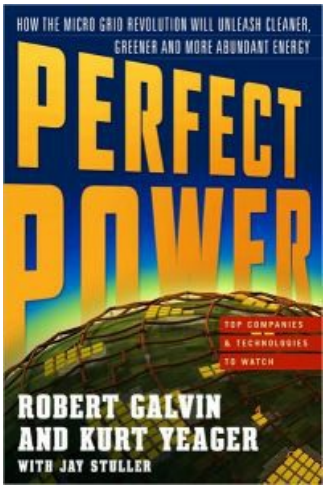

Book Perfect Power

How the MicroGrid Revolution Will Unleash Cleaner, Greener, More Abundant Energy

Robert Galvin and Kurt Yeager
McGraw-Hill, 2008

Recommendation

Just when you thought you already had plenty to worry about, experts Robert Garvin and Kurt Yaeger, and writer Jay Stuller report that the U.S.'s electricity supply system is woefully outdated and in danger of widespread outages. Then, *BooksInShort* is glad to report, their readable book also presents an apparently reasonable remedy: "microgrids." These smart, localized electrical networks conserve and store energy, and can redirect it to the parts of the electrical system that need it most. This bright proposal addresses a serious, but under reported problem. The authors, though perhaps more involved than most objective reporters, discuss electricity's scientific, social, economic and environmental impact. They make their solution more applicable and appealing by identifying companies that are developing microgrid technology. Unlike so many daunting problems, this one seems surmountable, if the U.S. – state by state – can muster the requisite funding and overcome the gooey regulatory status quo.

Take-Aways

- "Microgrids" are localized electrical networks that rely on "distributed generation" to store, supply and redirect electricity to homes, business and communities.
- Microgrids use "computerized controllers" that detect surges and store energy in real time.
- Distributing electricity on a decentralized basis is the key to increased productivity and efficiency.
- Daily, some 500,000 Americans suffer electrical blackouts that last two hours or longer.
- Power outages cost American business more than $100 billion annually.
- The average U.S. household wastes 7% of its home electricity by not turning off appliances and household devices, such as computers.
- Upgrading power grids worldwide will cost about $6 trillion over the next 25 years.
- Microgrids intelligently interface with existing utility bulk systems to share or sell power as the need arises.
- Quality power eliminates the need for surge protectors, transformers and converters.
- Houses, and commercial and industrial buildings use more than two-thirds of U.S. electricity. More energy-efficient building practices could save much of this power.

Summary

Six Sigma Electricity

The world's electrical generating system should have a source of constant electricity that meets the stringent demands of Six Sigma service. That would require constant, uninterrupted electrical power that works 99.99% of the time, despite lightning strikes, terrorist attacks, hurricanes and ice storms. This high standard matters because electricity is constantly essential. Worldwide, lack of electricity contributes to poverty. The availability of electricity is directly linked to economic output. It is the constant energy source behind new technologies that are changing the world.

> "The technology to achieve electricity service perfection exists."

Despite undisputed demand, the United States' electrical system is suffering from outdated equipment, including analog switches, relays and the distribution grid itself. Each day, some 500,000 Americans endure an electrical blackout lasting two hours or more. This loss of power costs U.S. businesses $100 billion annually. However,

both state regulators and the monopolistic electrical industry have stymied attempts to make the system more efficient. Electric companies' revenues depend on how much power they sell, not on its quality, efficiency or reliability. This denigrates the importance of customer satisfaction and may explain why the industry has not become significantly more efficient or reliable since the 1960s.

> "Woven together and managed by computerized controllers that – unlike human operators – operate at the speed of light, this emerging web of smart microgrids is like a medieval knight's chain mail."

Today, technology offers a better alternative – "microgrids." These systems enable electric companies to customize their power sources to meet each customer's demand. Microgrids rely on "distributed generation" to store, supply and redirect electricity as needed to homes, businesses and communities. These smart systems use "computerized controllers" to detect service surges and store energy in real time. Microgrids are cheaper to install than costly, large centralized power facilities with hard-wired distribution tower systems.

> The U.S. "electricity infrastructure cannot continue to survive on the life-support level of investment it has endured for the past 30 years."

Distributing electricity on a decentralized basis, rather than using large centralized plants and long-distance transmission grids, is the path to increased productivity, environmental protection and efficiency. The vision of decentralized distribution is not new. Thomas Edison originally proposed a decentralized model using direct current (DC) in about 1879. However, at the time, technology favored centralized, alternating current (AC), even though Edison went so far as to electrocute an elephant to show that AC was dangerous. "Topsy" died in seconds, but to no avail. In the late 1800s, AC generating stations were more profitable for investors, more cost effective for consumers and more achievable. Today, technology is no longer a limitation; modern investors and consumers would be better served by a decentralized, microgrid-based system.

