Achieving High Performance in Smart Grid Data Management

Making sense of the data deluge

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Achieving high performance in smart grid data management: The utility industry context

Today's energy utilities are confronted with an array of challenges unprecedented in their scale and scope, ranging from capital constraints to geopolitical concerns over carbon emissions and regional market competitiveness, an aging workforce and uncertainties in energy demand.

At the same time, the utilities industry is challenged to exceed rising customer expectations efficiently and cost effectively, while also reducing economic losses from power outages and quality issues—events that currently cost the US utilities industry alone approximately $188 billion per year.[1]

As utilities strive to overcome these challenges and achieve high performance, many are finding that the potentially transformational benefits offered by emerging technologies are being undermined by the limitations of legacy systems and infrastructures, which are neither designed nor equipped to integrate with new technologies to manage the two-way flow of power.

The solution—smart grid

Against this background, the smart grid has emerged as the way forward. The smart grid enables a utility to address the impact of the previously described issues in each of its three major business functions:

- **Power delivery**—Reliable delivery of sustainable, economical, high-quality electric power
- **Asset management**—Optimization of asset planning, monitoring, health determination and utilization
- **Consumer experience**—Supporting and enhancing all aspects of the consumer's interaction with the utility

There are many definitions for what constitutes a smart grid, but the fundamental principles required to deliver these capabilities are well-known. Simply stated, the smart grid utilizes sophisticated sensing, embedded processing, digital communications and software designed to generate, manage and respond to network-derived information.

As a result, the grid—and the utility's business as a whole—becomes more observable, controllable, automated and integrated, resulting in improved reliability and efficiency. What's more, the smart grid allows for improved asset and work management, as well as integration of renewable energy sources, distributed generation and storage facilities as components of the supply mix.

1 "Power Delivery System of the Future: A Preliminary Estimate of Costs and Benefits," Electric Power Research Institute, 2004, accessible on http://www.epri.com.

The smart grid has its own issues

However, the very asset that makes an energy grid smart—its wealth of data—also is the barrier that makes it difficult to manage. Accenture's own calculations suggest that the data volumes a utility must handle in a smart grid environment will be multiple orders of magnitude greater than operating a traditional grid.

This explosion in data reflects the fact that a smart grid involves not just more detailed meter information, but a wide range of intelligent devices and data types. To put this in context, if a legacy grid produces data equivalent to one copy of Charles Dickens' novel, *A Tale of Two Cities* every second, a smart grid can produce 846 copies (or more) of Leo Tolstoy's *War and Peace* every second.

This step-change means the implementation of new tools, architectures and processes is a prerequisite for managing smart grid data. And effective measurement, control and optimization of a smart grid demand a new approach to the related analytics and visualization capabilities.

As utilities move toward smarter grids, they will be challenged with an unprecedented deluge of data. A first step toward turning this potentially bewildering flood of new data sources into useful operational information, utilities and their stakeholders need to understand the holistic view of the data components and characteristics.

Dissecting the smart grid data deluge

Data is the fundamental currency of the smart grid. A clear understanding of how this data is generated, what it consists of and the benefits it can be used to deliver is critical to realizing the fullest possible returns from smart grid investments.

To understand these factors, it is important to remember that each smart grid function can support multiple outcomes—and that each outcome can in turn contribute to multiple benefits. Typically, the optimal approach is to design the smart grid's functions with the business objectives in mind, rather than designing a grid first and then seeking potential benefits after the fact.

In general, data management design in any context should optimize outcomes in two ways. First, it should extract clean, consistent and well-understood information that drives targeted benefits for the business. And second—having identified those benefits—it should minimize the costs of infrastructure needed to obtain and process the data necessary to deliver these benefits.

The need for observability

With a smart grid, the sheer volume and variety of potential data means this two-step approach is especially vital. And a further key attribute for managing, controlling and optimizing the smart grid is ensuring that the data across the grid is governed, readily measurable and observable.

This is a particular issue for utilities, as power distribution grids have historically tended to be lacking in detailed observability. Developing a true smart grid requires the creation of an explicit grid observability strategy. Parts of this strategy development already exist in most utilities, but the design will need to "close the loop" to optimize grid performance on a continual basis (see Figure 1).

Creating such a strategy requires a solid understanding of master data, as well as the nature and flow of smart grid data through the organization. This is an area where it is useful to learn lessons from other industries—such as financial services, airlines, retail—that are accustomed to managing and tracking vast amounts of data, often in real time.

In terms of the flow of smart grid data, we have identified five architectural stages that can be used to guide the design of the data management structure. As Figure 2 illustrates, data is initially **generated** by network devices such as meters and sensors, before being **transported** for storage and processing by various applications—the **persistence**

Figure 1. Using grid observability to drive performance.

