

Grid Solutions

THE IMPACT OF BIG DATA ON UTILITIES

Whitepaper

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GE VERNOVA

1. INTRODUCTION

We already live in a world of information and sensory overload that stretches the limits of our cognitive capabilities. In every industry this is increasingly true, and the utility industry is no exception. First there was data, now there is Big Data! There is a clear connection between the proliferation of embedded silicon in devices - large and small - and the ability to create information from these devices. Barely 20 years ago, one terabyte of storage was absolutely gigantic and seen as able to store all the data of many departments or entire companies. Systems that large were called enterprise warehouses. Today you can buy a 1TB external hard drive at a local electronic store for less than \$75. This is the new world of Big Data, where the ability to intelligently store and analyze data is rapidly being outstripped by our ability to create it.

Furthermore, raw data is just data, not information, and people like information. We like to organize, index, archive and efficiently retrieve information, not only on paper but also electronically. It has slowly grown from an information technology discussion to a business strategy and competitive advantage conversation in many industries like retail, banking, hospitality and healthcare. Information with relevant context alone can be useful in its ability to inform and accelerate decisions. In some rapidly commoditizing industries, business intelligence alone has created a sustainable advantage that could not have been secured with products or services alone.

In a Harvard Business Review article called "Competing on Analytics" (HBR Jan 2006), the author Tom Davenport writes that some companies have built their business foundation on their ability to collect, analyze and act on data (see Figure 1). They have reaped rich dividends from these investments in terms of market share, market growth and profitability. According to Davenport, Capital One credit card market share has grown by 20% every year since going public thanks to a rigorous, "competing on analytics" strategy. Walmart insists on sharing its analytical warehouse results with its suppliers with the retail link system to make them better partners and to improve its competitive advantage.

2. PROBLEM STATEMENT

Most utilities do not get a timely answer to many of the following underlying questions, despite significant investments in power equipment and IT infrastructure:

- I want to shed 20MW of load within the next hour. Who do I target? How do I know within the hour that I succeeded?
- What customers today are most likely to complain when I raise residential rates by 10% during the 2-4PM window? Where are they located?
- How many of my truck-rolls on average are unnecessary per year? How would I know?
- What 10 transformers should I buy on-line sensors for this year? Why?
- How do I comply with the feed-in tariff regulations while understanding the level of renewable penetration at which I have an unmanageable intermittency and power variability problem?
- How do we replace our aging electrical infrastructure without raising rates for our consumers, especially those struggling financially?

- How do we encourage customers to make better choices for in-home energy consumption while respecting their privacy rights and optimizing our consumer satisfaction ratings?

Creating business adaptability and competitive differentiation

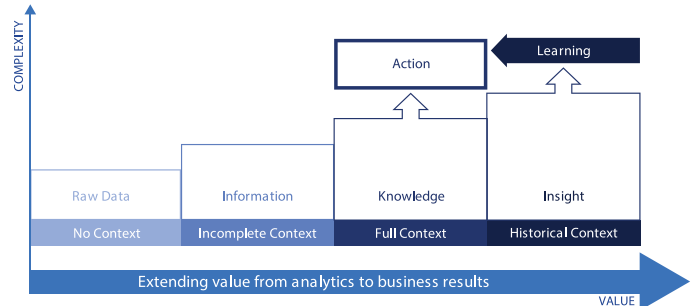


Figure 1: Value Journey

Analytics is a journey, not a destination. Grid Analytics solutions like Grid IQ Insight enable this continuum to curate, analyze raw data and transform it into actionable knowledge and insight that transforms a utility, one process at a time.

HISTORIC OPTIONS FOR UTILITIES

Surprisingly, the utility industry is one of the last to adopt business intelligence, especially considering they were early adopters of SCADA (Supervisory Control and Data Acquisition). SCADA front-end processors built on technologies that were best-in-class a couple of decades ago filtered out operational data to focus on the core information network operators need to run the grid. These SCADA systems push that high speed operational data 15 to 30 times a minute to an operational historian. The evolution of the Energy Management System (EMS) and the Distribution Management System (DMS) systems was essentially the evolution of closed-loop control applications built on this SCADA foundation for the transmission and distribution domain, respectively. The EMS and DMS systems are the core of what makes our grid so reliable and efficient today. This is not an undertaking to be underappreciated.

