby promoting a more sustainable energy future.

AI can also enable new **operational capabilities** like analyzing large data sets, adding insights from historical operations, and providing system operators with proposed operations and mitigating actions. With the help of AI, utilities utilizing TGO solutions could collect and analyze vast amounts of data from various sources, including weather forecasts, energy prices, and grid operations. By processing data with machine learning algorithms, AI can identify patterns, predict future trends thereby, providing system operators with actionable insights to optimize energy operations.

Realizing the Benefits of Grid Investments

Market and regulatory models must evolve to support the efficient allocation of resources and effective grid management. Developing distribution markets and Distribution System Operator (DSO) models can facilitate this transition. These models enable a more competitive and transparent energy market, encouraging innovation and investment in new technologies and resources. By providing a framework that supports distributed generation and demand response, new market models can help utilities and consumers alike benefit from a more efficient and resilient grid.

Lastly, breaking down siloes (planning across business areas and ensuring sufficient resources are allocated) will allow utilities to identify and prioritize grid investments that serve long-term business needs and strategic objectives. By focusing on these key areas, the grid can evolve to meet the demands of a rapidly changing energy landscape, ultimately delivering a more reliable, sustainable, and efficient power system for all stakeholders involved.

Total Grid Orchestration (TGO)

Recognizing the energy industries existential challenges, passionate thought leaders have been developing the concept of a Total Grid Orchestration (TGO). In concept, TGO represents a holistic approach to system-wide coordination, situational awareness, and risk management. In practice, TGO anticipates energy system constraints and collaborates with real-time resource responses to dynamically adapt to constantly changing influences on the Grid. TGO's approach will be utilized by grid planning, engineering, and operation stakeholders to inform near-term operational decisions and address:

System-wide Coordination

Ensuring all parts of the grid work together seamlessly to balance supply and demand in real-time.

Risk Management

Identifying and mitigating potential issues before they impact grid stability and reliability.

Situational Awareness

Utilizing advanced monitoring and data analytics to understand the current state of the grid and predict future conditions.

Integrated Planning and Operations

Bridging the gap between long-term planning and operations to ensure investments and operational decisions are aligned and optimized.

The mission of TGO is to optimize the electric grid's supplies and demands to deliver better outcomes through a balanced and scalable approach; and via dynamic grid lifecycle management, to bridge the gap between planning and operations to support the energy transition and ensure a reliable and sustainable grid. The eventual codified frameworks are intended to integrate within existing utility solution architectures, allowing the concepts of TGO to empower existing and emerging utility toolsets and bring together information from multiple point solutions, including:

- AMI Connected Grid Edge
- Advanced Distribution Management Systems (ADMS)
- Distributed Energy Resource Management Systems (DERMS)
- Virtual Power Plants (VPP) / Aggregations
- EV Charge Management
- Demand Response Management Systems (DRMS)

This expanded grid monitoring and enhanced visibility produces a real-time system portrayal like a digital twin to enable system situational awareness. Comprehensive system visibility and condition awareness is the foundation for Risk-Informed Integrated Systems and Operations Planning (R-ISOP). R-ISOP implements a risk framework for adaptive decision-making across systems and operations. This decision-making capability affects near real-time operational system improvements.

TGO is a paradigm shift in grid management and resource optimization offering a unified strategy that integrates all facets of the grid, ensuring a seamless and efficient transition to a sustainable energy future. By embracing TGO, utility leaders will be able to navigate the complexities of the energy transition, delivering reliable and affordable energy while meeting regulatory and customer expectations.

The TGO Alliance aims to accelerate research and development of grid orchestration approaches, tools, and technologies that can be immediately applied to benefit utilities, the developer communities, and the ratepayers. With the broad definition and impact of TGO, the potential benefits are equally far-reaching.

Affordability

With the rate of the energy transition rapidly accelerating due to the litany of regulatory, economic development, and environmental drivers, major infusions of Capital and O&M investments are needed to modernize the electric grid in a safe, reliable, and equitable manner. Maintaining affordability will be the greatest challenge to the speed at which this energy revolution occurs. This value-proposition of TGO is coordinating all the personas to a common mission of a safe, fair, and affordable energy system for all.

