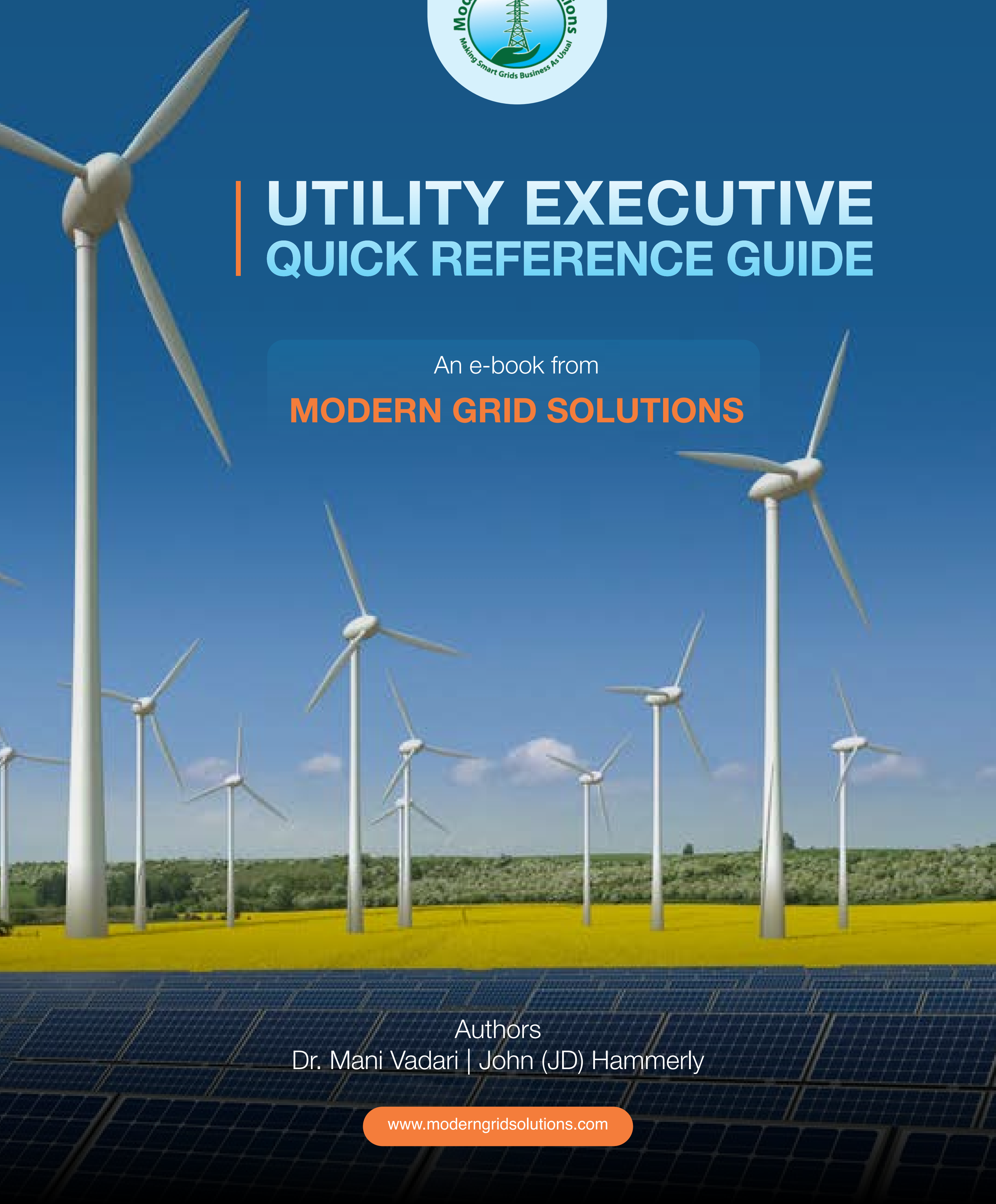
UTILITY EXECUTIVE
QUICK REFERENCE GUIDE

An e-book from

MODERN GRID SOLUTIONS



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INTRODUCTION

Modern Grid Solutions (MGS) is a cost-effective, global supplier of deep energy expertise and broad-experienced domestic resources. Our team members have been industry colleagues for over 25 years. Our approach focuses on delivering value-based and actionable guidance grounded by the depth of our team's expertise in New York, North America, and the world.

MGS's team consists of electric utility experts, each with a minimum of 25 years of experience delivering complex, innovative technologies, business, regulatory, and finance solutions to electric utilities, corporate clients, and policymakers. Our team has delivered strategies, tactics, and solutions to utilities, industry suppliers, and policymakers worldwide. Our experts bring breadth and depth in engineering, technology, economics, operations, and commercial areas directly applicable to utilities, suppliers, and regulators. Our client approach is through direct senior expert engagement. Our mantra is, **"someone on our team has already solved your problems at least three times."**

FOR UTILITIES AND POLICY MAKERS

Business Expertise

- Strategy, tactics, policy and process redesign
- Business architecture
- Transmission and distribution roadmaps
- Grid modernization plans
- Project and program management
- Strategic stakeholder and change management
- Renewable Portfolio Standards (RPS) support
- Economics and value modeling

Technical Expertise

- T&D system operations: EMS, DMS, OMS
- Generation operations
- DER and renewable dispatch
- Energy markets: design and deployment
- Energy and REC tracking system
- T&D automation and smart grid solutions
- GIS and asset management solutions
- Generation planning and renewables integration
- Big data management and analytics
- Solution and vendor selection

FOR SUPPLIERS AND CORPORATE CLIENTS

Business Expertise

- Business model design and analysis
- Electricity market entry, go-to-market and channel management
- Market sizes, volumes and trends
- Competitive landscape (SWOT) analysis
- Targeting for alliances, divestitures and acquisitions
- M&A, project finance, structured products, fund raising

Technical Expertise

- Solutions design and implementation
- Portfolio review and analysis
- Adjacency analysis and technology management
- Energy, REC and emissions trading

We are currently assisting and advising several electric utility clients to overcome the challenges our industry faces in the next decade. These challenges include:

Utility Transformation
Future utility business model and how to get there

Utility Information / Operational Technology convergence
Realizing efficiencies without disruption

