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How Distribution Utilities Succeed in Digital Transformation

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Executive summary

The formidable changes brought about by the growth of DER and connected, digital technology affects distribution utilities more than most other players in the industry. A cohesive strategy for employing digitization's constituent movements, such as the Internet of Things, IT/OT convergence, big data and analytics, and connected and smart technologies—and the policy and market frameworks undergoing adjustment to enable the many benefits made possible by digitization—is required for success.

Introduction

Powerful, global market drivers are causing changes within the utility industry on a large scale.

Distributed energy resources (DER) mark the starting point for these changes. Electrical distribution systems were built for centralized generation and passive loads and not designed to handle evolving levels of energy consumption, complexity, and decentralized generation. Traditional system architecture did not take into account the accommodation of distributed, customer-controlled energy assets like rooftop solar, microgrids, flexible demand-side resources, distributed storage and electric vehicles.

On a broad level, though not universally, this is causing different forms of disruption. Power generation is becoming increasingly decentralized, introducing new players to the market, and requiring greater interaction among all of them, such that each is an active contributor at their level of the decentralized approach. The forms these changes take vary according to geography, history, economy, and other factors.

Of all the existing players involved, these changes affect distribution utilities the most. Distribution utilities must prepare to simultaneously cope with additional network complexity and fundamental business changes. We fully expect these changes to reshape their operational processes, technology systems, and economic and revenue models.

In this paper, we recognize digital transformation as one key success factor for distribution utilities facing these challenges. Others success factors exist, of course, as innovation is not strictly limited to technology but is also required of business models, policies, and regulatory frameworks, though those areas are not the primary focus of this document. Here we examine how the adoption of IoT capabilities, data analytics, and cyber security have converged and ensure that distribution utilities will be a driving force in today's evolving energy world.

Distribution utility industry and market trends

Let's recognize the fact that we cannot simplify the nature of the distribution utility into a neat picture containing attributes applicable across the industry. For the purposes of a distribution utility, there is a high diversity of factors that vary according to geographical location and region. Those can involve policy and regulatory differences, variation in size, different energy resources, varying levels of access to energy, existing network designs and ability to evolve.

As the power sector is fundamentally reshaped by new technology and consumer and regulatory insistence on cleaner, more efficient energy, there's a series of complex discussions and planning taking place around and inside of distribution utilities.

A vision across geographies

While acknowledging the variation of distribution industry trends according to countries or regions, discussed in detail later in this paper, we see common causes of change to the business landscape for these utilities. Depending on a utility's location, circumstances, and level of advancement, these changes include some or all components of the following illustration.