TGO induces Non-Wire Alternative (NWA) principles to defer planned capital investments, unplanned customer load requests/upgrades, and daily operational expenses from energy supply costs as well as field services during storm-related and blue-sky events. Historically, ad-hoc NWA opportunities are predominantly applied to defer capacity-expansion capital projects. Today, load customers have opportunity to implement their own peak-shaving strategies to reduce their share of the service connection costs, while utilities should also enable rapid alternatives to reduce their rate-based portion of the infrastructure improvements necessary to connect the customer. TGO accelerates this to near real-time so that operating envelopes can have their system constraints (thermal, voltage, and frequency) avoided by individual and/or aggregated customer DERs, with localized market-pricing orchestrated throughout the day. Rate-payer affordability from TGO highlights the following:

Non-Wire Alternatives to Rapidly Increasing Capital Investment

- Rate-based Capacity, Reliability, and Resiliency Investments
- Developer-borne Interconnection Costs
- Unmanaged Regulatory Assets

Operational & Maintenance Expense Reduction

- Storm Related Events
- Peak Loading Events
- Abnormal System Support
- Power Quality Optimization

Reduction of Infrastructure Material Congestion Pricing

- Procurement Optimization with Planning and Operations
- Inventory Management Influenced by Value of DER



TGO digitizes the market-driven opportunity to support utilities avoiding the infrastructure-laden responsibility to overbuild for every future planning scenario. Many states, including federal policy, have laid the foundation for TGO with the Grid Modernization evolution to be a step ahead of the decarbonization of transportation and heat. TGO leverages and incentivizes these resources by influencing the value of static and transient DERs as well as Demand Response customers to target the highly constrained elements in the supply feed, or to help bridge the gap of upgrading system components during long-lead times. The ability for developer-owned resources and aggregations to toggle between market-pricing and retail-pricing further improves the tailwind economics for renewable generation and storage. With TGO, localized and mobile resources can provide the necessary supply to relieve the constraints on limiting elements placed on the DSO at any moment in time. These interconnected energy markets will inherently cause these supply charges to optimally reduce, while also forcing regulators and utilities to rethink what role demand charges will play in an orchestrated grid system:

Increased market competition from enhanced energy supply

- Centralized and decentralized system stability
- Competitive pricing and supply security

Incentivization of stationary and transient BTM resources

- Influencing the value of DER by operating envelope needs
- Prosumer enablement for market-based choice

As the extreme weather in the U.S. trends upwards with a record $95B in climate disasters in 2023 alone, emphasis is directed towards reducing restoration costs during Storm-related events and other unplanned outages. TGO's use case of supporting reliability and resiliency efforts during abnormal system configurations is paramount to controlling base utility rates. Additionally, during construction durations, reducing load at risk can be dynamically managed within an operating envelope in an effort to reduce both operational expenses and/or temporary capital investments. This impact of affordability is achieved by not only leveraging the grid modernization investments, but by orchestrating these tools together with the developer communities and regulators committed to updating the valuation frameworks of BTM resources.

Safety and Security Risk Reduction

While TGO is bolstering energy security during peak loading events, the platform predictively and dynamically triggers competition during low supply scenarios. TGO also provides incremental tactics to combat climate change vulnerabilities like Conductor Clearance risk and Wildfire Mitigation strategies.

Deferrals to utility capital investments and operational expenses to mitigate these high-risk safety events are just as hypercritical; However, this deserves a standalone value-proposition due to the incomprehensible costs for loss of life and community destruction. Additionally, by increasing and incentivizing the diversity of supply sources on our grid, we make the system even more robust from malicious attacks. By orchestrating the incentivization of rerouted energy flow, additional benefits to reliability include safety and security measures like:

- Conductor clearance capital deferral and operational avoidance
- Wildfire risk mitigation capital deferral and operational exposure reduction
- Extreme cold and blizzard resiliency islanding
- Homeland security

