Engineering the 21st Century Utility: A Changing Industry

The first in a series of whitepapers addressing the challenges of creating and operating intelligent utility infrastructure

A Bentley White Paper

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In the second half of the 20th century, Western nations' easy access to cheap and abundant energy, coupled with their ability to generate, transmit, and broadly distribute electricity, brought far-reaching prosperity. However, the old paradigm can't sustain energy delivery from fossil fuels while also meeting mandates for a cleaner, safer, and more sustainable world.

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The Challenges of Yesterday's Grid

The generation of electricity is the single largest source of CO_2 emissions in the United States, representing 41 percent of all CO_2 emissions.[1] Meanwhile, rapidly developing nations in Asia and South America are adding considerably to the environmental threat posed by carbon emissions. The onus to change is on all of us: consumers, industries, governments, and developed and developing nations alike. Clearly, it is in the best interests of the electric utility industry to lead the way.

Utilities worldwide are facing powerful economic incentives to reduce carbon emissions. As Angel Gurría, secretary general to the Organisation for Economic Co-operation and Development, explained during a speech at the World Energy Council: Energy Leaders Summit, "We are reaching a convergence in our understanding of the main elements of a cost-effective strategy to tackle climate change. … Cap-and-trade schemes, or emission taxes, are cost-effective because they induce firms to look for abatement options where they are cheapest, and boost incentives to scale up climate-friendly R&D. Leaders must build on recent developments and act now to make greater use of economic instruments.[2]"

For utilities, economic incentives may be just the beginning. Their failure to respond proactively and take control of their own destiny will likely result in their increased regulation by government. Without question, the tasks faced by today's utilities are formidable: plan for a sustainable, efficient, reliable, available, and affordable electric grid; reduce carbon and other noxious emissions; and simultaneously support the aspirations of developing economies.

To successfully complete these tasks, here are some of the challenges they must address:

- Pollution: Globally, power generation emits nearly 10 billion tons of CO_2 per year.
- Climate change: Worldwide concerns are fueling legislative demands to replace fossil fuels with renewable energy sources.
- Reliability: When the Chicago Board of Trade lost power for an hour during the summer of 2000, trades worth about $20 trillion could not be executed.
- Growing consumption: Worldwide energy consumption is predicted to double by 2040 compared with 2007.[3]

1 United States Environmental Protection Agency
2 Angel Gurría, "Energy, Environment, Climate Change: Unlocking the Potential for Innovation," London, 16 September 2008
3 How much energy will we consume in the future? Time for Change: Prediction of Energy Consumption Worldwide, www.timeforchange.org/prediction-of-energy-consumption

- Increasing demand for storage, transmission, and distribution capacity to support new energy sources such as wind, solar power, and micro-generation.
- Aging grid: The architecture of the grid has not changed in 80 years, and some equipment, specifically substation equipment, has reached the end of its life.
- Aging workforce: Retiring utility workers must train new workers so they can continue to maintain the utilities' 20th-century technology until it can be replaced.[4]

Experts around the globe agree that current investment is insufficient to meet new challenges or even maintain the existing grid. Increasing the challenge, the worldwide recession has temporarily slowed demand for electricity, making capital even more difficult to obtain. Utilities realize they must do more with less. For example, Paola Petroni, head of network technologies at Italian energy provider Enel, recognizes that investments must be spent "not just in laying new cable, but trying to use [energy] in a better way.[5]"

This means the multidisciplinary teams that utilities assign to reinvent, rebuild, and expand the electric grid are expected to use their resources carefully. In the process, they will encounter financial, political, scientific, and technical challenges. One challenge they already face – information management – will only get worse if the teams fail to take control of it immediately.

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To implement the "smart grid," which shows extraordinary promise, electric utilities will need to manage and distribute information more efficiently. Some utilities have used geospatial information systems (GIS) for this purpose since the 1980s and this technology has served them well. However, GIS systems do have drawbacks that today's utilities must overcome. Traditional GIS architectures are saddled with proprietary data stores, data structures, and languages, making these tools largely inefficient for the kind of workflows that a progressive utility requires. With these architectures, extensive graphic and business data remains outside the GIS. As a result, many utilities continue to have large amounts of unstructured data outside of an enterprise system, making the data difficult to access. This hampers the planning and engineering efforts of teams working to meet the challenges of the 21st century and results in lost time and money. To implement the "smart grid," electric utilities need a more efficient means of managing and distributing information.

The Promise of Tomorrow's Smart Grid

Even with cuts due to the recession, there is investment capital available. According to Richard Rudden of Black & Veatch Corp., "Capital investments for generation, transmission, and distribution will be substantial, averaging about $75 billion per year between 2008 and 2010.[6]" Moreover, a 2009 PricewaterhouseCoopers survey revealed that developing new generation capacity and renewing existing generation plants are priority areas for most utility companies.