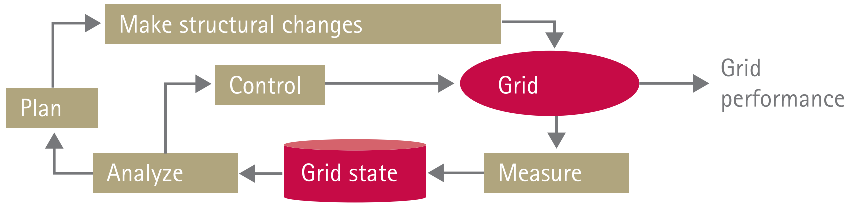
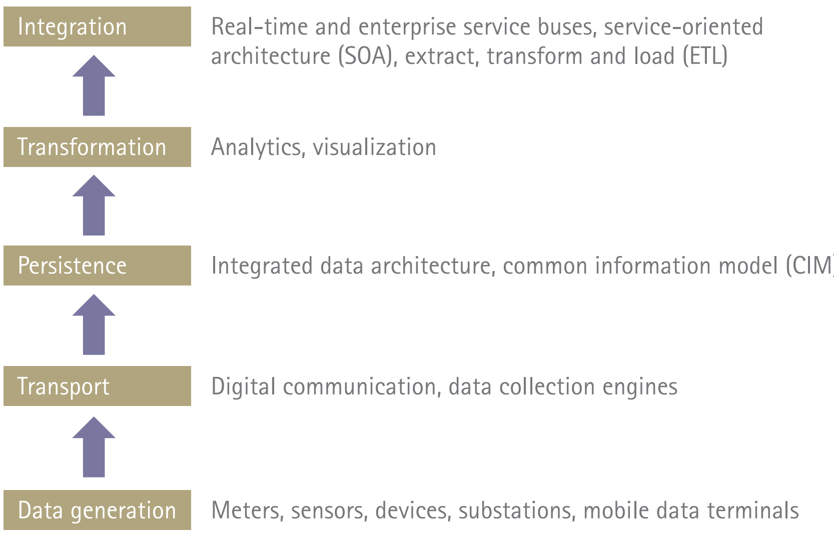


Figure 2. Five architectural stages of smart grid data management.



phase. Then it is **transformed** into actionable operations-oriented information for network and technical analysis, requiring new visualization capabilities. Finally, the resulting analytics applicable for the non-real-time operational consumption are **integrated** at the enterprise level to drive strategic decision making.

Five distinct data classes

What actually comprises smart grid data? Historically, some approaches have treated grid data homogeneously. But data should be treated and managed in different ways based on its source, characteristics and applicability.

There are five separate classes of smart grid data, each with its own unique characteristics.

1. Operational data—Represents the electrical behavior of the grid. It includes data such as voltage and current phasors, real and reactive power flows, demand response capacity, distributed energy capacity and power flows, and forecasts for any of these data items.

2. Non-operational data—Represents the condition, health and behavior of assets. It includes master data, data on power quality and reliability, asset stressors, utilization, and telemetry from instruments not directly associated with grid power delivery.

3. Meter usage data—Includes data on total power usage and demand values such as average, peak and time of day. It does not include data items such as voltages, power flows, power factor or power quality data, which are sourced at meters but fall into other data classes.

4. Event message data—Consists of asynchronous event messages from smart grid devices. It includes meter voltage loss/restoration messages, fault detection event messages and event outputs from various technical analytics. As this data is triggered by events, it tends to come in big bursts.

5. Metadata—Is the overarching data needed to organize and interpret all the other data classes. It includes data on grid connectivity, network addresses, point lists, calibration constants, normalizing factors, element naming and network parameters and protocols. Given this scope, managing metadata for a smart grid is a highly challenging task.

While the first three of these classes are relatively familiar to utilities, the last two have been less prominent to date—and are likely to present more problems as utilities adapt to the smart grid world.

Scoping out the challenges

Utilities face significant challenges across all five classes in applying smart grid data to their processes. The flood of raw data from smart grid devices and systems is not directly usable or even comprehensible. So it needs to be transformed into useful information before it can be acted upon—a task complicated by the fact that the useful information often is not obvious from simple inspection of the data.

Further complications include the need for some information to be used directly by automated systems, while other information must be presented to people in forms they can easily understand. Data also must be used on many different time scales depending on the application, with cycle times ranging from milliseconds to months. Furthermore, information must be managed in a way that matches the local industry structure and regulatory requirements.

Given these factors, our experience shows that most utilities face four major data management challenges in developing smart grids.

The first is in matching the data acquisition infrastructure to the required outcomes. This includes decisions around issues such as the number, kind and placement of data measurement devices, the use of communication networks and data collection engines, and the chosen data persistence architectures. Utilities have tended to take one of two broad approaches to these decisions—either minimizing the data acquisition infrastructure for a given set of outcomes, which is usually the preferable option, or taking a given data acquisition infrastructure and then working to maximize the benefits from it.