However, SCADA infrastructure was optimized for control and speed, not for rich analytics. Data historians also are different than SCADA systems. They compress and transport large amounts of operational data from SCADA and have focused on analysis rather than BI.

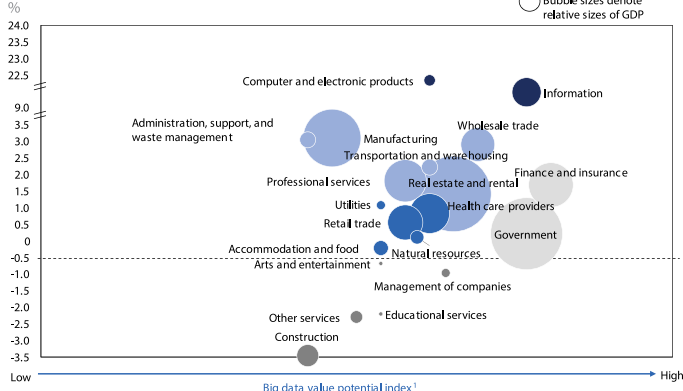
With new IT technologies today, we have an opportunity to leapfrog to the next level of advanced grid analytics. This new level builds on the strong bedrock in SCADA data that the utility industry is fortunate to have already invested in. Our needs to do this are not different from the past but are fueled by a renewed urgency and focus created by new drivers:

- Rapid proliferation of Intelligent Electronic Devices (IEDs) on the grid
- Associated rapid data proliferation from these IEDs and the cognitive burden it places on the human mind, creating a need for machine learning

- Steady convergence of operational IT and enterprise IT technologies and the coming together of IT, communication and grid-side cultures
- An aging workforce in many countries, creating a need to draw more new, young, tech savvy talent into the industry to support our aging infrastructure

Some sectors are positioned for greater gains from the use of big data

Historical productivity growth in the United States, 2000–08



1 See appendix for detailed definitions and metrics used for value potential index.
SOURCE: US Bureau of Labor Statistics; McKinsey Global Institute analysis

Figure 2.

Utilities in the middle of the pack for Big Data potential

- Regulatory drivers that are creating choice and focus on the rise of consumerism, tied with growing fossil fuel costs and worries about rising electricity costs. The emergence of incentives in some parts of the world and a growing urgency around cleaner, more efficient sources of power
- Rising tide of consumerism and the power of social networking provides a rich collaboration opportunity to engage and empower consumers and use their activity to help improve the productivity and reliability of the grid
- Aging electrical infrastructures need investments to boost reliability, power quality and productivity metrics. (According to an April 2011 EPRI report, the US power infrastructure industry alone needs ~\$400B of investment in infrastructure upgrades that are capable of providing between 2.8-6X ROI in the next 20 years. The world needs are 2-3X times this investment.)

Investments in Business Intelligence are not something most utilities are comfortable with or have budgets to do. What is new is often assumed to be risky. Business Intelligence is not without risks, but in all other industries it has touched, business intelligence has transformed organizations from reactive to proactive. A renewed commitment to the value of data, organizational leadership, and risk-taking is essential to embrace this change. It requires conviction that analytics will become mainstream in the utility industry too, as operational BI takes utilities to a new level of operational efficiency, customer intimacy and regulatory support than ever before. Utilities will need resolve and perseverance but ultimately information not physical assets will become the most important asset and the most reliable predictor of revenues and profitability in this asset intensive industry.

Figure 2 is a snapshot from a recent report by the McKinsey Global Institute that shows the utilities in the middle of the pack when it comes to productivity growth and its linkage to Big Data. There are

reasons to think that this may be a conservative view. Awareness among consumers about the costs to generate, transmit and distribute electricity – and the impact it's going to have on their monthly bill as electricity costs rise is increasing. The short term effect of this is a backlash by Public Utility Commissions and taxpayers worldwide. We need data-driven operational insight to help transform the current utility provisioning model into a sustainable model that keeps pace with energy demand and maintains its level of reliability and efficiency.

INTRODUCING GRID IQ™ INSIGHT

The opportunity for these Big Data solutions has brought enterprise IT players to the table like Oracle, Teradata, SAS, and IBM. One thing that is different about this industry is that a lot of data comes from the Operations Technology (OT) environment unlike other industries where a lot of data comes from external social media outlets. It already moves at SCADA speed, which is more than you can say for many other industries. To move the bar, we must build on these proven solutions.

