WHITE PAPER

Modernize your grid:

How utilities can get what they want, by doing what they must

EXECUTIVE SUMMARY

No matter where in the world you operate, every utility is confronted by a multitude of business drivers, competing for scarce resources, and imposing change on their business environment. Some are within your control but many are not.

Businesses who have already begun the journey to modernization have discovered that by changing the way they think and act, they can often satisfy multiple business drivers with a single investment.

In this paper, we will look at the rapidly-changing business environments that utilities face, where the issues reside, what must change and why. We will see some successful use cases, how forward-thinking organizations are making the transition, and the very significant return on investments these changes delivered.

Find out about:

- What motivates change?
- The renewables challenge
- Changing business in a changing world
- The cultural shift for Utilities
- Putting it all together
- How analytics can drive business value

WHAT MOTIVATES CHANGE? UNDERSTANDING THE CHANGE DRIVERS

The business change drivers that all utilities face, fall within three categories:

1. Regulation (what you must do)
2. Obsolescence (what you need to do)
3. Technology (what you want to do)

Regulatory changes
These are big motivators on political, economic, environmental and social levels. New mandates include critical infrastructure cyber-security protection, smart metering and meeting aggressive renewable energy targets. They might involve supporting home solar and reverse metering, electric vehicle charging, and time-of-use metering - complex requirements in mature grid environments that were designed for one-way energy flow billed on a thirty-day cycle.

Ageing infrastructure
A significant investment driver for most utilities, 21st century realities are rapidly making 20th century grid architecture and equipment obsolete. Under previous operating models, there had simply not been a reason to remotely access and control grid devices (even though old electro-mechanical relays and grid devices have been replaced by intelligent ones for over a decade).

In today's energy reality, managing two-way energy flow, automating the distribution system, and engaging customers all require significant investment to drive intelligence into the system and reduce the need for human resources. Utilities are investing in wide area, field area and meter data networks that can link information flow and energy flow, to modernize the entire energy value chain.

New technology

This brings the promise of business innovation such as grid automation, predictive and condition-based maintenance, asset life-cycle optimization, and dynamic voltage optimization. Any one of those can remove significant costs, yet on its own, can rarely justify the investment; it is very difficult to justify improvements to business efficiency that provide no discernible benefit for your customers.

While it is important to understand the differences, looking at these drivers individually can easily result in missed opportunities. Instead, operators can use those unavoidable regulatory and compliance changes, and make investments that will also address ageing infrastructure, to take advantage of technological advancements.

HOW TO GET WHAT YOU WANT, BY DOING WHAT YOU MUST

Economic dependence on reliable energy cannot be understated, so one of the most critical processes utilities go through is to prioritize when and where to spend money, to maintain reliable energy supply. Obviously, your first spending priority must be regulatory compliance, so your first question must be “Can our grid do this? What is required to comply?”

But you should also ask: “Can we remove obsolescence at the same time?” “Can we implement automation in the process?” “Can we follow an optimization framework at the same time as we meet regulations?” Even mandated modernization has multiple possibilities, so wise operators will leverage available capital to achieve many of their needs and wants.

Utilities are investing massively in compliance initiatives, particularly cyber security and renewable integration. From a business perspective, cyber security provides little return, beyond compliance itself. Conversely, integrating renewables is an act of self-defence to preserve grid stability.

Either way, modernizing the grid architecture - including the transition from radial to mesh grid topologies - is a very big deal indeed. A planned optimization framework can broaden the strategic intent of every compliance investment. Then, as compliance occurs, the optimization framework guides your technology and systems choices, and their specific monitoring and control capabilities, to improve the information flow that supports it.

RENEWABLES IN THE EUROPEAN UNION

The EU has a renewables target of 20% by 2020. By March 2013 the first progress report said in aggregate, they had achieved an impressive 12.7% and the increase in renewables is rising rapidly.