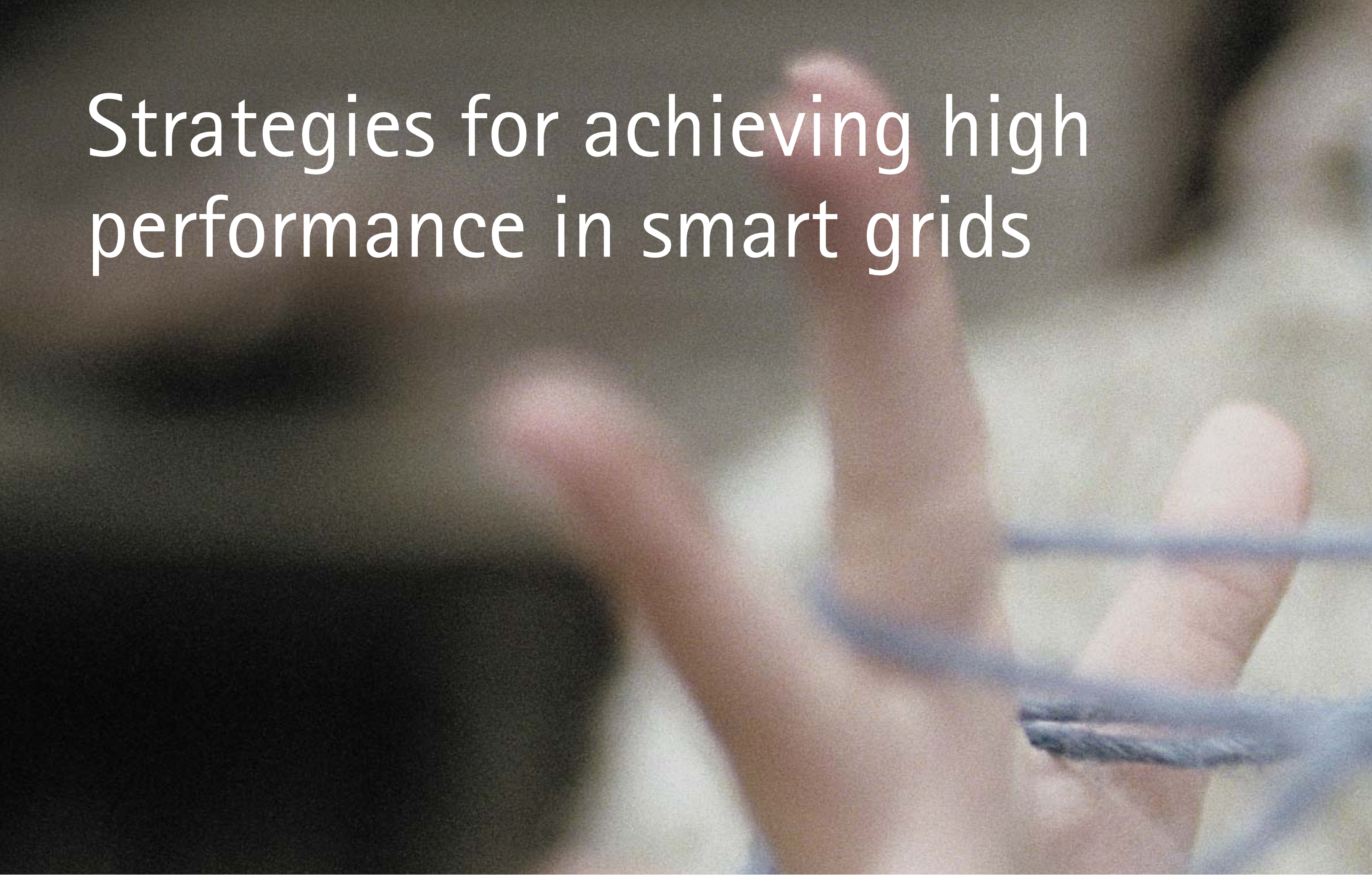
The second challenge is in learning to apply new tools, standards and architectures to manage grid data at scale. This involves pursuing the development and adoption of new open standards for interoperability, creating and managing distributed data architectures, and applying new analytics tools to make sense of the flood of data.

The third challenge is transforming processes throughout the business to take advantage of smart grid technology. Over time, as utilities tackle this need for transformation, smart grids will have the effect of reshaping processes throughout their business, as these are realigned to make the most of the opportunities and benefits. Accenture's High Performance Utility Model global client analysis suggests that 70 percent of retail/customer and transmission and distribution processes have medium-to-high impacts due to the advent of a smarter grid.