Grid modernization / Smart Grid
From pilot projects to the grid of the future

Operational Systems
Their role in a transformed utility

Asset Strategy
Managing the renewal of the infrastructure while avoiding surprises

Data Analytics
The advent of Master Data Management

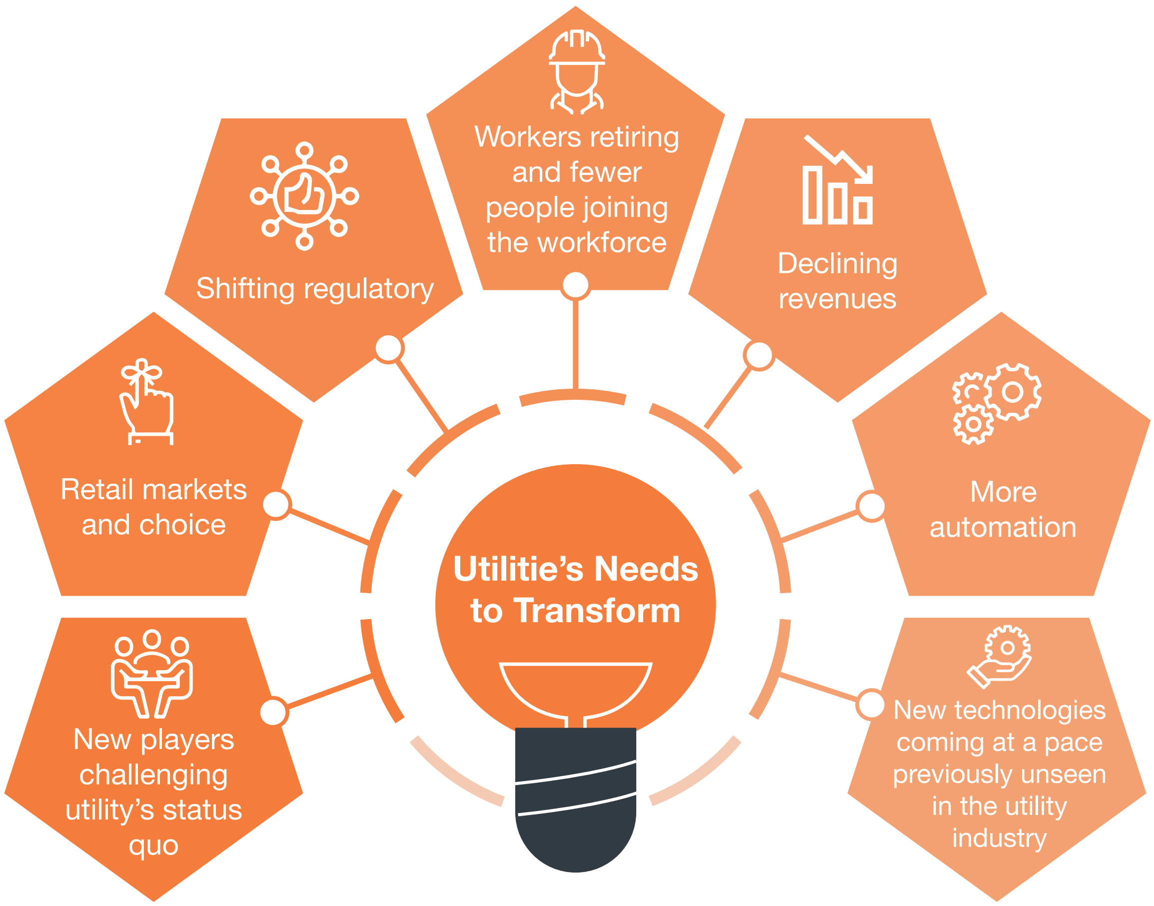
Internet of Things
Its impact on utility operations and relationships with utility customers

Data Governance
Ensures certainty and accuracy of incoming data creating increased value and trust

These are the most pertinent considerations to start the discussion. The following pages include high-level briefings on each topic.

UTILITY TRANSFORMATION

Adapted from Dr. Vadari's book, *Smart Grid Redefined: Transformation of the Electric Utility*



It's become challenging to be a utility as the industry foundation shifts.

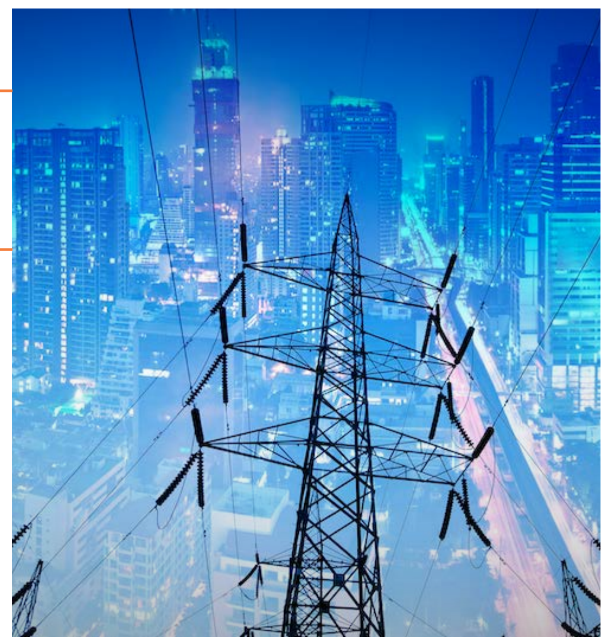
Many questions are being asked. For example, how should the modern utility respond when the following situations occur?

- DERs become more viable regarding cost, performance, reliability, and increased levels of dispatchability.
- The price of storage falls and when combined with DERs allows customers, aggregators, and the incumbent utility to deliver energy where and when needed across the energy value chain.
- Distribution Automation supported by adequate communications and decision support mechanisms allows various stakeholders, within the utility and outside, a full suite of situational awareness tools enabling the entire value chain to work as one entity.

- Microgrids are formed when parts of the utility spin off into their own semi-independent entities and interact with the incumbent utility either during steady-state or emergency situations.
- Electric transportation attains a critical mass of percentage penetration, requiring an extensive charging station network paralleling the existing gas station network in urban, suburban, and rural territories.
- Homes and buildings become truly smart with nanogrid-like controls performed cost-effectively with an increased level of automation, connecting to the home over the Cloud and reducing the need for direct customer involvement.