According to the European Commission’s Institute for Energy and Transport’s Joint Research study, 2013 saw investment of more than EUR 3 Billion in R&D, demos and deployment of Smart Grid-related systems (including integrating renewables). In 2015, over 600 Europe deployment projects were started - that number is likely to increase yearly through 2020. However, many utilities that have yet to cross the threshold (or that have sufficient biofuels to balance solar or wind) will reach the limit of their variability control before 2020

The renewables challenge

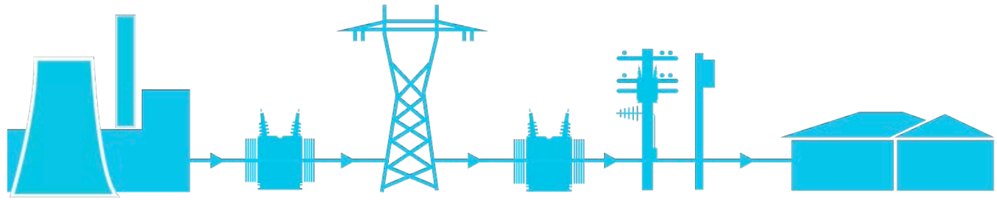
One of the first challenges is preparing for an increased mix of renewable energy, including co-generation where an industry may produce electricity as a by-product of their operations, such as biomass from farms. The fact that these sources of energy may be seasonal or weather-impacted, adds complexity.

Many utilities are essentially connecting renewables to their existing grid, and relying on their existing controls to absorb the variability inherent in renewables. When energy from renewables drops suddenly, voltage on the system drops. Controls jump in to rebalance the system, adding contribution from spinning reserves, or executing some form of load management. As long as the existing system can absorb the variability through its transformers, regulators and cap banks, power to the consumer remains unaffected.

But increasingly, renewables targets are moving utilities beyond their capacity to absorb variability. Eventually, you exceed your range of controls and the variability threatens power quality and voltage. Now, you have no choice but to modernize your grid architecture with active control systems. Traditional radial grid architecture will require additional substations, whereas modern MESH grid architecture can spread the variability across multiple existing substations.

The traditional energy value chain

In the traditional energy value chain - the path of the electrons as they are generated, transported, distributed and delivered to consumers - predictability shaped how the grid was designed. There was typically one generation provider (though there may be many generation facilities), and over-generation guaranteed enough energy to overcome losses within the system.



Most systems were designed for growth, but virtually all have experienced growth beyond expectation. If you introduce unplanned generation or unplanned loads (such as mandated renewables), you quickly reach your voltage control limits. So – by regulation and obsolescence - the imperative for more agile utilities increases.

"An incremental reduction in traditional generation can still contribute to mandated renewables compliance, but the grid must be modernized to support a more flexible energy value chain."

Upgrading the energy value chain

The modern energy value chain needs voltage regulation throughout the system. With distributed generation, some sources may still be regulated with common interconnects, transmission substations, and connections into traditional systems, centrally managed and working with existing generation and transmission control environments. So when it is cloudy and there is no wind, traditional generation runs near capacity; when the sun is shining, the generator can reduce its output. Fully integrated systems maintain constant output capacity by controlling and balancing each source, depending on conditions.

An incremental reduction in traditional generation still contributes to mandated renewables compliance, but the grid must be modernized to support a more flexible energy value chain.

CASE STUDY:

A utility in the Pacific Northwest monetized power at its source and followed it through the energy value chain, increasing and decreasing its value depending on source contributions, peak loads and other operational factors. It then applied analytical algorithms that could optimize energy flows to deliver the lowest cost watt under any given conditions. They achieved all this with their existing physical infrastructure, and the monitor and control systems they already had. They simply used them differently.

It's simply data and mathematics. Information is aggregated, correlated, analysed, and reported to produce a better outcome. This level of active control drives impressive business value, yet the underlying driver is renewables compliance.

When you couple renewables (what you must do) with the replacement of legacy grid devices with intelligent ones (what you need to do), you end up with wide-area sensory and control to monitor and control the system more closely. The results can be astounding.

CHANGING BUSINESS IN A CHANGING WORLD

Across the utilities sector, there are leaders and followers in the drive to modernize. That is often reflected in the way businesses communicate with their customers and communities. Some are very proactive - on Twitter and Facebook, sharing stats and engaging in conversations about energy costs, reliability and renewables.

Others continue to communicate through their monthly bills, and a passive web presence. They still have work to do, to achieve the communication that customers, partners and regulators expect – or demand - in the 21st century.

The same applies to their approach to grid design. Utilities historically spent money on infrastructure and technology reactively; they rarely embraced consistent standards across their footprint for more than a few years at a time. Instead, regional operations make decisions based on OEM relationships, and the stage of evolution their part of the grid is at. Well-intentioned "modernizations" resulted in multiple applications and networks supporting the same functionality, slowly increasing resources, skills and maintenance cost.