The fourth challenge is managing master data to enable the benefits from smart grid capabilities. As utilities increase customer experience through channel management, outage notifications and energy advice, effective master data management is the core nervous system to foster success and growth.

So, given the deluge of data and the challenges it raises, what approach should utilities take? We will now examine strategies for achieving high performance in grid data management.

Strategies for achieving high performance in smart grids



In our view, there are two prerequisites for overcoming the challenges of the smart grid data deluge. One is ensuring that the five data classes we previously highlighted are reflected in the data integration architecture. The other prerequisite is the effective use of the right analytics to turn the mass of data into usable information and business intelligence.

If designed properly, the data architecture will provide the capabilities utilities will need to deal with future change and evolution in their smart grids and business environment. To do this, the architecture will need to include more than just data stores, but also elements such as master data management, services and integration buses to effectively share data and information.

The critical role of analytics

The data architecture must provide a sound platform on which to apply relevant and sophisticated data analytics. Grid data is simply too voluminous for people to comprehend directly, and a large amount of data will be used by systems without human intervention. As the smart grid taxonomy in Figure 3 illustrates, technical analytics are critical software tools and processes that transform raw data into useful, comprehensible information for operations decision making.

As the taxonomy shows, creating operational intelligence is one important aspect of analytics, but in a smart grid environment there is much more to consider. To date, Accenture has catalogued more than 200 smart grid analytics and several classes of technical analytics such as:

- Electrical and device states (including traditional, renewables and distributed energy resources).
- Power quality.
- Reliability and operational effectiveness (system performance).
- Asset health and stress (for asset management).
- Asset utilization (e.g., transformer loading).
- Customer behavior (especially in terms of demand response).