It takes deep domain expertise and a proven track record in this industry to understand our customers and their unique challenges. Each region has a different set of problems and challenges that have varying levels of urgency. Many of these projects require a deep understanding of utility operations, data flows, and data protocols that exist due to the multitude of products available in this market. Companies like GE Vernova and others with strong operational subject matter expertise have the breadth and depth of offerings to comprehend the integration challenges, not just on the IT side, but also from the operational side. Utilities will do well to choose a combination of smart grid and IT companies who work well with each other, have collective domain expertise, and are focused on solving their customers' problems. The easy thing is to assume that the entire underlying infrastructure works well. In practice, we find there are a lot of analytical applications already deployed that are often in conflict with each other. We have to carefully think through the best way to orchestrate the analytics, whether centralized, decentralized or locally deployed.

Recently developed analytics like FDIR (Fault Detection, Isolation and Restoration) work well only on networks that are simple and radial. More careful thought needs to be given to orchestration of such algorithms around decentralized usage as well as local usage. Applications like Integrated Volt Var Control (IVVC) have great potential to address power quality issues and help utilities get more out of their network investments but sometimes its algorithm is at odds with signals coming from another system like a demand response management system which is working in its own silo.

BENEFITS

The promise of Grid IQ™ Insight (see Figure 3 below) and other solutions like it, is the creation of next generation algorithms that will transform the industry. These “killer apps” have not been defined in many areas. It will take a few years to refine these algorithms and prove their validity and accuracy. They may work well on a stand-alone basis and may also work as a group across bi-directional and complex mesh networks. New solutions like

residential demand response must work well with proven methods like load curtailment in the commercial and industrial space. We need to see beyond these residential and commercial meters. We need more granular data that enables better customer behavior analysis over time and better understanding weather and other uncontrollable events. It takes more than just IT skills and the domain expertise of numerous industry organizations working together to create these solutions.

We can anchor these emergent algorithms and their value around Reliability, Efficiency, Productivity, Customer Empowerment and “Clean”. We see opportunities in the areas below and are anxious to talk to our customers to learn about their pain points:

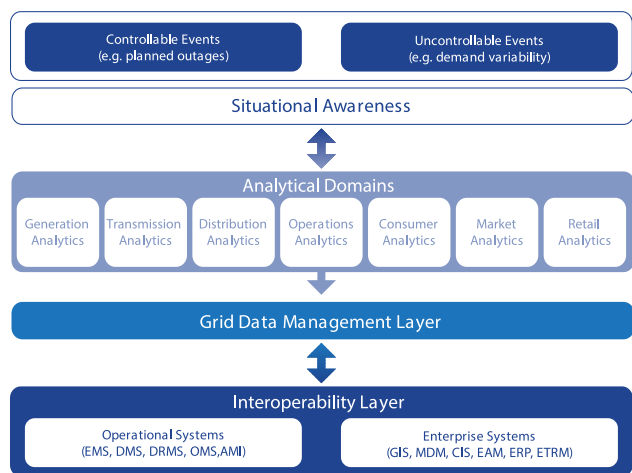


Figure 3.
Big Data Insight Architecture

- **CLEAN:**
 - Carbon Offset Metrics
 - Emissions Management
- **PRODUCTIVITY:**
 - Asset Portfolio Optimization
 - Service Restoration costs optimization
- **RELIABILITY:**
 - Outage Analytics & Predictive Management
 - Distributed Energy Resources Yield Optimization (Solar, Wind, PHEV/EV, Batteries etc.)
 - Low Voltage Analytics & Performance Optimization (Power Quality, etc.)
- **EFFICIENCY:**
 - Smart Distribution Network Optimization
 - Substation Analytics and Performance Optimization
- **EMPOWERMENT:**
 - Consumer Analytics & Behavior Optimization
 - Retail Analytics & Revenue Optimization

OPERATIONAL TECHNOLOGY/ INFORMATION TECHNOLOGY

CONVERGENCE AND THE VALUE OF DATA

Utilities have the luxury of having a solid information technology backbone. The core operational systems have almost always been connected to the SCADA and historian infrastructure. According to John McDonald, IEEE Fellow and NIST Standards Governing Board Chairman, 80% of the value of operational data is untapped. We need to build upon these existing investments and the untapped operational data. Examples of this data include:

- Circuit breaker status (open/closed) and recloser status
- Line current (in amperes)
- Bus voltages (in volts)
- Transformer loading (real and reactive power)
- Substation alarms (high temperature, low pressure, intrusion)
- Phase measurement units

Non-operational data is also where we see a lot of proliferation that needs to tie to business impact:

- Digital waveform recorders (e.g., Beckwith)
- Circuit breaker contact wear sensors
- Transformer oil sensors
- Line sag monitors
- Data from new sensors like fault current limiters etc.
- Weather sensors (temperature, etc.)