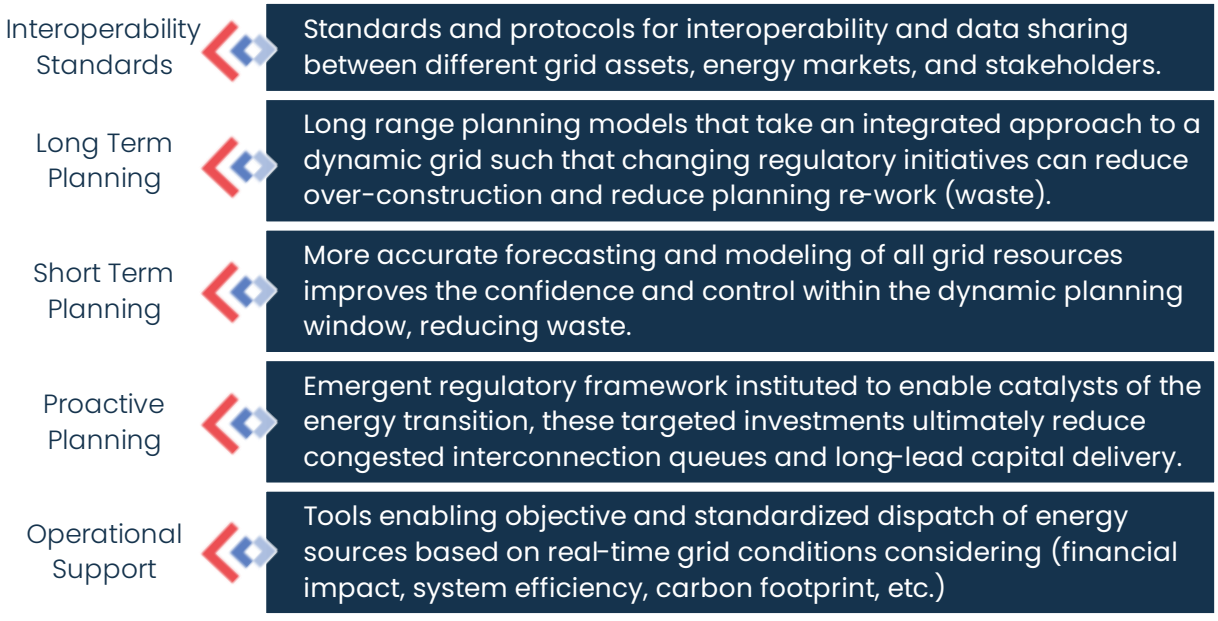
Reduced Timelines

As the electric grid continues become more dynamic and volatile, the ability of utilities and customers to respond have increased in urgency. TGO can support that urgency through the following focus areas:

- Average Customer Interconnection Timelines Reduction (Phased implementations based on system constraints)
- Reduced lead-time in materials from decreased simultaneous infrastructure demands
- Outage duration reductions from enhanced DA/FLISR schemes integrated with TGO operating envelopes
- Continuous Integrated Resource Planning
- Coordinated planning, project management, and operations to optimize capital delivery project lifecycles from integrated resource planning (System support for legacy generator retirement and alternatives to outage windows)

New Capabilities

The current tools and systems used to plan, design, and operate the grid may not fully support the different approach required for the grid of the future. To address these challenges, new tools and systems can have cascading benefit through the application of advanced analytics and machine learning algorithms, cybersecurity measures, DERMS and DRMS integration, and improved standards and protocols for interoperability.



Reliability and Resiliency

TGO can help mitigate the impact of extreme weather events and grid disruptions by optimizing resource allocation and enabling rapid response to changing conditions. Scenario modeling and probabilistic risk analysis can help predict, prevent, and respond to frequency, capacity, and voltage events which would affect reliability. Identifying and prioritizing risks and creating models to predict and prevent undesired outcomes can improve reliability by preventing outages or reducing the impact or duration. The identification and definition of these risks can then be translated to the planning phase and mitigated through resiliency projects that reduce the risk factors and likelihood of those events occurring.

- Improved event prediction and response through Probabilistic Risk Analysis reduces outage duration and impact (CAIDI/SAIDI).
- Real-time situational awareness and control of the grid, using advanced sensors and potentially machine-learning to monitor and manage grid assets.
- Prevention of both planned and unplanned outages resulting from capacity, voltage, and frequency constraints by optimizing the use of distributed energy resources in conjunction with the complete, integrated generation portfolio.