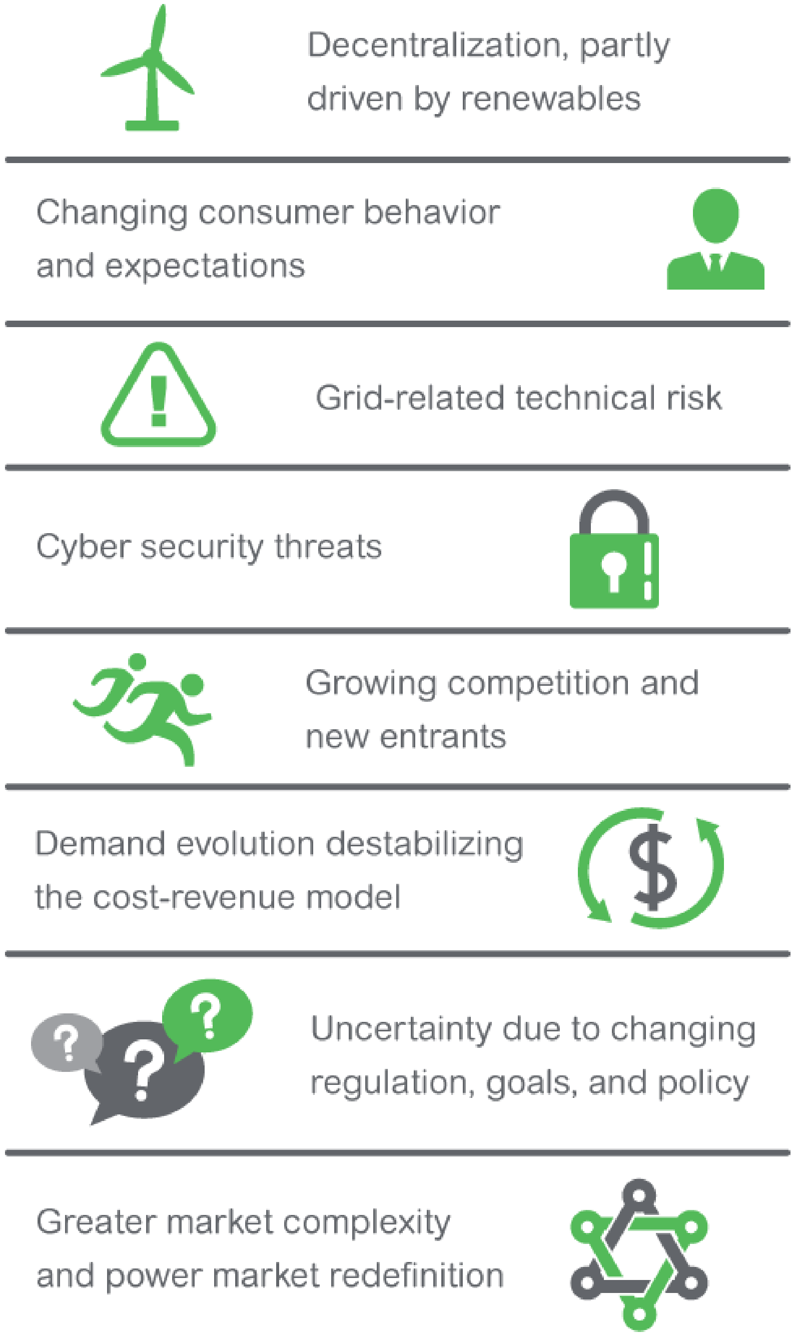

Figure 1

Drivers behind the changing distribution utility business landscape

Views of specific regions

Today, should we compare the maturity of electrical distribution models and the barriers to transitioning to ones that better accommodate DER and smarter grid development (in terms of relatively better automation, efficiency and hosting capacity for renewables and new loads), we see a mixture of advantages, disadvantages, and a variation of current strengths, weaknesses, and relative maturity between distribution utilities in Europe and the U.S.

U.S.

In the U.S., there are many utility-of-the-future regulatory and grid modernization initiatives. The most prominent of these are taking place in the states of New York and California.

New York

The New York Public Service Commission issued the Reforming the Energy Vision (REV), with the goal to rebuild, strengthen, and modernize New York's energy system. The REV strategy is being put into action by the New York State Energy Plan, whose goals include a 40% reduction (from 1990) in the energy sector's greenhouse gas emissions, an increase to 50% of generation from renewables, and a 23% decrease (from 2012) in buildings' energy consumption—all by 2030.

Part of the REV is to transform New York utilities into Distribution System Platform (DSP) providers. According to the New York state energy plan, the purpose of DSP providers is to "modernize electric distribution systems to create a flexible platform for new energy products and services, to improve overall system efficiency and to better serve customer needs. The DSP providers will incorporate distributed energy resources into planning and operations to achieve the optimal means for meeting customer reliability needs."[1]

In other words, DSP providers will be the ones responsible for facilitating the integration of various DER on the network. The core of this aspect of the REV is to make the integration of third-party DER a primary concern of utilities, thus reforming their business model and practices. That is, they aim to ensure that utilities are incentivized to look at DER as a viable alternative to traditional grid investments.

The New York Public Service Commission (PSC) has given the green light to substantial reforms for how utilities derive their revenue. New York utilities, in addition to being allowed to derive revenue through traditional cost-of-service investments, can now also leverage the following:

- Capital investment deferment
- Market-based platform activities, e.g., grid-related services a distribution utility could offer to DER developers
- Market-based performance measures, e.g., "Earning Adjustment Mechanisms"

California

In California, something similar is happening. The California Public Utilities Commission (CPUC), is undergoing a broad examination of its utilities' business and regulatory models, and taking steps to outline the future of its utilities. It considers the traditional cost-of-service utility model outdated because its basic principles—the concepts of asset acquisition and sales growth—contradict California's famously forward-looking energy conservation policies. More competitive markets and a potential unbundling of utility services could lie ahead thanks to new technology and financial innovation, which blurs the previously well-delineated boundaries of the utilities' natural monopoly role.