Today's U.S. Power Grid

During the "Great Heat Wave" of 2006, large portions of New York needed so much electricity that heavily-used circuits failed. Elsewhere that summer, outages in California and the Midwest affected medical facilities, airports, Internet companies and thousands of other businesses. Afterward, however, an association of electrical grid operators issued a misleading press release saying that they had handled the record demand "without incident." Perhaps these utility operators could have claimed a partial victory in the 2006 outage if they had compared it to the "Great Northeast Blackout" of August 2003, which plunged 50 million people in four states and two Canadian provinces into darkness. That outage drained $10 billion from the U.S. economy.

> "In terms of service quality and choices, what consumers have today is the electrical performance and choice equivalent of the old analog, black rotary-dial telephone."

In many blackouts, a seemingly minor problem, like a short at a substation, trips circuits and disrupts transmission down an entire line or across a whole network. The current grid, which delivers 40% of the U.S.'s electrical needs, is largely obsolete. Most of its 1950s-vintage relays, power lines and transformers are nearing the end of their expected performance lives. Natural events, like snowstorms, can cause disproportionate damage to the aging system. Meanwhile, cash-strapped state utility boards generally favor piecemeal maintenance over replacing old gear.

> "The electricity that powers our lives is actually an invisible process that only exists in the infrastructure that produces, delivers and uses it."

The entire process of transmitting electricity from the U.S.'s 16,000 power-generating plants wastes money and energy. Some coal-fired electrical plants consume 25 tons of coal a minute, and then squander 60% of the energy produced through wasteful heat loss, emissions or heated water that is released unused. More energy is lost in the transmission process as the copper conduction cables heat up and start to sag, further degrading the power. Electrical transmission systems elsewhere suffer similar problems. For instance, India loses about 26% of its electricity in the process of transmission and distribution.

> "The electricity system is at once remarkable and increasingly vulnerable."

The average U.S. family wastes 7% of its home electricity consumption due to failure to turn off computers, phone chargers and other plugged-in devices. A Carnegie Mellon University study found that U.S. buildings use twice as much energy to heat and cool a square meter of space as European buildings. Most use 1,000 kilowatt hours a year to heat or cool a square meter of space, even though the job could be done with only 100 kilowatt hours using modern technology. Commercial and industrial buildings, and homes, use more than two-thirds of the U.S.'s electricity, mostly for lights, heaters, air conditioners, hot water heaters and entertainment devices.

> "The electric utility industry has a very poor track record of proactive infrastructure investment and innovation."

Modern society's demand for electricity is not only growing, it is changing technologically. Earlier generations of analog devices could withstand power disruptions, but today's microprocessors are not as forgiving. Sensitive digital instruments – for instance, life-support machines in hospitals – can crash in the face of power surges, sags and harmonic changes of less than one-sixtieth of a second. In light of such problems, the U.S. military re-examined its energy vulnerability after the September 11, 2001, terrorist attacks. The Defense Department concluded that installing more microgrids on U.S. military bases worldwide should be a top priority.

Power Problems

Electricity is invisible, but its power becomes evident as it is created, transmitted and applied. Electricity is the flow of electrons under pressure (volts), which allows more electricity (watts) to flow through transmission lines. Unlike other forms of power, electricity is hard to store, so it is best used immediately. An electric utility that cannot store power must have the generating capacity to meet peak demand periods, instead of being able to release banked energy as needed. In this regard, the current electrical utility industry is grossly inefficient. Its infrastructure is geared to meeting peak demand periods that span only three hours daily. The grid generally runs at less than its full capacity the rest of the day. This inefficient structure distorts pricing among residential, industrial and commercial consumers, giving retail customers little control over their electricity bills.

> "Electricity rates are based first on ensuring that the regulated monopoly utility recovers its costs and makes a profit under all operating conditions."

One of the factors impeding reform is that 50 separate state agencies – all with different rules and standards – regulate the U.S. electricity supply. The lack of standardized local or regional building codes keeps the U.S. from saving energy on a large scale. Instead, state utility regulators impose restrictive policies on power companies to preserve their status quo as state-regulated monopolies, and regulatory policies tend to discourage innovation and private investment in the grid.

> "Once electrified, any appliance, machine or process can become more energy efficient... continuously."