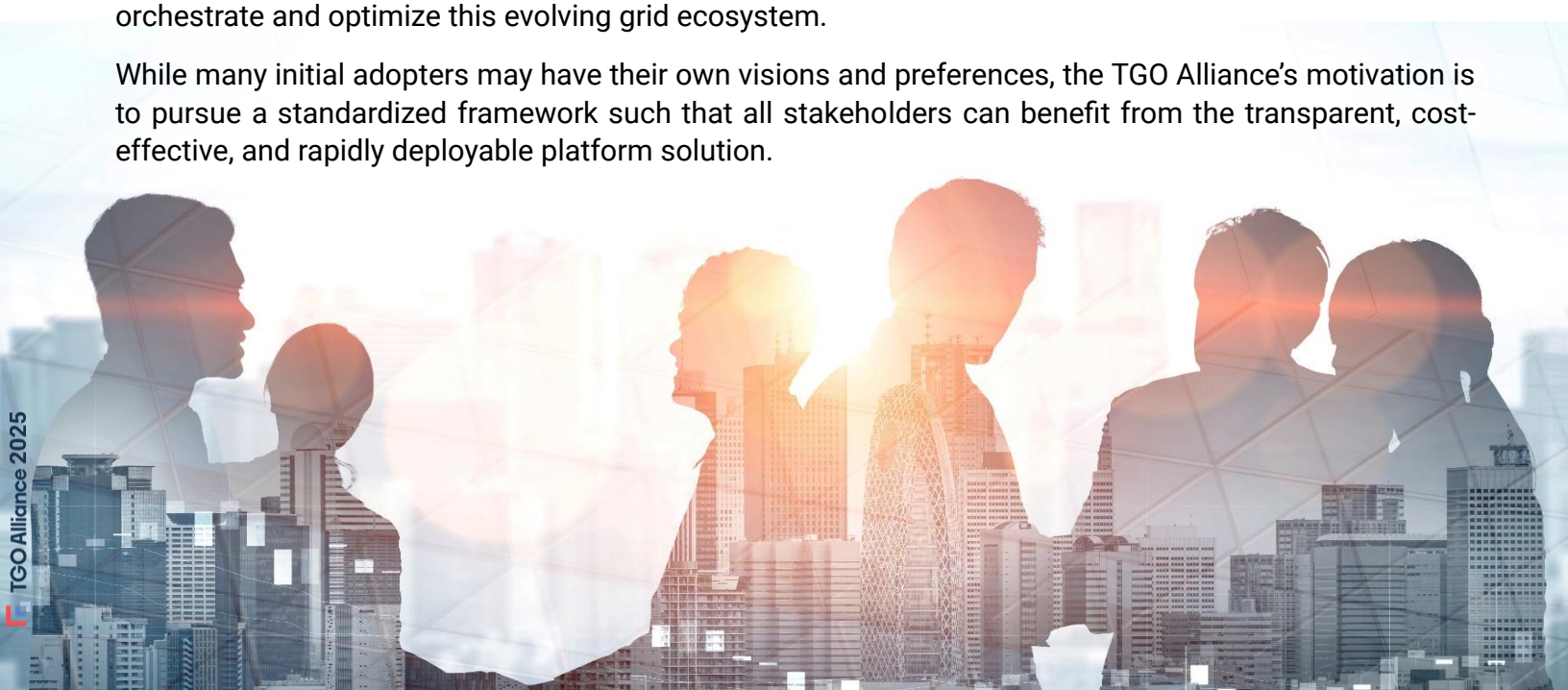
Organizational Alignment

Total Grid Orchestration (TGO) can facilitate organizational alignment within a vertically integrated utility by providing a common framework for planning, operations, and decision-making across different business units and functions. This includes alignment of short term and long-term operational goals driving coordinated resource planning and enabling collaboration and integration between different business units and stakeholders, by providing a common language and understanding of the grid and its components.

Conclusion

The energy transition requires urgent action to accelerate the pace of change and meet global climate goals. Advancing and implementing TGO solutions is crucial for addressing the challenges of increased energy demand, grid reliability, and affordability. Stakeholders across the energy sector must collaborate to invest in grid modernization, adoption of BTM resources, and development of innovative solutions to orchestrate and optimize this evolving grid ecosystem.

While many initial adopters may have their own visions and preferences, the TGO Alliance's motivation is to pursue a standardized framework such that all stakeholders can benefit from the transparent, cost-effective, and rapidly deployable platform solution.



TGO Alliance

The Total Grid Orchestration (TGO) Alliance, a consortium of utilities and solution providers across North America, has committed to codifying the vision of the TGO concept. This utility-driven alliance shares a commitment to promoting dynamic, integrated, and transparent grid orchestration, enabling the grid platform to continue delivering reliable and affordable services.

The TGO Alliance fosters a collaborative forum to establish an industry-wide framework for grid orchestration across planning, engineering, and operation through a unified risk assessment and mitigation approach.

We strive to enhance situational awareness and integrated planning and operational capabilities across Generation, Transmission, Distribution, and BTM assets, maximizing distributed and variable energy supply and demand optimization. The TGO Alliance is working to create frameworks which can be utilized by solutions vendors, utilities, and the prosumer community to optimize the electric grid and deliver better outcomes through an agnostic and scalable approach.

To learn more or get involved, please visit TGOAlliance.org, or email Alliance Manager, Kayleigh HasBrouck at HasBrouckK@bv.com.