As distribution in California changes from a centralized network to one that's increasingly open and flexible, distribution utilities may join generation and transmission entities in becoming open to competitive markets.

[1] *The Energy to Lead*, New York State Energy Plan, New York State Energy Planning Board

The CPUC directed its utilities to draft Distribution Resource Plans (DRPs)—the roadmaps for how the state's major utilities will merge DER into their grid operations, investment, and planning regimes. They did so. PG&E, like the other utilities affected by the CPUC's directive, analyzed the hosting capacity of thousands of feeders in order to identify optimal locations for the deployment of DERs within their service area, helping enable higher DER penetration. That utility also identified the need for additional investments and drafted a plan to enhance its distribution capacity planning tools and methods.

Europe

The electrical distribution business across Europe is quite diverse. The number and size of Distribution System Operators (DSOs), as well as ownership and licensing structures, varies widely among EU member states. Their future role[2] will turn them into both system operators and neutral market facilitators of Europe's increasingly decentralized electrical energy system. Regarding the latter, DSOs are required to provide non-discriminatory access to their networks for other entities, such as generation companies and service providers.

There are many initiatives relevant to these challenges at both the European Union level, which issues regulations and directives that member states are strongly pressured to adopt, and within the countries belonging to the EU. These initiatives are also tailored to regional, national, and local variables.

At the EU level, numerous entities—the European Commission, various forums like the European Technology Platform for Electricity Networks of the Future (the key forum on smart grids, established by the European Commission), utility associations like Eurelectric, GEODE, CEDEC, and EDSO, as well as regulators such as the Council of European Energy Regulators and the Agency for the Cooperation of Energy Regulators—are currently working toward a new model for DSOs. They are examining, modeling, and planning for revised regulatory frameworks, incentives for innovation and performance, new tariff structures, and the DSOs' extended roles in Active Distribution System Management and as neutral market enablers and, increasingly, as managers of big data. All the nuance and complexity of preparations for fundamental transformations caused by distributed generation, prosumers, storage, and interactive demand also extend to emerging regulatory practices for new businesses related to distribution grids.

One of the latest developments in this area is the European Commission's Clean Energy for All Europeans proposals. This package is set to undergo the legislative procedure in the European Parliament and council of member states in the coming 18 months.

The package has four main axes. One axis affects renewable generation, and the remaining three affect DSOs. Of those, the first is around new energy efficiency targets for 2030 and involves defining energy supplier obligation schemes and metering functionalities, as well as standards for the active energy efficiency for buildings. The second concerns energy flexibility in order to support decentralization, give more freedom to end-users to access demand response, self-generation dynamic pricing, allow them to provide flexibility, and empower DSOs to use flexibility. The third axis is about governance so that the organization of energy markets can be strengthened at the European level.

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[2] *Power Distribution in Europe: Facts and Figures*, Eurelectric

Whatever eventual legislation that is guided by this package could one day have sweeping impacts that enable the energy transition in Europe. Key issues for European distribution utilities—data management, wholesale and retail pricing, and consumer rights—are each addressed in the proposed legislation.

India and Africa

While Europe and the U.S. are spearheading the energy transition, other global giants like India and Africa are also preparing for the same magnitude of energy distribution changes. This country and continent, however, are approaching the energy transition from two different sets of circumstances.

India currently has a power surplus. Electricity consumption is meeting, at best, only 60 % of the installed capacity of 360 GW, including during peak demand. Despite the power surplus, India's distribution sector is challenged with chronic issues including unhealthy distribution companies, power outages, and commercial losses (theft and unmetered connections). These factors are limiting social and industrial growth and, as a whole, the country is unable to set the pace for economic growth. According to the World Bank, "…many factors that constrain performance are under the control of the utilities themselves—underpricing, physical losses, and inefficiencies in bill collection—underlining the importance of limiting the government's role, strengthening regulatory governance, and bolstering competition so that utilities are both pushed to be efficient and permitted to run on commercial lines."

In view of this, the reduction of techno-commercial losses (<15%), the improvement of SAIDI, the enhancement of economic and financial viability, and the improvement of operational efficiency of more than fifty state-owned distribution utilities are the key growth drivers of India's Ministry of Power. Additionally, the government has set a target of 100+ GW of renewables by 2022.