Moving on from technical changes to the business model changes, how should the utility respond when these circumstances exist?

- A New York REV or similar style retail market required in utility franchise territories, forces the unbundling of a utility's distribution services.
- Aggregators aggressively enter the marketplace and take customers away from the utility.



While this is not the entire set of scenarios that may appear on a utility's horizon, this is a good sufficient subset that should be on the mind of every utility executive. "Off-grid" customers may be a trickle today, but may become a flood once attractively priced technology is readily available.

Utilities would do well to learn lessons from other once-successful companies such as AT&T, Kodak, Xerox, and others to ensure they do not make the same mistakes. Utilities should act now to anticipate actions their customers may take in the future and work towards embracing them into their business model. The regulator is an important part of this equation since they determine the utility's possible activities and services offered to the customers.

What is the role of the utility in the future? Does the utility go by the wayside and cease to exist? Or, does the utility succeed, and if so, in what form?

UTILITY IT STRATEGY: THE CONVERGENCE OF IT & OT

Utilities are integrating their Information Technology (IT) and Operational Technology (OT) systems to achieve efficiencies necessitated by flat or declining load, escalating labor cost, aging infrastructure requiring renewal, increasing reliability expectations of our digital society, shifting generating patterns, expansion of distributed and lower-cost generation, regulatory resistance to rate increases, and the requirement for compliance with RPS and renewable mandates.

For decades, back-office and operational systems had been carefully separated. The IT and OT systems were procured, implemented, and maintained by different organizations, many times with disparate standards, isolated communications networks, protocols, and independent processes.

Much is changing, however. OT systems are beginning to take on the look, feel, and interaction of IT systems using common mechanisms such as ESB, standard APIs, TCP/IP-based protocols, and web services and so on. In recent years, many smaller utilities have begun transitioning to cloud solutions realizing both value and convenience.

Further, facing economic pressure, utilities are standardizing processes and supporting organizations throughout their enterprise, often across multiple operating companies under a single holding company. Integrating IT and OT is critical to value realization. To achieve this value, utilities must undertake a strategic approach. This approach must deliver value now and lay the foundation for tighter integration in the future.

To be successful, a utility's OT/IT integration strategy must avoid the commonly accepted solutions and encompass the following:

Integration feasibility

What is possible considering the cost versus value of integrating OT- and IT-specific applications under practical financial constraints?

Integration prioritizing

Which integrations generate the most impact and value while managing risk and organizational limitations?

Impacts and appropriate utilization of cloud solutions

Today, target candidates are non-mission-critical applications, which reduce cost while bringing additional efficiencies. For some utilities, however, mission-critical applications may migrate to the Cloud in the future.

Optimization across IT and OT

Translating operational and engineering problems into economic value and optimizing that value to justify and implement a successful solution.

New services

Position the IT infrastructure to offer new services to the customer behind the meter.

To be successful, utilities need to be more innovative and engage with emerging solutions and vendors capable of altering the fabric of the accepted norms and departing from their traditional suppliers. Further, this convergence yields lowers costs and practical advantages such as reducing competition.

GRID MODERNIZATION AND THE SMART GRID

Adapted from Dr. Vadari's book, *Smart Grid Redefined: Transformation of the Electric Utility*

The Smart Grid can be defined as a modernized electrical grid, a reliable and secure transmission and distribution (T&D) infrastructure that can meet demand growth in the future. Simultaneously intelligently responding to the behavior and actions of all tconnected electric power users, to power in a reliable, efficient, economic, and sustainable manner.

The Smart Grid is not simply about implementing technology. It is really a complete business transformation for electric utilities challenging the status quo that requires changes to people and processes. If these changes are considered in totality, the implementation will be successful. If not, the benefits will be lower than expected, requiring the utility to evolve from a Smart Grid to Grid Modernization. Utilities need to evolve the way they conduct their business and the regulators must provide the impetus.

Intelligence in the grid is generally associated with the ability to:

Mainly because of cost, the first two elements have been sparse until now. No single, pivotal event triggered the onset of the Smart Grid. Rather, a series of somewhat disconnected events and expectations led to this revolution.

Modern customer expectations

The customer who is more used to the smartphone era expects their utility to provide quick feedback on outage status, more choice on power use, and the ability to interact via smartphone applications.

Modern customer actions

Electric utility customers also enact changes impacting the grid. They install wind farms, solar PVs, buy electric cars, etc., which change the delivery landscape and the traditional utility/customer relationship.

More affordable information technologies

For newer IT systems that are smaller and consume less power, it follows they should also be more affordable also. Sensors and controls are being designed that, due to cheaper access to ubiquitous communications, allow the utility operator to better control the flow of power at a lower cost of installation.

IT and architecture advances

Cloud computing, mobile computing, machine learning, big data analytics, and artificial intelligence are enabling companies to implement advanced solutions more easily and at a lower cost.

More options for solving the same problem

Newer OT (Operations Technology) alternatives under a broad grouping called Distributed Energy Resources provide increased possibilities for generation, transmission, and power consumption.

Much progress is being made in all these areas. Newer technologies are being developed, costs are falling, and more capabilities are becoming available. These all lead to more opportunities to support increased sensing, controls, and intelligence in these network.

The perfect storm influenced by these changes alters the entire power system landscape and requires Grid Modernization.

OPERATIONAL SYSTEMS AND THEIR PLACE IN A TRANSFORMED UTILITY

Adapted from Dr. Vadari's book, *Electric System Operations: Evolving to the Modern Grid*

Advanced operational systems encompass the set of applications, algorithms, and technologies enabling analysis, diagnosis, and prediction of conditions in the modern grid. They help determine and take appropriate corrective actions to eliminate, mitigate, and prevent various conditions such as outages, power quality disturbances, and so on. Getting data into these complex systems and getting controls into the field requires distribution automation, including sensors and controls supported by real-time communications.

Collect data and monitor grid components

Sensors and devices deployed in the field and integrated with operational systems enable near real-time assessment of the grid.

Analyze data

Near real-time data collected from the field is analysed to provide accurate, critical information to downstream applications enabling operational efficiency.