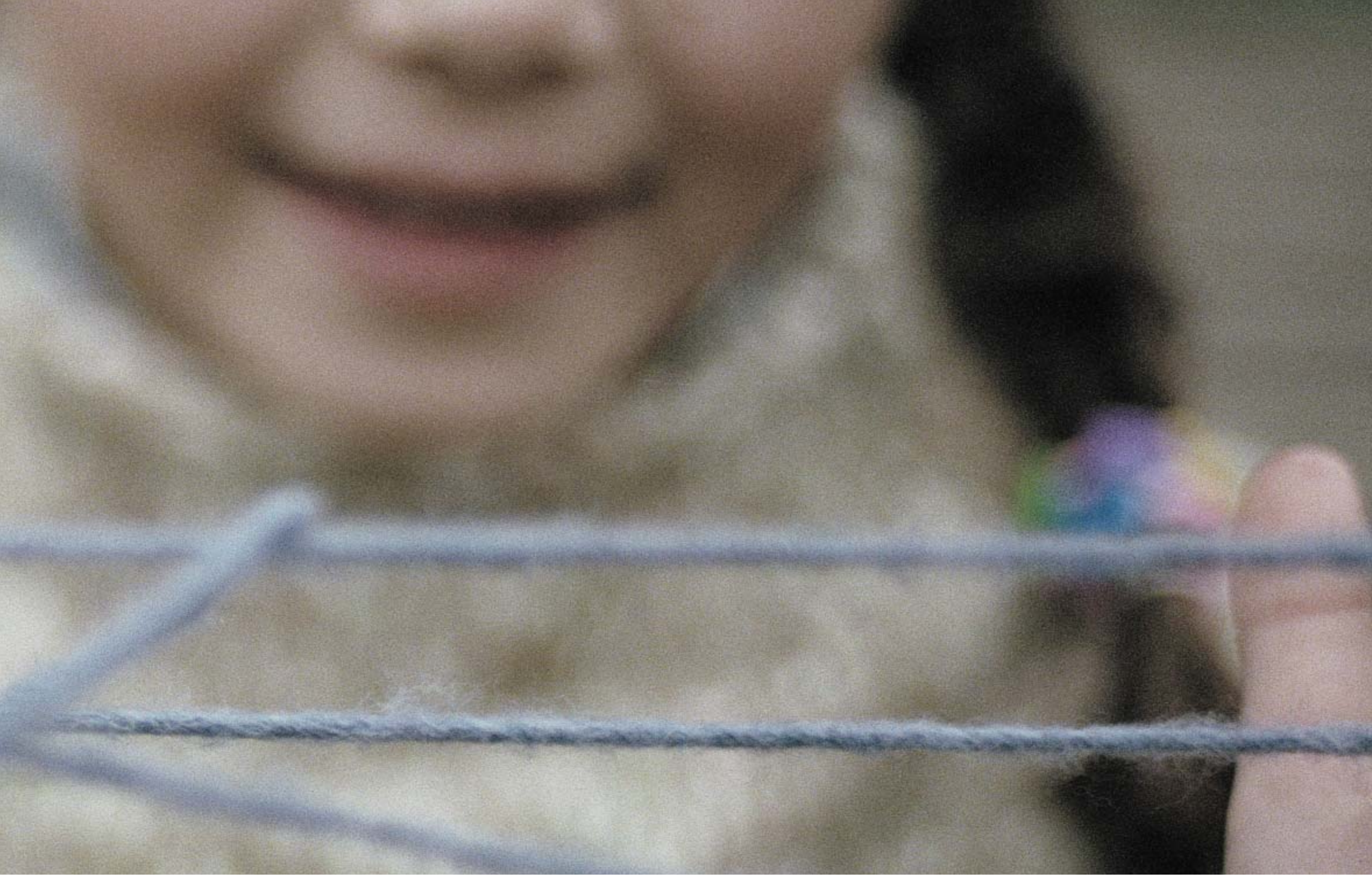


Figure 3. Smart grid taxonomy, showing the role of analytics.