Many of the challenges utilities face are the direct result of this technology disparity. Investments were tactical with very little strategic intent - there were separate outage management systems, GIS platforms, data warehouses, little distribution monitoring and control, and single-purpose networks. For example, one utility had accumulated more than 20 unique network types supporting SCADA alone. They supported and maintained flavor-of-the-month wireless, twisted pair, four wire, dial up, microwave, satellite and cellular… you name it.

Fortunately, those days are over, as utilities – by choice or compulsion - establish common standards across their business. Today, utilities leadership focuses on increasing functionality across their business, and extracting maximum value from capital investments.

The changing energy value chain has a unifying effect, so utilities can establish collective standards, design principles and operational tools and procedures that improve deployment repeatability. What does that mean for utilities?

- Major platform decisions have long-term strategic value beyond tactical requirements.
- Utilities collaborate across operational departments that were once "silos". IT assumes cyber security compliance responsibility and enterprise integration. Incident, event and issue management are integrated at the operations center.
- Greater links between IT and OT. Information Technology Information Library (ITIL) disciplines are being implemented in OT; design management, release management, capacity and performance management are now central to the OT domain; deployment and coordination management sit alongside change management and asset management.
- Combining configuration management and knowledge management improves the efficiency and effectiveness of grid operations.

Advanced Distribution Management Systems (ADMS) is a perfect example of a solution that extends beyond a specific use (such as renewable integration) to become a unifying modernization force. Because modern ADMS does not orphan existing SCADA systems, most devices that can be connected to legacy SCADA can also integrate with ADMS. And ADMS supports a huge range of data acquisition schemes, to trade off the value of the data against the cost of the networks that transport it.

REACTIVE TO PROACTIVE: A CULTURAL SHIFT FOR UTILITIES

So where do we start? Most (if not all) utilities begin by optimizing the networks they already have. As a result, wide area networks that were once the domain of grid operations are now delivering enterprise applications and other business services over common transport networks.

Automating data gathering and analysis can dramatically reduce operating expenses. The data that determines grid performance, analyzes outages, restores services and meets the demands of customers has always existed, but gathering it was costly. Crews drove the streets, visually examining and assessing damage, and outages often cascaded upstream, potentially causing generation to automatically shut down, resulting in widespread blackouts and substantial economic loss.

Distribution automation can detect outages, determine the distance to the fault, characterize the fault, automatically correlate events from substation to feeder to reclosers, and know who to send - with the right tools and skills - to restore service.

A utility with smart metering might also use the meter data network for:

- power quality measurements,
- supporting distribution automation,
- street light control,
- grid monitoring.

Less obvious however, is how readily-available data can also be used to anticipate faults, take proactive measures to prevent outages, and provide insights that improve planning and management of the grid.

This is automation beyond monitor and control of assets. It means reusing data intelligently, and developing ways to analyze and apply those new insights. For example, energy flow information can provide tremendous insight into the health of equipment, so that proactive, condition-based maintenance can take place, and more effective load balancing or stress-reducing configurations can be made.

When you combine embedded intelligence, pervasive connectivity and advanced analytics, the result is:

- an orchestrated grid,
- optimized asset lifecycles,
- reduced windshield time,
- improved situation awareness and response capabilities.

And you can have all this while achieving compliance to regulatory mandates that integrate renewables, and improve your overall system efficiency and reliability.

PUTTING IT ALL TOGETHER

With all this business value for the taking, you cannot overlook the networks that connect field devices to the applications that monitor, analyze and execute control schemes that result in optimized grid performance and resilience. Communications will be a major part of the conversation, to manage rising operational expenses, provide visibility and enable integration.

That conversation inevitably leads to the nirvana of grid communications - push-to-talk-capable, private broadband LTE network that is cheap, pervasive, secure, and fully integrated with grid operations. Mobile voice and data, substation backhaul and end-point connectivity? It would do it all.

Unfortunately, spectrum, site development, equipment and operating costs make it a non-starter for most utilities. Public LTE has a significant role (workforce management, meter data backhaul and device monitoring) but there are limits. You simply cannot rely on public wireless for critical control.

However, you can easily increase utilization of your LMR system. LMR has always supported legacy monitor and control environments, yet the one-channel-one-transaction model was inefficient, and jeopardized service for mission-critical voice. Performance was uncertain and results often sub-optimal.

Utilities transitioning from legacy MPT or Analog Voice network to a DMR Tier III network can anticipate some important changes:

- mission-critical voice and data on one network,
- channel capacity has effectively doubled (without extra channel acquisition),
- coverage is at least as good as your analog networks,
- other compliant DMR Tier III mobiles and portables work on your network,
- you have data service management resource.