The African continent, on the other hand, generally has little to no strong electric grid infrastructure. Africa ultimately needs a continental transmission grid that supports renewable integration, but the first step toward that will also be about local energy systems like microgrids. Much in the same fashion as cellular telephony developed on the African continent, modern distribution networks can avoid many of the complex problems associated with overhauling any existing models, which offers unique opportunities and benefits for modern electrical distribution systems to take shape.

Research perspectives

These examples illustrate at least one common theme: the existing and future growth of DER. But DER is not only plainly altering revenue models and regulatory oversight of distribution utilities, but other factors as well. The U.S. Electric Power Research Institute notes the technical and operational aspects of the energy transition. They argue that "the need has arisen to integrate DER in the planning and operation of the electricity grid and to expand its scope to include DER operation." And if such distribution systems are to provide safety, reliability, affordability and environmental responsibility—then collaboration is required in four areas.

- Interconnection rules, communications technologies and standards
- The assessment and deployment of advanced distribution and reliability technologies.
- Strategies for integrating distributed energy resources with grid planning and operation.
- Enabling market evolution through policy and regulation.

A leading academic perspective basically agrees. MIT's Energy Initiative recently released a study[3] evaluating the emerging issues around technology, policy and business models in the electric distribution sector focused mainly on the U.S. and Europe. They highlight the need to improve electricity tariffs and rates, improve distribution utility regulation that enables the development of more efficient business models, implementing strong cyber security, better utilizing existing infrastructure to keep costs down, and improving market design in order to better integrate DER and reward flexibility.

A key solution to distribution utilities' transformation challenges

The big-picture challenge is figuring out how utilities can accomplish two main objectives.

- Integrate DER, both behind and above-the-meter controlled energy assets such as rooftop solar, behind-the-meter batteries, flexible demand-side resources, etc. A U.S. definition of DER, which varies from the common European definition of DER, also includes EVs and microgrids.
- Address changing energy demand, reducing losses, ensuring security and reliability, and changing their business models to stay in business.

The decentralized model and IT/OT approach demands that distribution utilities face certain challenges around efficiency and flexibility. Achieving these goals is only possible via a deep digital transformation. Aside from the regulatory and policy changes needed to enable modern distribution utilities to be successful under this new industry landscape, digitization is the one common thread that these organizations can seize to make the most of their future.

What digitization means

Digitization offers a series of solutions in terms of technologies and business models to address the numerous challenges exposed in previous sections of this paper. Digitization could even completely disrupt the sector, perhaps to the same magnitude as other industries have been challenged by shared-economy companies. It also unleashes new possibilities.

As a consequence of increasing digitization, the digital utility is without a doubt a data-centric organization. It has multiple facets.

- Smart grid advancements: These enable the embedding of smart, automated controls that improve network resiliency, safety, and efficiency. Grid visibility is improved, especially at the grid edge, e.g., voltage adjustment along an LV feeder containing DER.
- Data-driven asset strategies: These allow smarter investment planning and more efficient maintenance operations. We see incentives from regulators designed to make distribution utilities more comfortable investing in new technologies and new approaches instead of traditional network reinforcement.
- Smart metering: Beyond its original customer billing use case, smart meter analytics can deliver impressive outage management improvements, VoltVar optimization, theft detection, and asset management. And they're necessary for the grid operators to understand and manage behind-the-meter DER.
- DER management: Including microgrids and virtual power plants, this is made possible by big data and analytics-driven alignment of supply and demand.

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[3] Full report, *Utility of the Future*, MIT Energy Initiative

Digitization for utilities includes the following concepts.

IT/OT convergence

Operational technology (OT) encompasses operating equipment like circuit breakers and control room applications like SCADA systems that monitor a network. Information technology (IT) systems, like enterprise asset management (EAM) or customer relationship management (CRM), on the other hand, allow machines to exchange information with humans. Utilities have experienced an increase in both quantity and quality of IT systems and OT systems, and the two are now pushing their way into each other's traditional boundaries.

IoT

Overlapping to some extent with IT/OT convergence, the Internet of Things (IoT) is about connected devices that communicate. Distribution utilities are now finding an increasing number of vendor offerings that include new, connected technologies. And they have a wider spread than ever. Apps and hardware offer mobility and remote control. Distribution network devices can provide pervasive sensing and the ability to receive and transmit their data. Cloud and traditional software advancements offer analytics in a cyber secure environment.