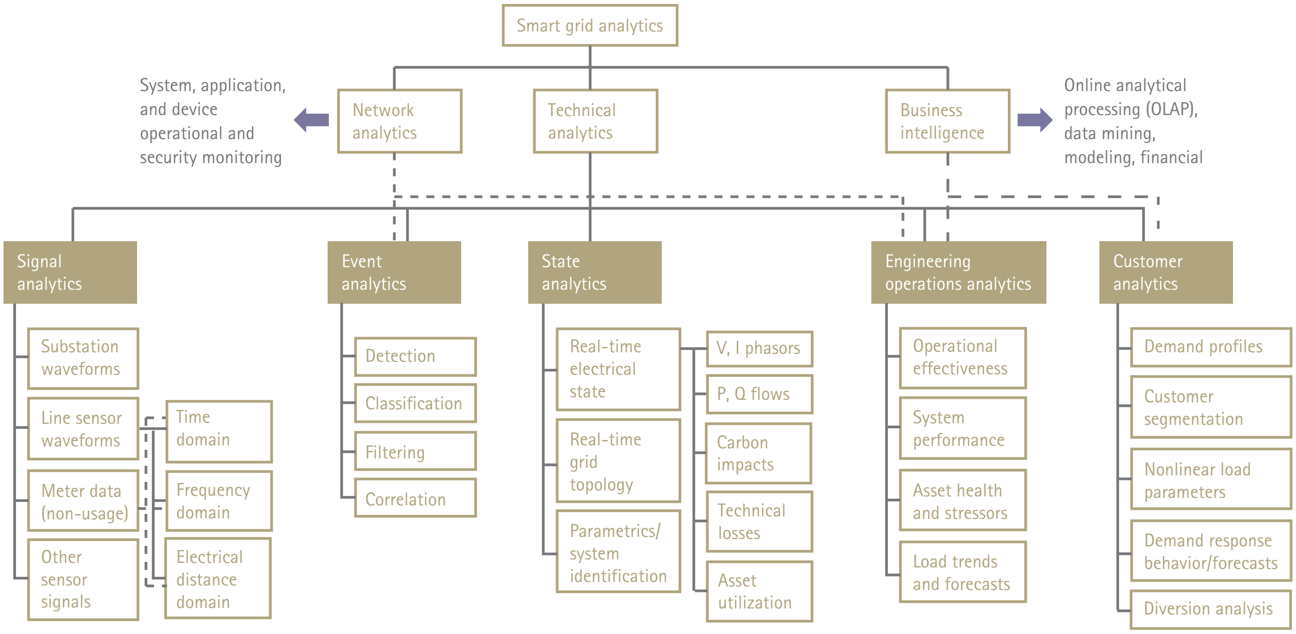
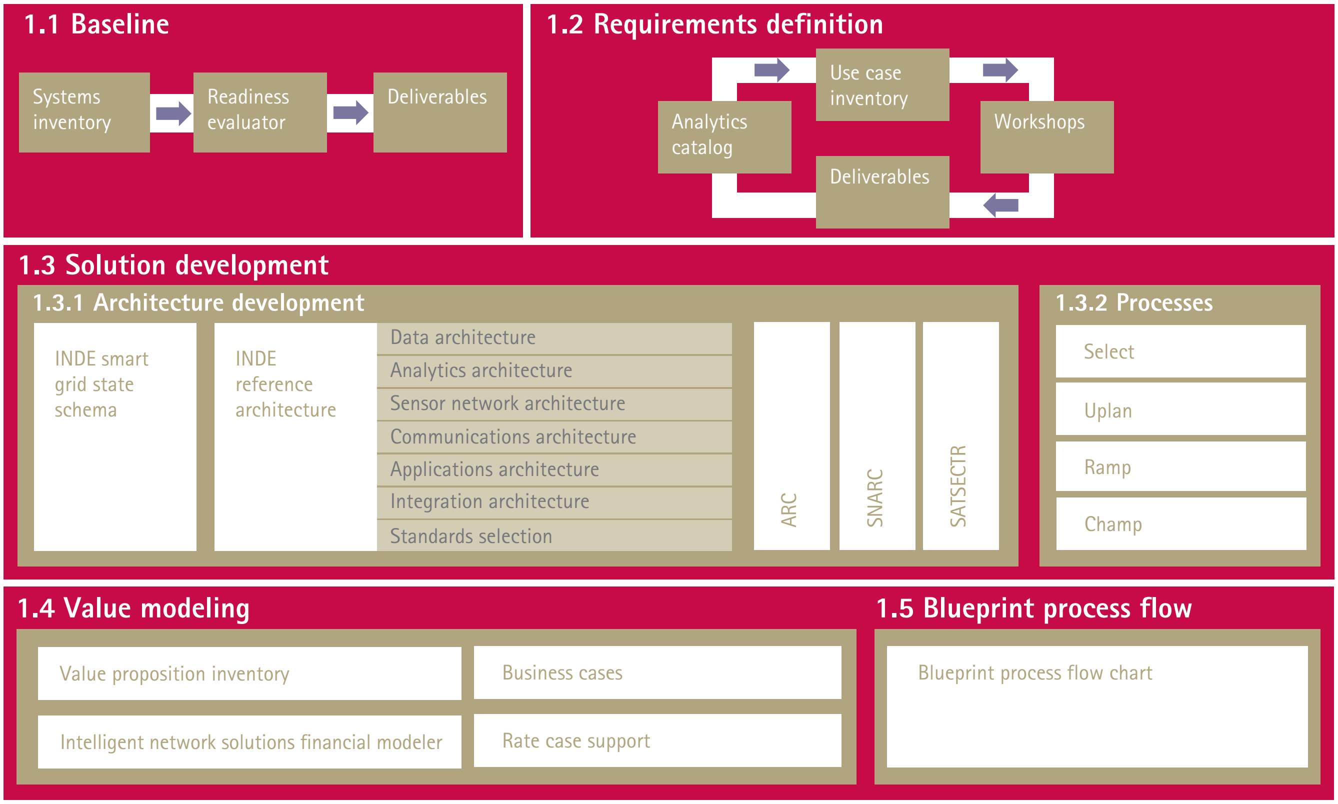