Diagnose and solve problems

Analyze the near real-time data to indentify solutions for existing, emerging, and potential problems at the system, subsystem, and component levels.

Take autonomous action

Advanced algorithms in combination with real-time communication systems enable autonomous action for problem detection and response.

Provide information for Grid Operators

Complex power-system data in near real-time is converted to actionable intelligence to aid the grid operator in rapid decision making.

Examples of operational systems include:

Supervisory Control And Data Acquisition (SCADA)
SCADA, the eyes and ears of the utility, is a centralized, real-time control system that interacts with devices in the field. SCADA provides monitoring and control.

Energy Management System (EMS)
The EMS is used by system operators to take the data from SCADA and other sources to optimize the performance of the transmission system.

Outage Management System (OMS)
The OMS, fundamentally a business system, is the system of record for all outages. The OMS enables the operator to assess the extent of power outages.

Advanced Distribution Management System (ADMS)
A combination of Distribution-SCADA, OMS, and advanced power-flow applications is called an ADMS or Advanced DMS, a system used to continually monitor the state of the distribution system and work to improve its efficiency and performance by proactively managing the network. Advanced applications such as Fault Location Isolation and Service Restoration (FLISR), Volt-VAR Optimization (VVO) are examples of applications integrated into the ADMS.

Distributed Energy Resource Management System (DERMS)
An emerging system to manage Distributed Energy Resources (DERs) such as Distributed Generation and renewables, Demand Response, Storage, PHEV/PEV, microgrids and others.

Dos and Don'ts of DA

Don't ignore the business case. Implementing these systems is expensive.

Do understand the importance of Geographical Information Systems (GIS). Automation works best when it considers the connectivity of the power system.

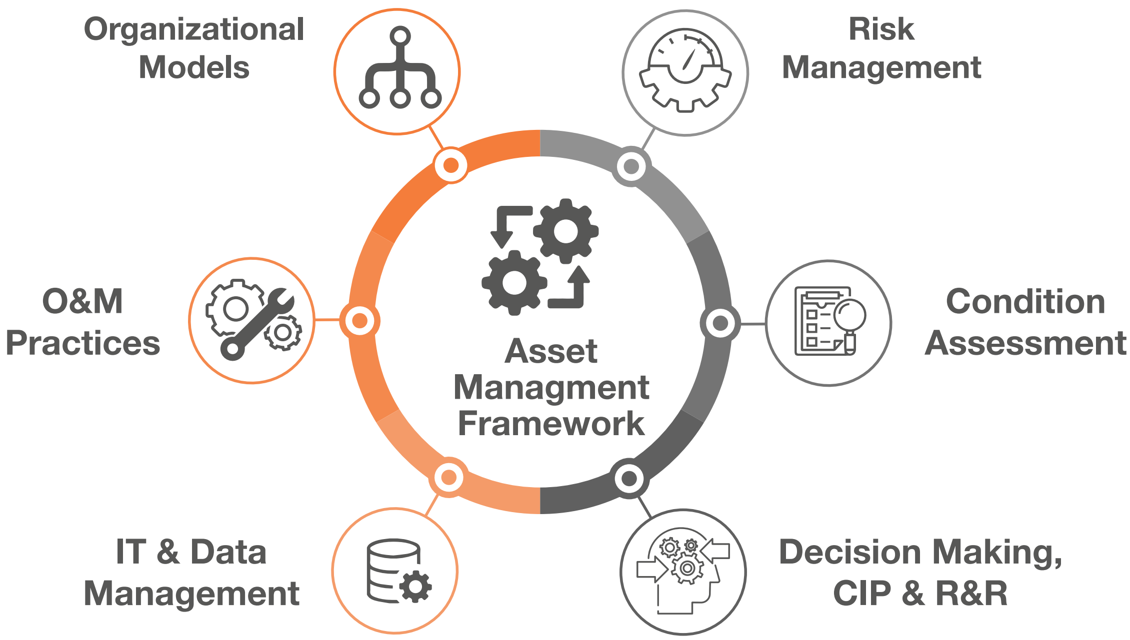
Do expect technology to change and improve. Include defining architectures that anticipate technological changes and plan financials assuming implementation costs will go down.

Do design for cybersecurity. Implementations are now moving away from private networks to IP-based protocols and public networks, making them vulnerable to cyber-attacks.

The system's visibility and controllability will improve, aided by improvements in the accuracy of system representation. With these advancements and sophisticated capabilities, utilities can realize a self-healing future.

ASSET MANAGEMENT AND STRATEGY

Utility asset management has moved from a financially-centric activity to an engineering and IT-driven process to reduce cost, failures, and outage durations while improving overall reliability and availability. The electric utility industry has moved quickly beyond using tools like Maximo as the only asset management tool to add new solutions for critical problem-solving such as condition monitoring, failure prediction, refurbishment/ replacement scheduling, long-term planning optimization, and, above all, risk analysis and mitigation. Some utilities are implementing these new solutions under the umbrella of Asset Health Centers. These products are being made by companies such as ABB, GE, and others.



This new era of asset management faces significant challenges and opportunities such as:

Data and its usability: Many utilities have much of the data needed to improve their asset management processes and utilize emerging applications significantly but sometimes:

- Certain key data required to utilize the data available is missing.
- The quality of the available data varies greatly. Some likely are accurate and currently represent what and when it was installed, how it has been maintained, and its health history, while others have not been maintained as judiciously.
- Even those utilities having the necessary data struggle in identifying where it is, who maintains it, how to convert it, and how to organize it going forward.
- Many utilities have ample data on larger, high-cost, and higher impact assets but lack sufficient and accurate data on high-volume, lower-cost "populations" assets, which contributes significantly to the overall cost.

Risk and mitigation prioritization

Utilities understand the complexity of identifying risks and required mitigations because:

- The identical assets have a greater or lesser impact on reliability and likelihood of failure subject to where they are installed in the grid.
- Risk mitigation likely requires outages. Each outage varies significantly in the complexity of its scheduling and impact on operations.
- An asset's health can vary greatly based on its use. For example, a heavily but consistently loaded transformer usually outlasts a lesser loaded transformer that faces major load fluctuations.
- The inclusion of newer technologies such as EVs whose owners are encouraged to charge at night is ignoring the impact on the life of grid-assets designed to cool down at night.