Utilities do a great job with 20% of the operational data. 80% of the operational is largely ignored from an analytics perspective. The deluge of non-operational data creates a huge new opportunity for analytics.

CHARACTERISTIC	OPERATIONAL DATA	NON-OPERATIONAL DATA
Data Format	Usually Limited to individual time sequenced data items	Usually a data file that consists of a collection of related data elements
Real-time vs Historical	Usually consists of real-time or newer real-time quantities	Mostly historical data, trends over time
Data Integration	Easily transportable by conventional SCADA RTUs using (non-proprietary) protocols	Typically use vendor specific (proprietary) formats that are not easily transported by SCADA communication protocols

Figure 4.
Operational and Non-Operational Data Characteristics

Utilities want to protect the investment they have already made and move from smart metering pilots to grid efficiency and smart distribution management. Utilities are also keen to see data standards emerge so they can develop a substrate of metadata that lends itself to sophisticated analytics.

Below is GE Vernova's approach to move from raw data to Grid IQ™ Insight. We believe this approach will work for many utilities. The idea is built on a report from Phil Russom, Director, TDWI, who recently released an article on Big Data Analytics, in which he talks about the three Vs of data. GE Vernova proposes 5 Vs to Big Data in the Utility space - Variety, Volume, Velocity, Variability and Value (see Figure 5 below). GE Vernova does not recommend the approach advocated by some which is the approach of first lets collect all the data and then something useful will come out of it. Our approach is one of discipline and frugality. Once we understand the process that needs transformation, we drill down into the variety of data needed, the volume and the velocity of the data and the variation in the raw data. It is only the analysis of the variations in data and its correlation with the business KPI that has any value to the customer.

These 5 Vs of data are critical to thinking about a holistic operating data management philosophy and carefully thinking through a framework of extracting value from raw data based on these dimensions. This will protect the utility from concerns around high integration costs and ROI. It ensures there is the right diligence and discipline to curate data systematically based on real business value today rather than the promise of value that may be realized one day in the future. The business KPIs that matter to a utility (see Figure 5) are typically around return on investments, reducing operating costs, customer satisfaction and customer retention, efficiency and productivity improvements, managing regulatory reporting and attracting new talent.

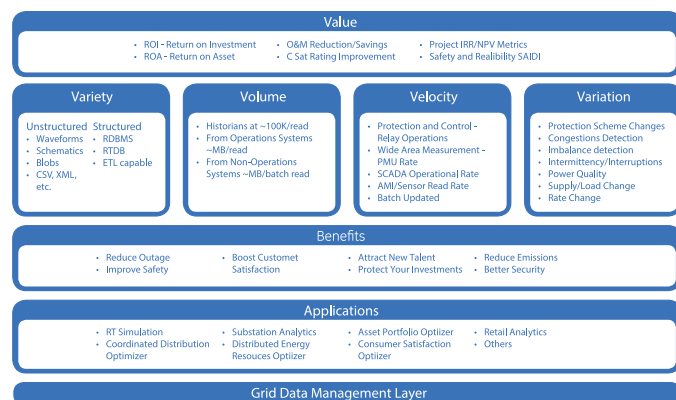


Figure 5.
Applications and Benefits

Creating ease of interaction, reducing training barriers to entry, and minimizing legacy system push back

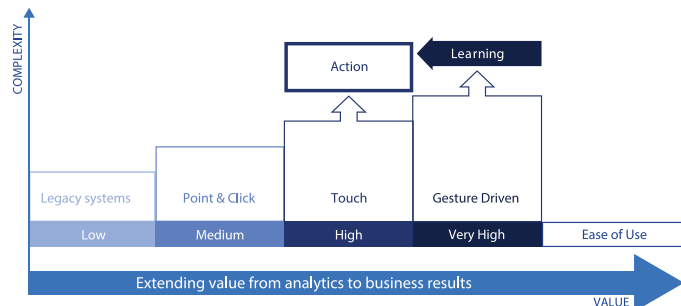


Figure 6.
User Experience Continuum

OVERCOMING COGNITIVE DISSONANCE

Many of us grew up in a world where we read operating manuals for days and went to training classes for weeks before we learned how to use some of the operational and enterprise software systems we use today. We started with dumb terminals and slowly morphed from using a mouse on computer screens to using our thumbs to type on a Blackberry. The tactile iPhone revolution took just a couple of years to move us from digital pages with fingers to the new era of digital books.