Figure 4. Accenture's smart grid blueprint development methodology.



Note: ARC = Architecture Configuration, SNARC = Sensor Network Architecture, SATSECTR = Sensor Allocation via T-Section Recursion

Building the architecture

No two utilities will have the same smart grid. Employing a flexible methodology to develop the right architecture and components for each utility environment is critical. In addition, the ability to design the right technical and operational analytics for each utility's unique needs will have a profound impact on the data management architecture. We use a blueprint to design smart grid data management capabilities and solutions (see Figure 4). Drawing on tested reference models, tools and processes (including observability strategy development), this type of blueprint methodology can help utilities optimize the predictability of the outcomes.

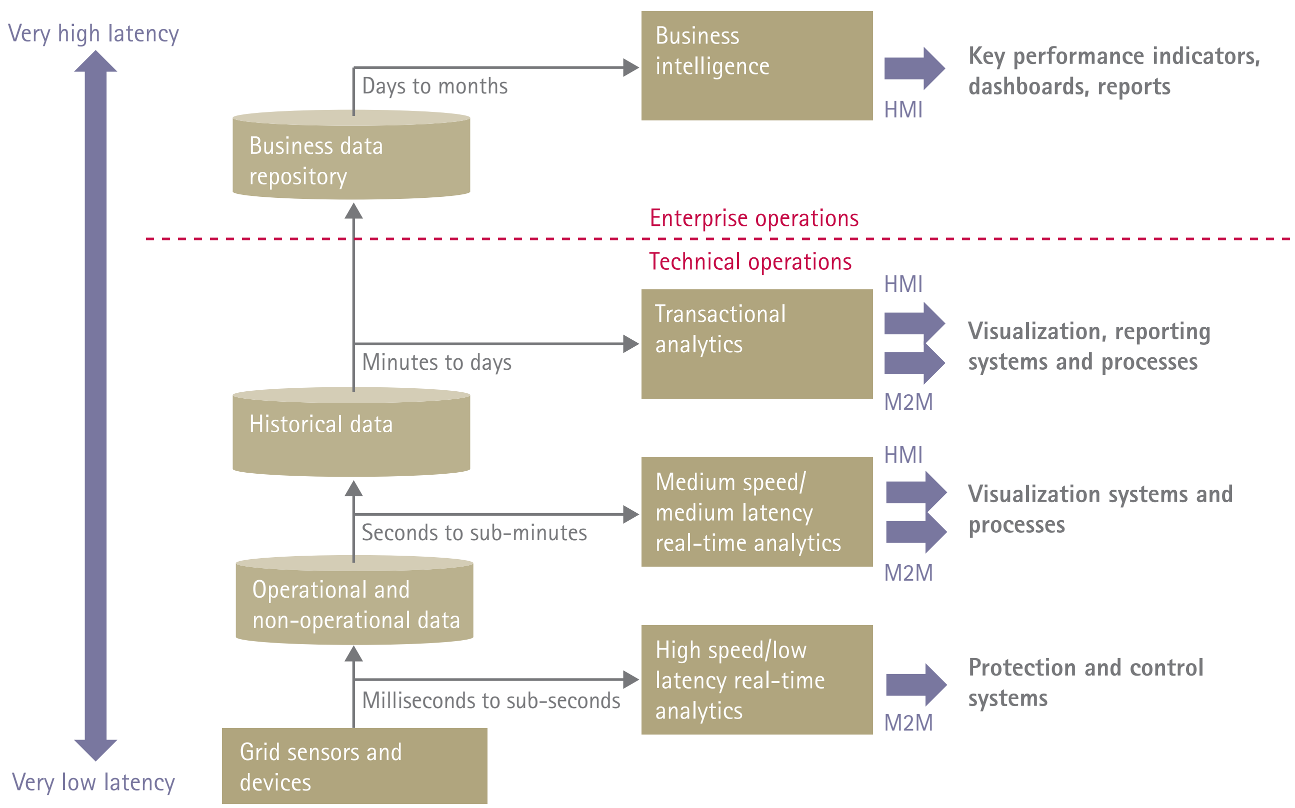
The data latency hierarchy

When incorporating analytics into the data management design, we find that two major considerations are data time scales ("latency") and volume scalability. Due to varying application requirements, some analytics must be available at high speed and with low latency (milliseconds), primarily at the level of grid sensors and devices. Others fall into the seconds-to-minutes range, including those for operational processes such as operational efficiency verification, real-time utilization optimization (load balancing) and outage management, while still others may play out over hours, days, weeks and even months.

To incorporate varying levels of latency accurately into the data management architecture, utilities should construct a data latency hierarchy of the type illustrated in Figure 5. This enables the data to be treated and analyzed differently on the basis of its latency and applicability, ranging from the lowest-latency data, where real-time technical analytics feed into protection and control system, to the highest-latency where operational analytics can feed into business intelligence management dashboards and reporting.

A key consideration in constructing the proper use of analytics is that large volumes of data associated with distributed assets can make centralized computation of analytics problematic. Proven and workable solutions to this include implementation of distributed data management and analytics.

Figure 5. A data latency hierarchy for smart grid applications.



Note: HMI = Human to machine; M2M = Machine to machine

Maximizing the benefits

On top of these basic requirements, there are a number of techniques and approaches that utilities can use to drive the benefits from smart grid. One is complex event processing—a relatively new computing platform that involves continually running static queries against multiple dynamic data streams. This enables a utility to manage the bursts of asynchronous event messages generated by smart grid devices and systems when an event (usually a problem) arises on the grid. Event processing or complex event processing is not widely utilized in the utility industry and a fundamentally different approach to the standard transaction management approach used universally today. However, this approach does have proven scalable usage across other industries, such as financial services and airlines. Complex event processing must be considered holistically as a key component of the new data management approach with the advent of the smarter two-way grid.

Alongside technical and operational analytics involving massive numerical computations from the smart grid, another valuable platform for consideration is visualization techniques—effectively a direct extension of analytics for the human eye and brain. By replacing hard-to-understand columns of streaming numbers with well-considered graphic depictions integrated from multiple sources, visualization platforms can provide instant comprehension and avoid "swivel-chair integration," or the process in which a human user re-keys information from one computer system to another.

Finally, as we previously pointed out, the smart grid creates an overwhelming need for redesign and re-engineering of processes throughout a utility's operations; Accenture research shows that approximately 70 percent of processes are affected by the smart grid. To make this change as smooth and effective as possible, utilities should look to develop their business process transformation plans at the same time as smart grid application and services designs.

Achieving excellence in smart grid data management: Seven top tips

Accenture's expanding knowledge and experience of smart grid data management has enabled us to draw up a list of seven key points of leading practices when developing and implementing smart grid solutions:

1. Recognize smart grid data classes and their characteristics to develop comprehensive smart grid data management and governance capabilities.

2. Consider how data sources can support multiple outcomes via analytics and visualization to realize the maximum value from the sensing infrastructure.

3. Consider distributed data, event processing and analytics architectures to help resolve latency, scale and robustness challenges.