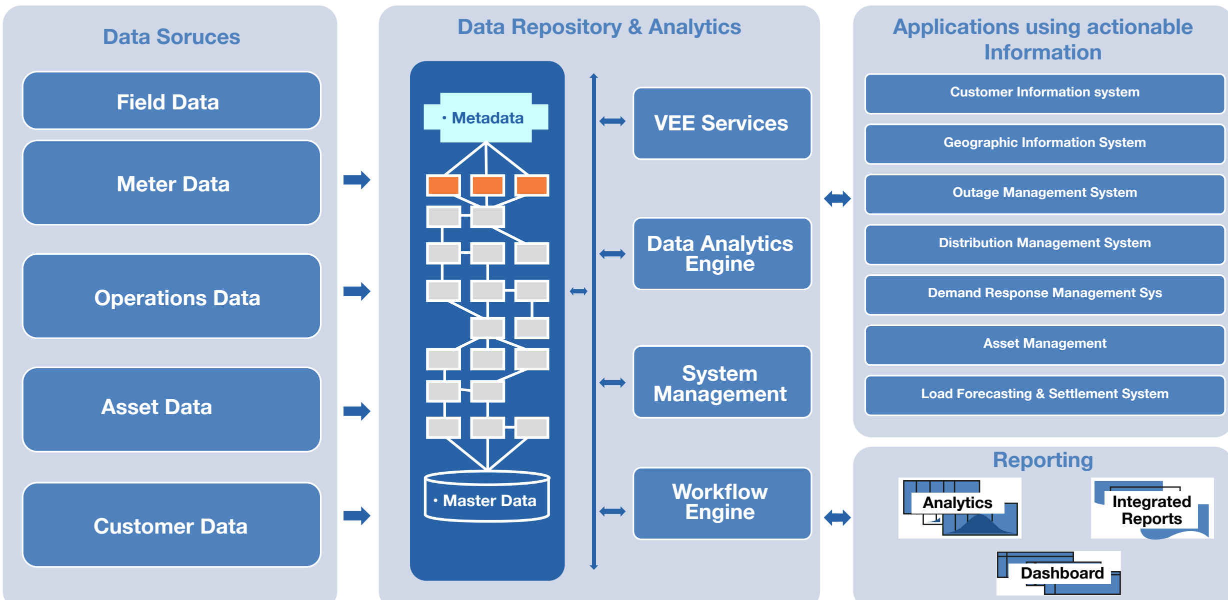
Asset failures often happen in the off-prime shifts (nights, weekends, and holidays), requiring the dispatch of a crew at a multiple of the cost of a preventable failure and providing the utility with the opportunity to improve customer satisfaction by completely avoiding some kinds of outages.

Advances in asset management improve the utility's reliability metrics and customer satisfaction and provide significant improvements in long-term planning and financial forecasting.

DATA ANALYTICS
MASTER DATA MANAGEMENT

Adopted from Dr. Vadari's book, *Smart Grid Redefined: Transformation of the Electric Utility*

Data analytics is not new to the utility industry. Utilities have always analyzed data to improve the operation of the electric grid and utility processes. In the past, however, utilities lacked sufficient data to analyze. This is changing.



- **Transmission data:** In addition to SCADA data coming in at every two secs, newer technologies such as PMUs are now bringing data 30-60 times a second.
- **Distribution data:** New data sources from distribution automation devices are rapidly growing, bringing large amounts of data into the utility.
- **Meter (customer consumption) data:** The advent of AMI is changing one data point read per month per customer to several data points being read remotely every 15 minutes per customer.
- **Asset data:** As the cost of sensors and communications fall, utilities are putting more monitoring on key assets and bringing in additional data.

Currently, much of the work done on data analytics at utilities is done in a targeted manner – not as a company-wide strategic initiative. As a result, utilities have islands of analytics. Some examples are listed below.

This approach restricts the user to a subset of analytics applications and constrains them from going across the analytics systems to provide greater value to each other. We believe utilities must move towards a Master Data Management. There are four basic steps to developing a data analytics roadmap.

Develop an analytics strategy

It requires a thorough understanding of technological and organizational limitations and opportunities to chart a path toward building a common analytics vision.

Assess readiness

Assess the utility's readiness from a technological and organizational perspective based on the current state of different ways data is procured and stored, both manually and in computer systems.

Follow key guiding principles

Every organization needs to follow a set of guiding principles. Having these principles documented sets the stage for the entire organization to follow them consistently. This ensures the cleanliness of the data being managed and, in return, the accuracy of the analytics results.

Develop the roadmap

Define how this strategy will be achieved over time based on critical constraints such as budgets, resource availability, and points such as future changes to the business framework.

Analytics presents a level of disruption, and many organizations fail the first time they attempt a major analytics initiative. Extracting value from data to drive intelligent business decisions requires a cultural shift within a business to institutionalize analytics-based decision management.

The analytics strategy should assess an organization's unique business challenges, match those challenges with relevant data and resources, and establish processes that grow capabilities and institutionalize analytics to ensure key decision-makers have access to actionable results.

INTERNET OF THINGS

The Internet of Things (IoT) presents an opportunity for utilities to monitor and potentially control a wide variety of devices such as building management, home automation, CCTV, electric vehicle charging, asset health, and GPS-enabled devices. It allows a utility to access devices in the field, both on the grid and/or behind the meter, without necessarily using utility-owned proprietary networks and collection equipment.

This data can provide the utility an opportunity to:

- Better understand utility customers' electricity use to:
  - Improve load forecasting
  - Anticipate distributed energy resources production and available controls
  - Provide customers with incentives for modifying electricity consumption.
- Control utility-owned/operated and customer-owned resources
- Enable assets "reporting" on their health and advise on corrective actions
- Allow new utility services to customers (e.g., DSO), leading to the increased potential for retail energy markets.