4 "All Things Considered" National Public Radio, April 30, 2009
5 "Girding for a Global Revolution," EnergyBiz Insider E-Newsletter, March 2, 2009
6 "Beacon of Light," EnergyBiz Insider E-Newsletter, March 11, 2009

The survey reports that, "Eighty-three percent are seeking to make medium to large investments in new generation and 79 percent are seeking to do likewise in transmission.[7]"

Governments around the world are beginning to support these priorities. For example, U.S. President Barack Obama has declared a policy goal to increase investment in renewable energy sources that reduce carbon emissions. As J.P. Cunningham, of the Atlanta-Journal Constitution, points out, "For the first time in seven decades a U.S. president has drawn attention to the need for investment in the electrical grid: this time in expanding and modernizing an established grid. The federal government is providing billions of public dollars, including a $4.5 billion investment in the transmission grid.[8]" And support is also evident in Europe, where Utility Week noted that "Denmark's parliament has provisionally approved a plan to invest €3.5 billion to upgrade the country's electricity grid between 2009 and 2016.[9]"

Nuclear power, once seen as an unclean and potentially unsafe technology during the era of cheap and abundant fossil fuels, is receiving new attention because advanced nuclear reactors do not emit carbon dioxide. However, coal will still be the largest source of power generation over the next several decades. "Coal is an abundant resource in the world ... It is imperative that we figure out a way to use coal as cleanly as possible," said U.S. Secretary of Energy Dr. Steven Chu, during his Senate confirmation hearing, January 13, 2009.[10]

"Modern utilities must develop and support an increasingly broad portfolio of generation types."

Modern utilities must develop and support an increasingly broad portfolio of generation types, including large-scale renewables that are a growing part of the power-source mix. Pressure to reduce carbon emissions has elevated the importance of including renewables in utilities' short-term generation strategy. Within the last decade, advances in technology have brought the industry more affordable renewable generation contributions from wind and solar power. Currently, wind generation is the fastest growing and most widely used renewable technology. In the United States, the amount of electricity generated from wind has nearly doubled between 2006 and 2008. Additionally, in January 2010, Gordon Brown, the former prime minister of the United Kingdom, announced his support for nine next-generation offshore wind farms that will provide an additional 32GW of clean energy to that nation's electric grid.

Micro-generation – the use of small scale renewable power generation sources by home owners and businesses – has the potential to relieve some of the stress on the existing grid. A report in Associated Press Weekly stated, "What smart grid visionaries see coming are home thermostats and appliances that adjust automatically depending on the cost of power; where a water heater may get juice from a neighbor's rooftop solar panel; and where on a scorching hot day a plug-in hybrid electric car charges one minute and the next sends electricity back to the grid to help head off a brownout.

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7 "Utilities global survey: A world beyond recession: Key Observations," PricewaterhouseCooper, London, May 7, 2009, www.pwc.com/extweb/ncpressrelease.nsf/docid/18B08C9B5A2BCDA8852575AE006EC395

8 J.P. Cunningham, "Outdated Grid Needs to be 'Smarter,'" Atlanta Journal-Constitution, May 12, 2009, page A-10

9 "Denmark approves €3.5bn to upgrade electricity transmission grid," Utility Week, Feb. 6, 2009, www.utilityweek.co.uk/news/europe/denmark-approves-35bn-to-upgra.php

10 As quoted by the U.S. Department of Energy, "Clean Coal Technology and the Clean Coal Power Initiative," www.fossil.energy.gov/programs/powersystems/cleancoal/index.html

"It is where utilities get instant feedback on a transformer outage, shift easily among energy sources, integrating wind and solar energy with electricity from coal-burning power plants, and go into homes and businesses to automatically adjust power use based on prearranged agreements.[11]"

"The 'smart grid' enables better monitoring and management of the grid using a variety of technologies, including software applications that will aid the design and operation of this infrastructure."

Constructing new infrastructure, even with massive resources devoted to the task, takes years to complete. The Associated Press Weekly report continued, "Existing lines need to be made 'smarter,' making it possible for utilities to better predict the reliability of the system and also to allow consumers to have more information related to usage.[12]" The "smart grid" enables better monitoring and management of the grid using a variety of technologies, including software applications that will aid the design and operation of this infrastructure.

As Thomas J. Friedman, author of Hot, Flat and Crowded: Why We Need a Green Revolution and How We Can Renew Our Global Future, puts it, "The energy internet … has the power to give us more growth with fewer power plants, better energy efficiency and more renewable energy… by smoothing out the peaks and valleys in energy demand.[13]" Using software to make the existing grid smarter will help in the short run. In the long run, however, massive infrastructure upgrades and extensions will be necessary. In the coming decades the utility industry worldwide will analyze, map, extend, refurbish, inspect, and secure the 21st-century grid using every available dollar, euro, rupee, and yuan."

The Bentley Solution for Engineering the Next Generation Utility

Bentley offers a solution that helps utilities obtain maximum benefit from their resources. Bentley doesn't construct power generation plants, erect transmission towers, build substations, or respond to power outages. Rather, Bentley provides an open, integrated solution specifically addressing the analysis, engineering, and workflow requirements of multidisciplinary engineering teams. The heart of the Bentley solution is a managed environment that tracks workflows, maintains critical information, and helps utilities and external contractors work together more efficiently. The solution covers conventional fossil fuel power generation, nuclear power generation, transmission corridor analysis, planning, and mapping, transmission infrastructure design, the design and management of distribution infrastructure (for all commodities), and substation design and management. From plant to point of service, Bentley is the only software vendor that helps utilities create, manage, and operate the infrastructure for the smart utility.

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11 H. Josef Hebert, "Smart grid' – power lines move into digital age," Associated Press Weekly, June 6, 2009
12 Ibid
13 Thomas J. Friedman, Hot, Flat, and Crowded: Why We Need a Green Revolution and How We Can Renew Our Global Future (London: Allen Lane, 2008), p. 240