The world's next generation of utility experts grew up picking up a new game to play on their Microsoft Xbox or Nintendo Wii and then playing it in a matter of minutes without any training. This is a clear sign that anything else is too complex. Game developers do not overlook this fact and often use it as the single biggest economic incentive: user adoption and ease-of-use. Be simple and intuitive, otherwise the game is doomed to economic failure. We will depend on this generation to build and support the next wave of grid analytics and operational systems to manage and operate our electric utilities. The level of sophistication and complexity of these systems will not change; they will only grow and become more complex. In addition, it's key to make it easy to adopt and easy to use.

IMPLEMENTATION STRATEGIES

See Figure 7 on the next page. Underestimating user experience and user resistance is a critical mistake. Some will prefer mouse clicks while many have already moved to touch paradigms and some are looking beyond that to the future. Solutions that help deliver operational insight are not products that are purchased off-the-shelf, nor are they custom experiments. This is an information science, and it requires companies with specialized skills to collaborate with its customers. The process for a utility to develop a roadmap for success requires consultative dialogue and active exchange of ideas with a few trusted partners or companies. Ultimately, the result is a successful, jointly-developed plan that clearly identifies key stakeholders and has clear milestones.

DISCOVER	DEFINE	DELIVER	VALIDATE
<ul style="list-style-type: none"> • Proof of Concept • 90 day plan • Workshops 	<ul style="list-style-type: none"> • Solution design • Product definition • Stakeholders identified 	<ul style="list-style-type: none"> • Implementation services • Coaching & Training • Rapid knowledge transfer 	<ul style="list-style-type: none"> • Business value thoroughly documented
<ul style="list-style-type: none"> • A consultative design workshop that needs some preparation and homework on both sides • Selection of and operational process that can be used as a test substrate for the overall opportunity the utility seeks • Rapid prototyping and delivery of value to the right stakeholders to validate viability, help the utility retire some risks and get a sense for overall returns 	<ul style="list-style-type: none"> • A robust set of sessions with various stakeholders to build a comprehensive plan of processes that need transformation • A dedicated set of resources across the teams that rapidly decompose the processes into traceable design artifacts that can be built into analytical algorithms • A clear set of business KPIs and metrics to set the project to measure success • A prioritized plan to achieve the goals set for the teams 	<ul style="list-style-type: none"> • Development of tailored configured algorithms that address the inefficiencies in the processes • Delivery and configuration of algorithms based on the data from the targeted applications from the utility's infrastructure • Tuning the algorithms for finer results, sound data cleansing and curation methods 	<ul style="list-style-type: none"> • Continuously monitor the effectiveness of the algorithms and reports to help meet the business KPIs • Validate the effectiveness of the solution in terms of delivering bottom line financial performance • Establish governance groups of stakeholders to effect the change necessary to deliver desired business results

Figure 7.
Analytic Development Strategy

ORGANIZING FOR SUCCESS

- a. **GOVERNANCE BOARD:** One of the biggest challenges that utilities will have is organizational readiness and sponsorship of new initiatives. We are already seeing the innovator-class utilities in this space create new, dedicated analytics initiatives such as Grid Analytics, Intelligent Grid or just Smart Grid Analytics. These initiatives are sponsored by both the key executives from the operational and IT side. The Operational Insight team must have a dedicated leader that has the trust and support of all the various organizations across the business. Some key executives whose support is paramount here are the CEO, CFO, CIO and CSO. Key advocates like the VP of Operations, VP of Marketing and Customer Service, and VP of Asset Management are often part of a Governance Board that helps get the organizational support that is key to this strategic initiative.
- b. **CHANGE MANAGEMENT:** Some processes will need to change or be adapted - to meet this new paradigm in utilities. For example, historically the industry has been served well by its robust focus on cost and its need to procure best-of-breed components and products through a rigorous procurement process. This process is optimal for mature products in mature markets with known competitors and known values. The field of