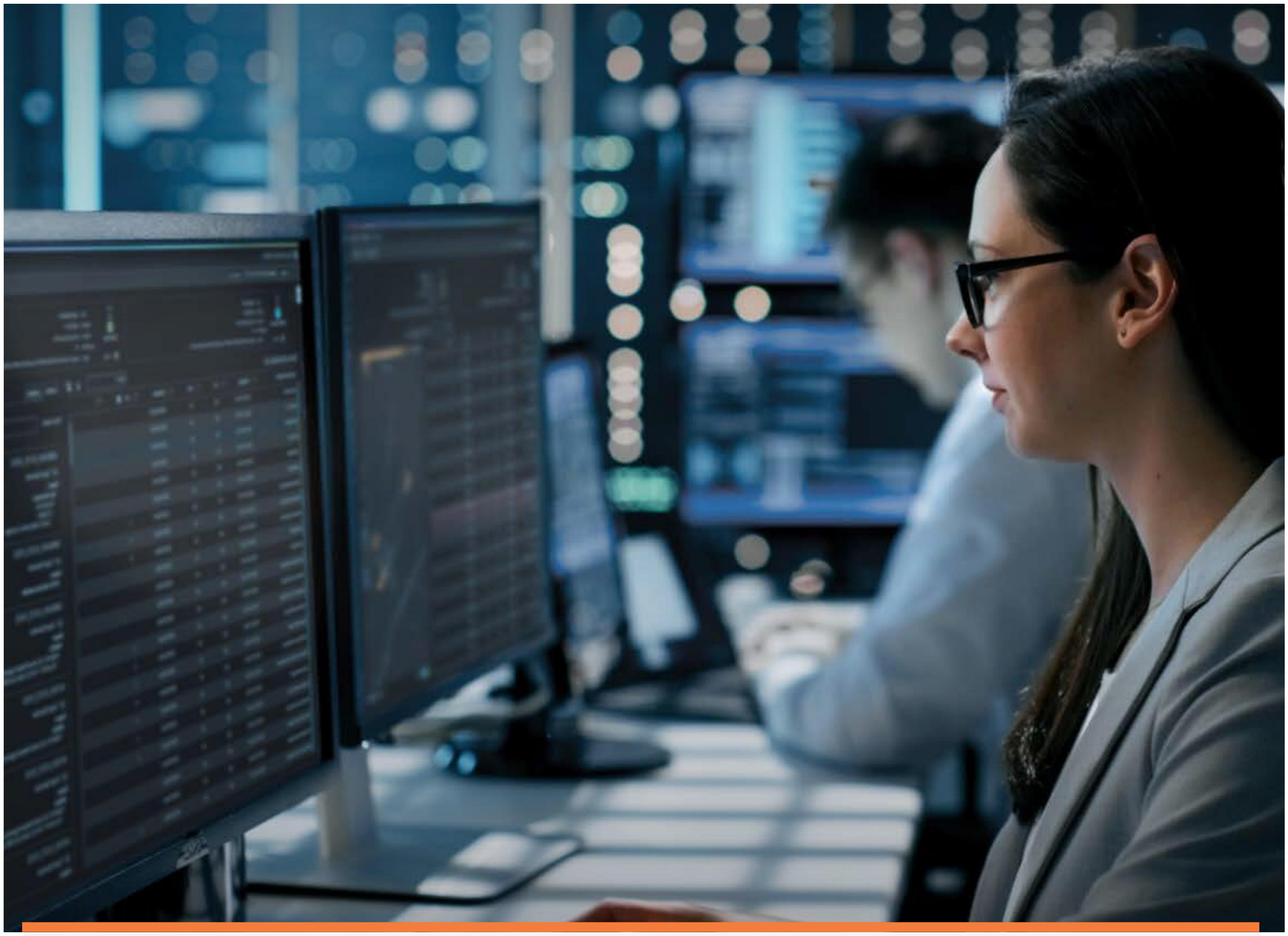
IoT also presents many challenges which need to be planned architecturally right from the beginning.

Customer Expectations: With the revolution of device-to-device communications (e.g., Amazon Alexa), customers will expect a similar experience to other capabilities, which would make their life easier.

Communications:

Protocols: There are many incompatible standards at the lowest common denominator (dumbing down of smart devic es). Until standardization becomes "ubiquitous," abstraction of all IoT messages into a common form by the subscriber will be required.

Reliability: Dependence on external networks requires addressing communications issues.



Security: Device-to-device communications must provide a trusted data source without incurring significant overhead. Several companies we work with are testing solutions, but only a few provide certainty of the message source with minimal overhead.