Data harmony

While distribution utilities' IT and OT systems converge and they adopt IoT technologies to bring about higher efficiency, reliability, and performance, even more value comes from the underlying data. In addition to seamless and open communication exchange, these organizations require open IT/OT interoperability as today's networks manage a far greater number of interactions than ever before.

These data must interact within and among systems that haven't previously communicated with one another, with a wider variety of data, more components, and more applications, all while coping with system lifecycles. Stronger, more efficient, and better automated distribution grids will rely on internationally recognized standards in terms of data models, data integration, and open data and communication for smart grids and grid edge technology. Conquering this major challenge will let distribution utilities boost their efficiency by operating open-vendor systems.

It will also support the increasing need for data exchange with other actors involved in the power ecosystem, including TSOs, distributed generation operators, aggregators, and prosumers. For this reason alone, standardized data models and interfaces belong at the core of a utility's business. And when data exchange takes place not only across internal DSO systems but also with and among external platforms such as market systems, there is a strong need to address data integrity and trust mechanisms.

Strategies to succeed in digital transformation

The following provides guidance for planning and implementing digitization initiatives, focusing on points that we consider mandatory to achieve success.

Set targets

One important prerequisite to successful digital transformations for distribution utilities is to clearly define the business drivers and goals of digitization. A clear definition of success at the outset of digital integration projects is mandatory for informed decision making throughout the process.

The next step is to clearly link those business drivers and goals to the utility's budget and progress. Clear targets are key for digitization efforts, and clear targets require concrete budgets. Measurement is crucial. Approaches where short-term progress can be easily measured with performance indicators have been particularly successful.

Map the route

To build a roadmap of digital transformation, utilities must define roles and responsibilities to determine and validate drivers and requirements, and define priorities through business cases. Then they must document the roadmap, and communicate it both internally and externally as applicable.

The roadmap should include identified phases of device and software implementation, identify and select the appropriate delivery models, regularly evaluate return on investment, and include the associated steps for proper preparation. It should codify the plan with respect to short-, mid-, and long-term timeframes according to business stakes. A comprehensive digitization roadmap is essential to identify how to best shape and integrate digital technology and processes into a utility's business environment.

Find agility in IT/OT

Digital transformation must, of course, take place in an environment of existing IT architecture and processes. This gives stability and support to the large transactional systems that enable the day-to-day operations of the distribution utility's business.

To manage change in IT/OT systems and practices, they should be approached in an agile way. Unlike a conventional engineering approach, teams engage in their work using an iterative test-and-learn principle. This grants the greatest possible freedom when it comes to taking action because experience shows that agile teams are better at fostering digital success. The trick is finding the balance whereby the existing IT environment can flexibly respond to changes without operational impacts on the OT environment.

In our experience, we see that integration requires industry specialists who must come from an OT background and work in conjunction with IT professionals—people who fully understand both sides of the IT and OT equation and how the equipment works. That includes cross-domain skill sets such as security, ADMS, SCADA, protection and control, sensors, and telecom. ADMS integrations undertaken by pure IT players are less efficient and less effective.

Harness data with robust standards

With the future of the distribution utility business revolving around data, its modeling, collection, management, integration, and governance could not be more important. It's the core component of digitized mechanisms for asset management and grid operations, as well as future grid orchestration.

Distribution utilities benefit not only from deploying IT, OT, and IoT technologies that adhere to interoperability standards, but also leveraging the comprehensive set of open standards for the power business, which has been developed by the IEC TC57 committee. These standards are essential for interoperability and sustainability, and leverage both IEC 61850 and CIM as the two main pillars, which were initially created for substations and the grid.

Their semantic data model is extensible (now covering generation, EV, etc.) and agnostic from the communication network. This is a key pillar for an efficient and sustainable integration and analytic development, and is complemented by the IEC 62443 series of standards to include organization, processes, and technologies, as well as the ISO 27000 series of standards for the IT side.