Data capability on your voice network provides a compelling business case for DMR Tier III. Outage management and analytics are just two examples.

Outage Management

Let’s start with how it was done historically. A tree falls on a remote power line, creating a high impedance short circuit to ground. It will likely impact power quality, but may go completely undetected from an operations perspective. Over time, it becomes a direct short. An upstream grid device detects the sudden rise in current and drop in voltage, causing a fuse or breaker to open, a low voltage transformer to explode or (if they are lucky) a recloser to spring open.

Assuming the recloser is attached to a timer, it will open, wait for a (configurable) time, then close. If the short persists it will open, wait, and then try again. After the third try, it will remain open until someone manually recloses it. Now, irate customer calls alert you to the outage, triggering the time-consuming, resource-intensive and costly process of detecting, identifying, isolating and remediating the fault.

What happens when distribution automation is deployed? The recloser detects the fault instantly, and feeds that information back to the advanced distribution management system. It keeps the circuit open, identifies downstream switches that could isolate the short circuit area, and restores power everywhere else. It also identifies points the fault lies between, and estimates the distance to the fault, based on waveform data captured in the recloser’s embedded intelligence. And power is restored much sooner.

An outage management system can then poll and gather data from devices that may have been impacted. A remote asset monitoring and management system can

determine the type and duration of the event each device experienced, and assess the implications on maintenance and life expectance.

Analytics that drive business value

Grid automation and analytics are game-changers, and will certainly be at the forefront of developments down the track. As a pool of information grows, analytics can correlate, parse, model, estimate and massage data until there are sufficient insights to drive actions. Those actions drive optimization.

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For now, most utilities simply want to access, monitor and manage devices. That may not be as advanced as automated fault detection, or complex distance-to-fault calculations, but it is incredibly practical, and saves utilities a ton of money. Let's look at key business benefits coming out of grid modernization - advanced distribution management systems, grid automation, and digital mobile radio - right now:

- **Remote asset monitoring and management is reducing truck rolls**. A large US power utility (with an electricity customer base of more than two million), has estimated the average cost of a truck roll at $500 - labor, fuel, insurance, vehicle expenses etc. Using government grant money to upgrade their communications monitoring and visibility, they eliminated 130,000 truck rolls a year - over 350 a day. Annual savings total US$65M from just that one benefit; there are many others that will multiply savings and efficiencies.
- **Strategic prioritizing justifies continued optimization**. If you start by targeting infrastructure and equipment that cost the most to get to, then deploy radio terminals to remotely monitor and manage those, chances are each terminal will pay for itself in just one avoided callout. You can demonstrate a return on investment by comparing reduced (or avoided) outage to justify further terminal deployments.
- **Automated fault detection, isolation, and service restoration reduces outage frequency and duration.** Grid reports can tell you where the fault is, and what the system did mitigate the problem. You can dispatch resource to the right place with the right skills, equipment and tools to fully restore service on the first trip. Ultimately, that keeps both customers and regulators happy.
  In a C3 Energy Report filed with the US Dept. of Energy, Duke Energy reported $330M in benefits.
- **Conservation voltage reduction reduces energy consumption and system losses.** Tuning the system to a slightly lower voltage forms the basis of virtual power plants that reduce consumption through voltage reduction caused by fluctuating renewables output. The system absorbs variability yet still delivers constant output to the consumer.
- **Predictive (condition-based) maintenance replaces scheduled preventative maintenance.** Traditional maintenance schedules had little to do with the condition of assets, and everything to do with the calendar. Using returned poll responses to provide a continuous view of voltage, current and phase, analytics can associate high stress events, peak voltage, currents, and durations, to show what an asset has experienced. Is it within the normal limits? Accumulated stress events mean you can predict and prevent failures, understand your assets' overall condition and predict life expectancy. Load balancing schemes can take the stress off.

WHERE TO NOW?

Even from the data you currently collect, we can see that the power of math is limitless in the insights it can provide. Analytics take it a step further, to deliver insights to drive actions. So the next challenge for utilities is no longer just to know what is happening - it is the capacity to act on it.

As you begin your optimization journey, there are systems, products, and people out there, ready to help you do exactly that.

About the author:

Philip Mullins is an independent executive consultant who has specialised in emerging technologies for more than 30 years. As well as applying his thought leadership expertise to utilities and communications, Philip's career includes working with the US Air Force, IBM, Motorola, and most recently, Tait Communications.