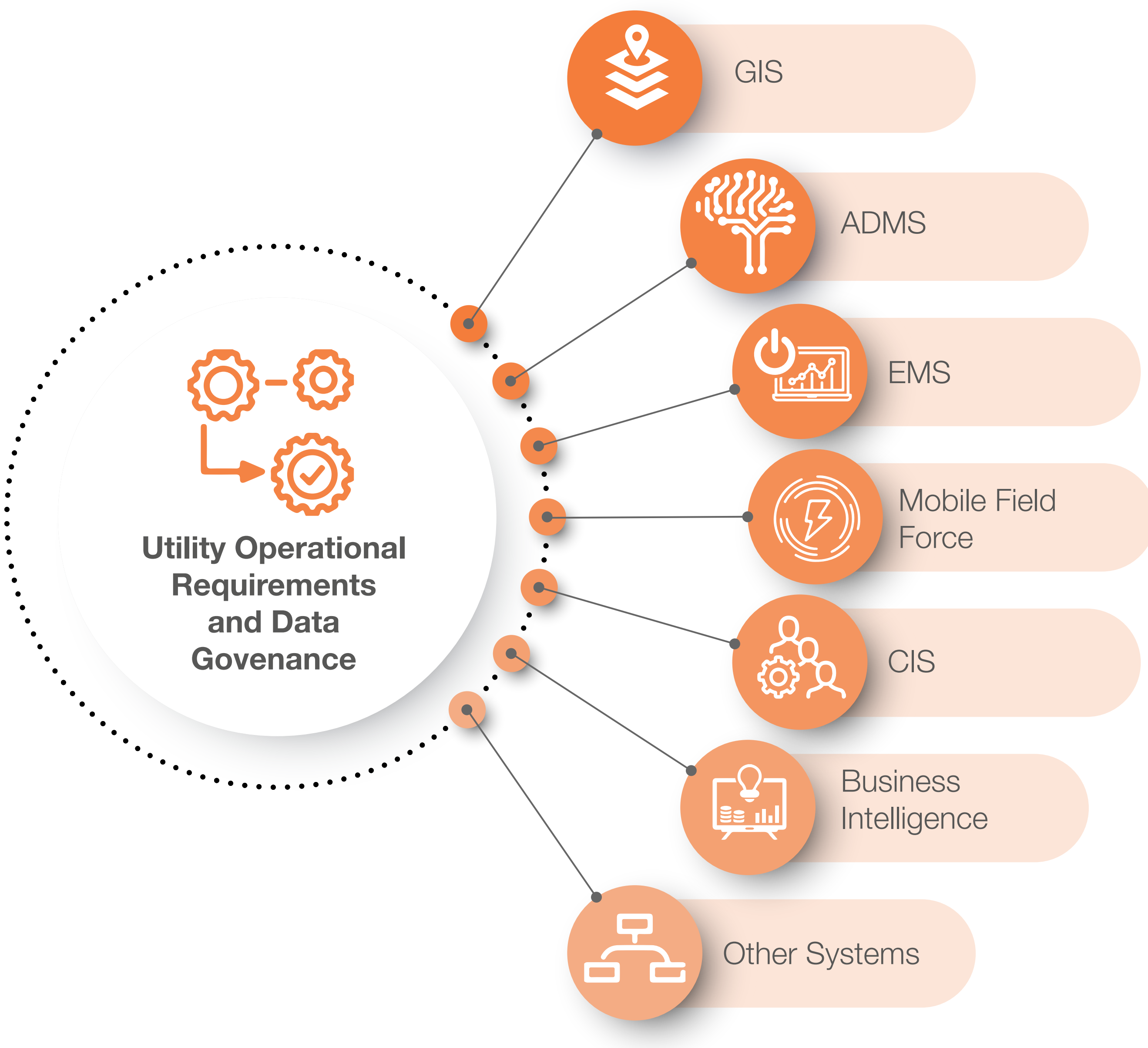
Privacy: Knowledge of electrical use provides insight into users' habits and lifestyles. In June 2018, California passed a new law that lays out the responsibility of those collecting data on customers. Although far from ideal, this legislation promoted the adoption of similar laws in other states to clarify and establish common principles for customer data collection. Further, smart meter data's privacy rules have prepared utilities for IoT impacts, but who can access raw data and how that data will need to be anonymized and aggregated for wider dissemination remains problematic.

Data governance and management: If Intel's prediction "20 Billion new sensors by 2030" is realized, data volume, velocity, reliability, and retention quickly become a potential impediment to extracting value from the data.

IoT offers the availability of extensive, previously unavailable data that can significantly improve the efficiency of utility's understanding of both its own assets and current situation as well as what the utility customers are experience.

DATA GOVERNANCE FOR OPERATIONAL SYSTEMS

The success of any company's North Star initiatives requires each system and associated processes to receive high-quality data from other North Star systems reliably and, in turn, supply trustworthy data to other systems in a North Star ecosystem. For a transformed utility, this ecosystem includes ADMS, EMS, GIS, Mobile Data, MDM, CIS CRM, analytics, asset management, and engineering solutions. This ecosystem of solutions spans not only all operational systems but also bridges into the information technology domain. Given the data interdependence of these initiatives, key aspects such as governance, ownership, accuracy, and update frequency represent critical data challenges to delivering these projects' forecasted value in time to support the utility's promise to customers, regulators, and shareholders.



OUR UNDERSTANDING OF THE SITUATION

Each ecosystem component expects its required data to be available reliably, of sufficient quality and updated by robust, repeatable processes as necessary. This understanding results in several key questions:

01 Which system owns/creates the data?

02 Which system consumes the data?

03 Where and when can the data be extended or modified?

04 What is the data's journey? Where does it start from and where does it end?

05 What is the level of data quality expected – what and how will it be used??

06 What is the planned update frequency – e.g., it is needed every 5 minutes, once a day, etc.?

07 What processes are NOT in place to maintain the data at the required level?

08 Who should own which processes?

09 How should the organization ensure the data is current, accurate, and available to all who require it?

10 What is the data's latency? – e.g., the time lag between "as-designed" and "as-built" data entry in GIS.

COMPLICATING FACTORS

Although shaped by common precepts, the journey to reliable data governance will have different starting points and proceed down different paths for each utility. Some systems will be legacy with differing ends-of-life, others are being procured, and many are in mid-flight. Regardless, each system must have its necessary data available when needed, and receive data of acceptable quality to support each specific capability for every system under all operating conditions to deliver the anticipated value.

Data governance's scope should, at a minimum, encompass all operational systems supplying data to or extracting data from GIS, CIS (excluding data deemed private), EMS (excluding NERC CIPS data), ADMS, mobile systems, work and resource management, business intelligence/data analytics, and others. Data governance analyses require a deep understanding of the overarching data model, data governance policies, and the nuances and challenges of the individual system's requirements. The variability of legacy solutions and data, as well as, unclear ownership and data maintenance processes complicate progress and increase complexity.

THE JOURNEY AND VALUE

All data begins its journey when it is created, grows through enhancement and refinement, and travels, delivering the expected value of other systems based on interdependences between the various OT and some IT systems at the utility and sometimes beyond. All along this journey, data requires stewardship to ensure its accuracy and timeliness are adequate to fulfill the needs at each stop, a project, system, or organization expecting to deliver value. Beyond data ownership and its growth, the data's volume, variety, and velocity are central to stewardship.

Data and its model are critical utility assets that enable efficiency, value creation, and transformation

OPERATIONAL SYSTEMS ENTERPRISE ARCHITECTURE

SETTING THE CONTEXT:

Utilities continue to look to mergers and acquisitions (M&A) as a strategic lever to mitigate risk by leveraging economies of scale. Beyond financial metrics, it's important to acknowledge the impact on existing processes and systems across merging operating companies.

The central question to ask is, "Are the right personnel performing the right work using the right systems AND is the right information showing up in other downstream systems for others to perform their duties?"