Take a case approach to analytics

With digital grids, information has started to proliferate. Utilities are now realizing that it is one thing to collect data and quite another to manage and analyze it in a way that can deliver the best possible value to the business. As a result, few utilities can currently claim to be getting the full benefit of their smart grid deployments. By expanded capabilities in scheduling, planning, simulating, managing assets and managing operations, advanced analytics represent a truly new approach for greater efficiency and better decision-making processes.

The good news is that technology is available to handle the ‘data deluge’ and can deal with ‘Big Data’ coming from AMI deployment and other data sources.

In reality, the real transformation is located elsewhere.

Such programs require a change management component to move from a silo-based approach to a more connected and interconnected way of working. Indeed, a successful analytics deployment is necessarily based on a cross-domains collaboration because the definition, design and operational use of analytics breaks organizational silos.

Moreover, being at the convergence of IT and OT, analytics projects should blend IT and OT skills along with deep domain expertise. Deep knowledge of enterprise application integration and BI technologies (datamart, OLAP, data mining, etc.) is the domain of IT. OT experts master the O&M processes and requirements attached to substation systems, feeder automation systems, sensors beyond the substation, and more. Domain experts (mainly O&M but also engineering) ensure proper design and the relevance of outcomes.

Finally, analytics programs should be considered in a stepwise approach with priority given to use cases supporting the highest business stakes according to each particular context: revenue protection, asset performance, grid stability, grid modeling, etc. It’s important to start by considering use cases rather than jumping into the technology for the sake of technology.

Focus on cyber security

While interoperability standards have flourished and continue to develop to bring about data that is accurate and analytically useful, cyber security continues to be a significant topic, as evidenced by the growth and evolution of the ISO 27000 and IEC 62443 series of standards. It’s been made even more critical by the convergence of IT/OT, and the proliferation of connected, intelligent network devices and hardware.

It’s most useful to view cyber security through the lens of risk mitigation. This lets utilities devise a targeted approach that considers their network in the most practical way, as well as its people, processes, and organization. Strong and comprehensive cyber security creates defense-in-depth by building security into its very design, and via retrofit or bolt-on approaches. Integrated cyber security strategies also define the organization’s policies regarding concepts such as patch management, data integrity, data privacy and compliance. End-to-end data integrity, from the sensor level to the application level, is more important than ever.

Bridge gaps in expertise

It's important that distribution utilities also remember to focus on people-related gaps in two areas. First, the convergence of IT and OT often creates a need for new processes and roles. For example, vertical integration means merging IT and OT architectures, and hence new cyber security processes across the board, from the field to control room. This requires specialized staff, or training of existing personnel.

Next, there is a need for new and different skills within new environments. Traditional electromechanical specialists and operations personnel may need to be redeployed. Distribution utilities should consider training people on new technologies and standards in areas such as alarm management, wireless systems, condition monitoring, and machine learning algorithms, as well as predictive analytics and other advanced topics.

Conclusion

The formidable changes brought about by the growth of DER and connected, digital technology affects distribution utilities more than most other players in the industry.

A cohesive strategy for employing digitization's constituent movements, such as the Internet of Things, IT/OT convergence, big data and analytics, and connected and smart technologies—and the policy and market frameworks undergoing adjustment to enable the many benefits made possible by digitization—is required for success.

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Contact us

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Glossary

ADMS: Advanced distribution management system

CEDEC: European Federation of Local Energy Companies

CPUC: California Public Utilities Commission

CRM: Customer relationship management

DER: Distributed energy resources include a variety of supply-side and demand-side resources such as distributed generators (renewable or back-up), controllable (or flexible) loads used for demand-response, energy storage (electrical or thermal) and electric vehicles (which play a dual role of both load and energy storage). A common definition of this term across geographies is elusive.

DSO: Distribution system operator

DSP: Distribution system platform

EDSO: European Distribution System Operators' Association for Smart Grids

GEODE: An organization whose mission is to "establish equal opportunity access to European energy infrastructures for all those involved in serving the customer needs on energy, with the aim to create a truly competitive European energy market."[4]

IT: Information technology

IoT: Internet of Things

OLAP: Online analytical processing

O&M: Operations and maintenance

OT: Operational technology

REV: Reforming the Energy Vision, a strategy to rebuild, strengthen, and modernize New York's energy system

SCADA: Supervisory control and data acquisition

TSO: Transmission system operator

[4] Geode website, principles page: http://www.geode-eu.org/home/about-us/principles