Big Data is new and its potential value is immense. Particularly in the early years of this field, it is critical to balance the need for risk reduction and the total cost of ownership with the recognition that some level of risk taking and entrepreneurship is imperative to creating new markets and ideas. Therefore, the procurement process must reflect the adaptation necessary to accommodate this reality. As another example, it is possible that some of the savings and opportunities are in areas that are sensitive to some constituents and stakeholders, who see it as their key domain and control the budgets. It is only natural for this team to face pushback as it makes recommendations to improve the utility's financial future. The Governance team must have the resilience and empowerment to effect the changes necessary to extract the maximum value from these investments.

- c. **DATA GOVERNANCE TEAMS:** Standards are rapidly emerging and threatening an ongoing cost struggle to maintain system integrations. One way to keep costs down is to force all players in the space to use, and strictly enforce, standards-based interfaces to manage costs and break down the operational silos. Standards like DNP 3 are mature in the SCADA area, and new standards like IEC 61850 and IEC 61968 are key to creating a new layer of collaboration across the enterprise. The most practical way to ensure both existing -and emerging - standards are working well is to empower a Data Governance team across the utility silos. This Data Governance team would consist of stakeholders like the Protection and Control, Distribution, Asset Management, Transmission, Meters, Customers, and Enterprise teams with the objective of driving consistency and persistence of shared data across the enterprise.
- d. **INTEROPERABILITY:** Another non-negotiable is to ensure that the operators of the old proprietary systems receive a clear message to comply with the new protocols and standards, and there is increased connectivity and connectedness in the OT/IT infrastructure that forces the convergence of these two historically separate silos.
- e. **SERVICES:** The Operational Intelligence Leader (or Operational Insight Leader as noted above needs to have a dedicated team of business consultants, architects, communication technicians and business analysts that focus on the technical side, are obsessed with measuring the value of DELIVER phase regularly report the key performance indicators to the Governance Board. This is critical. Any such initiative is bound to run into process inertia and meet a set of people who feel disenfranchised or alienated. Regular communications and executive support are key as this team to focuses on value delivery to move the utility forward. Many organizations often underfund investments only to struggle later as they realize that technology is only the enabler and a team of service providers are the only real forces that can help deliver value from the investments.
- f. **FLEXIBILITY:** These initiatives need to be light on their feet while keeping the long term goal constantly in the forefront. As such, the necessary recalibration and course correction isn't possible as they meet inevitable obstacles and failures. Again, this reinforces the need for solid governance so the team does not drift off its strategic course, but has the experienced coaches and mentoring from key executives as it delivers the value.

g. **MANAGING RISK:** Most of us are averse to risk. Sometimes, this means we prefer the status quo to any change. Like other smart grid initiatives, this one has some challenges. In other industries, most of the risk has been accurately identified as too much focus on technology and not enough on people. We strongly urge our utility colleagues to look at parallels in other industries like retail, transportation and banking. In these industries, these initiatives have shown they are not always a quick-win but invariably end up creating a sustainable competitive advantage for those practitioners who invest strongly in this area.

For example, the HBR article we referenced in the Introduction discusses how companies like Marriott get higher returns on their assets than their competitors and still grows year over year in a highly competitive market because it uses a sophisticated Revenue Optimization algorithm that sets prices optimally to maximize yield and occupancy at the same time.

CONCLUSION

Utilities are at a crossroads. Many remain in monopolistic markets where creating strategic competitive advantage is not necessary since they have few to no competitors. For others it's a critical need. However, all of us know that nothing is going to stop the rising tide of consumerism and the tremendous awareness in the world around rising energy prices. We need to be good custodians of precious natural resources and efficient in the energy transformation and delivery process. This will allow us access to funds to provide a foundation of affordable electricity to sustain our usage. We need the funds and the rates to match our ability to be competitive and profitable to satisfy our stakeholders and meet our society's needs for a cleaner, more efficient and sustainable future without compromising the reliability and productivity that got us here.

GE Vernova believes that an analytical solution like Grid IQ™ Insight is a key investment that utilities must consider seriously as they reach for the next generation of analytics and operational efficiency.

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FEEDBACK

Please send your feedback and suggestions to giridhar.iyer@gevernova.com

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