The general budget-conscious emphasis on constructing low-cost buildings presents another issue, since most of these structures turn out to be energy-inefficient. Energy-efficient building designs could save vast amounts of electricity; better roof and façade design, in particular, could lead to meaningful savings.

Microgrid Solutions

Over the next 25 years, power companies and governments worldwide will spend about $6 trillion to upgrade power grids worldwide. The U.S. alone will need an estimated $2 trillion for replacement equipment and new capacity. Complying with U.S. environmental regulations will cost billions more. Utility companies that cannot promise uninterrupted service in exchange for any rate increase will find it very difficult to raise money in the capital markets. In terms of federal dollars, the U.S. Department of Energy has a $24 billion annual budget, yet it allocates only $125 million for infrastructure improvements. // // Microgrids are an alternative to monopolistic "bulk power grids." Microgrids interface intelligently with existing utility bulk systems to share or sell power as needed in an efficient, effective process.

> "The biggest impediment to the smart grid transformation is neither technical nor economic, but regulatory barriers left over from an earlier era."

The Galvin Electricity Initiative, headed by [author] Robert Galvin, advocates installing a new microgrid system to move the U.S. away from reliance on centralized utility monopolies. Recognizing the pivotal role of heightened consumer awareness, the Initiative has assembled experts in telecommunications, the environment and public policy, as well as engineers, to develop programs for delivering a "perfect power system."

> "Electricity is a miraculous natural phenomenon."

The ideal microgrid-based system would be self-repairing, resilient to physical and cyber attacks, and able to deliver reliable, quality electricity at reasonable rates. With quality power, consumers would not need surge protectors, transformers and converters. A smart microgrid could pay for itself in three to five years, and it offers other benefits related to security, convenience and the environment. For now, outdated financial incentives and regulations prevent private companies from installing electrical grids in local communities. The "electrical supply is regulated primarily at the state level," so state prohibitions against installing private electrical lines over a public street in an area under the aegis of a monopolistic electric utility are a major impediment to microgrid development. Such laws are remnants of the 1900s when states granted local exclusivity to utility companies. Related, outdated local building codes additionally impede competition, keeping consumer costs artificially high. This also has a negative ecological impact.

> "Recognition by influential leaders and consumers alike that our electricity supply system is dangerously unreliable, inefficient, and shockingly vulnerable to disruption and attack is the first and most important step in this transformation of electricity policy."

However, the energy industry can overcome these obstacles. Only 30 years ago, AT&T had a stranglehold on U.S. telecommunications. Consumers had to rent phones from the company in order to connect to its national network. However, courts and regulators eventually broke AT&T's monopoly. In the process, they created new industries that thrive on competition and innovative technologies. The electrical energy industry is at a similar inflection point today.

> "Electricity is, and will continue to be, the ultimate agent for progress."

Building a smart grid nationwide would create a wide variety of new jobs, ranging from engineers and boilermakers to electricians and electronic technicians. Unlike other types of jobs, these cannot be outsourced overseas. The electrical power industry needs workers in new technological fields that produce energy by processing a wide variety of materials. For instance, a waste treatment plant in Millbrae, California, is converting grease from local restaurants into methane gas that powers its own electricity. Other new energy sources include nanotechnology, cow manure, tidal movements, wind turbines and solar power.

Smart Gear

In 1992, the U.S. Environmental Protection Agency introduced the Energy Star program to combat waste and build consumers' awareness of energy-efficient appliances. Today's smart appliance market goes much farther, offering such innovations as telephone and security equipment, which monitors and remotely controls residential heating, cooling and electrical use. These smart systems, which rely on routers plus DSL or cable connections, will give consumers and businesses more control over the cost and environmental impact of their utility choices.

Smart appliances can make home electricity use more economical. These machines can communicate with one another to reduce demand, and can release stored energy at opportune times to provide energy to larger grids and save money. Efficient interconnected grids could also receive and use real-time information about weather, light or moisture. Companies offering such smart control devices for home use include Cisco, Intel, Motorola, Samsung, Panasonic, Mitsubishi and Sony. Estimates predict that this market will be worth $30 billion over the next 10 years. Johnson Controls, Honeywell, Invensys and Siemens also offer smart electrical monitoring systems for commercial buildings.

About the Authors

Robert Galvin heads the Galvin Electricity Initiative. He is the former Chairman and CEO of Motorola, Inc., where he pioneered "Six-Sigma Quality." **Kurt Yaeger** is former President and CEO of the Electric Power Research Institute. **Jay Stuller**, who worked in public affairs and communication for the Chevron Corporation, has written seven books and nearly 1,000 articles.