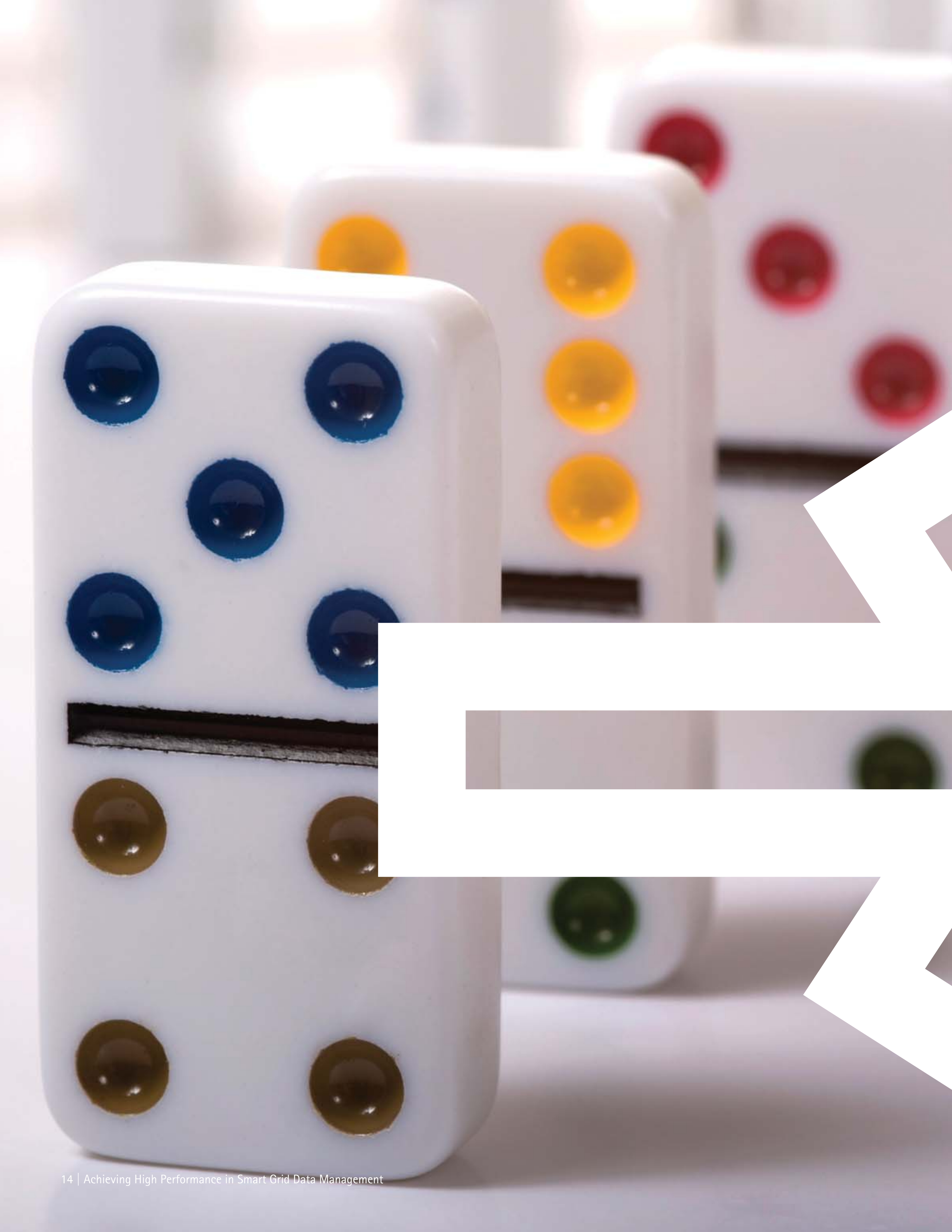
4. Holistically consider the smart grid challenge when planning data management, analytics and visualization capabilities—not just advanced metering infrastructure—to avoid stranded investments or capability impediment.

5. Design data architectures that leverage quality master data to match data classes and analytics/application characteristics—a giant data warehouse is rarely maintainable.

6. Look to new tools such as complex event processing to handle challenges around processing new classes of data; managing the new smart grid data deluge via historical transaction processing approaches is likely not scalable.

7. Develop business process transformation plans at the same time as—and in alignment with—smart grid designs.

Following these points of leading practices can improve a utility's chances of reaping optimal long-term returns from its smart grid investment.



To find out more about how Accenture can help your utility design and implement a smart grid data management solution that will support your journey toward high performance, please contact:

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Accenture's more than 7,500 utility industry professionals include many of the industry's leading smart grid, advanced metering, sustainability, cyber-security, customer care, network communications and system operations consultants, who have worked with more than 360 clients in 43 countries for more than 30 years to tackle the unprecedented challenges facing today's utility companies.

From generation to in-home energy management, from strategic blueprints to operational data analytics, and from the boardroom to the operations center, Accenture offers the skills and experience that utilities and their customers need to frame their vision of a smarter grid and then achieve its many benefits.

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