Connected Assets
Digital twins
IoT/Sensors
Smart Meter / Grid
Geospatial modeling
Data Analytics
Mobility
Cyber Security
Blockchain

Asset optimization, minimize unplanned down-time, and enable new business services.

Operations Technologies
IT/OT Convergence
Distributed Energy Resoruces
Electric/Autonomous Vehicles
Storage
Microgrids

Keep pace with evolving changes in the grid and beyond the meter.

Intelligence
Cloud
Drones
Robotics
Open Integration
Artificial Intelligence
Virtual/Augmented Reality
Wearables

O&M cost savings by applying predictive analytics, machine learning, and artificial intelligence, creating smarter systems & more meaningful insights.

Connected People
Channels
Social Media
Online
Mobile App
Collaboration
Knowledge Management
Fluid workforce
Digial trust

Enable employees and customers and interact with them at an unprecedented pace.

OUR UNDERSTANDING OF THE SITUATION

The operational systems covered here are – GIS, CIS, AMS, Work/Resource Management, Mobile Dispatch, and ADMS. Our experience with many utilities has taught us that multiple systems can often accomplish the same work. Here are the relevant questions we recommend asking...

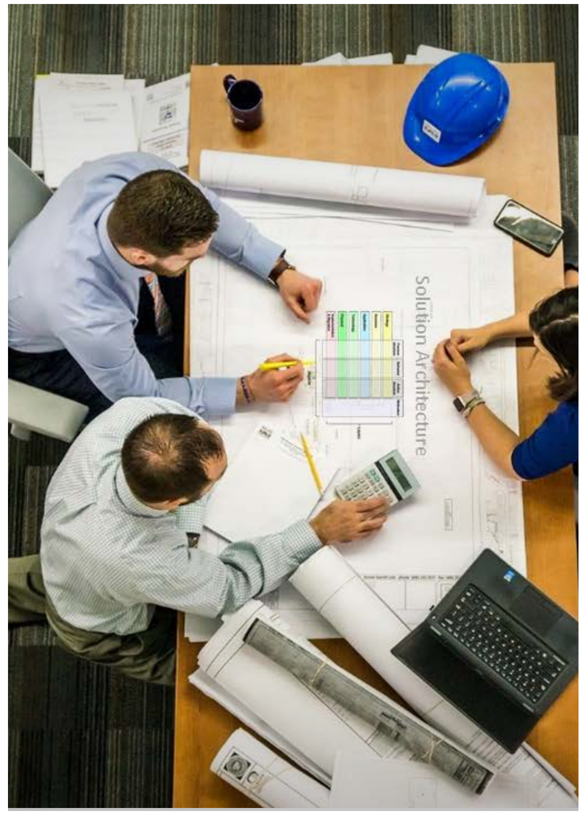
- Work orders can be entered in the ADMS or the mobile dispatch system. Which should be the master system?
- The GIS is the source of the as-built model. Should all systems using this model be updated at the same time?
- The ADMS is the final arbiter of the as-operated (and as-switched) model of the system. Should field crews and the control center see the same as-operated model when working together?

We are aware of the discipline required to establish and define the enterprise architecture and, subsequently enforce how different processes across the enterprise will use their specific systems to perform the necessary operations while at the same time, confirming that the information utilized to make decisions can be trusted. While the latter requires a well-designed data governance approach, the former requires a structured approach to enterprise architecture.

COMPLICATING FACTORS

One of the most significant complications of enterprise architecture is system integration. Whether it's because of a merger or as a result of restructuring, there will be issues. Here are some questions to keep in mind...

- Are systems fully synchronized, and is each system's model updated simultaneously?
- Are all work types covered, e.g., storm/blue-sky, centralized/decentralized, single/multiple no-light, others?
- Are all aspects of the work considered, i.e., people, process, and technology?
- Are future movements being considered? For example, what happens when AMI data is available closer to real-time?



THE JOURNEY AND VALUE

This journey starts by rationalizing all the work within the systems impacted by or necessary to perform work, the operations systems, and their interactions.

It also requires a layered mapping of the data sources, destinations, update frequency, update processes, required accuracy, and, most of all, data ownership.

Ownership from a system, data, and process perspective is the most important because it is the foundational construct. Completing a high-level mapping of this interaction while keeping in mind the frequency and certainty of the update processes allows systems to deliver their expected value.

This activity needs to be done in a layered manner after an executive agreement has been obtained at each level. A business case, roadmap, and prioritization must be developed at each level to ensure that changes are backed up with a sound business judgment. This activity needs to be done with the availability of a viable multi-system data panorama.

Each system can deliver its expected value and allow individual systems the ability to evolve, embracing new requirements and business needs asynchronously.

DR. MANI VADARI & JOHN (JD) HAMMERLY

Dr. Mani Vadari is a well-recognized electric industry leader and visionary, with over 30 years of experience delivering business and technical solutions for transmission, distribution, and generation operations, wholesale markets, Smart Grid, Cyber security/threat assessment, and Smart Cities. Mani has a multi-year track record of delivering value on a wide range of technology and business solutions. As President of Modern Grid Solutions, he leads a team of experts who deliver complex and innovative technology, business, regulatory, and financial solutions to electric utilities, suppliers, regulators, corporate boards, and policymakers worldwide. Mani is a Technical Consultant to the New York State Smart Grid Consortium where he participates on an architecture role in the core REV (Reform the Energy Vision) team.

Mani is also an Affiliate Professor at the University of Washington, and an Adjunct Professor at Washington State University. Mani has published two popular books, *"Smart Grid Redefined: Transformation of the Electric Utility"* and "E*lectric System Operations – Evolving to the Modern Grid, 2nd edition*," and has authored over 100 industry papers, articles and blogs.

Mr. Hammerly has worked in the industry counseling and advising regulators, market designers and operators, utilities, industry suppliers, and investors. He offers his expertise on the nature of markets, their impacts, tools, skills, and business models necessary to participate in the markets successfully, and the organization to support markets as a market operator or participant. An early believer in the value of electricity markets, Mr. Hammerly guided Alstom to become the leading supplier of energy market solutions. He was the only non-utility member of FERC's "HOW" and "WHAT" committees that laid the blueprint for US wholesale electricity markets. In addition, he testified in front of Congress on the vulnerabilities of the grid and the operational systems supporting it.

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