The Galvin Electricity Initiative Microgrid Workshop

June 27 and 28, 2006
Chicago, IL

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GALVIN ELECTRICITY INITIATIVE
Sponsored by The Galvin Project, Inc.

Galvin Electricity Initiative
3412 Hillview Avenue
Palo Alto, CA 94304
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Galvin Electricity Initiative

The Galvin Electricity Initiative seeks to identify opportunities for technological innovation in the electric power system (broadly defined) that will best serve the changing needs of consumers and businesses over at least the next 20 years. Of paramount importance will be ensuring that the electricity system provides absolutely reliable and robust electric energy service in the context of changing consumer needs.

For more information about this publication or the Galvin Electricity Initiative, please contact Galvin Electricity Initiative at 650-855-2400 or visit us at www.galvinelectricity.org.

Executive Summary

The Galvin Electricity Initiative conducted a 1½-day event, *The Microgrid Workshop*, for 34 participants representing multiple stakeholders in the microgrid industry. These included representatives of equipment suppliers, microgrid designers, electricity utilities, research organizations, academia, and industry trade groups. The Galvin Electricity Initiative staff and consultants led the workshop and briefed attendees on the technical and marketing research being conducted for the Galvin Electricity Initiative, which has focused on microgrid systems as a foundation of the Perfect Power System. "Perfect Power," as defined by Initiative funder and visionary Bob Galvin, is a power system that is no-fail and trouble-free to the consumer.

The workshop was held in Chicago, Illinois, on June 27 and 28, 2006. Participants convened to review progress and preliminary findings of the engineering and marketing analyses conducted for the Galvin Electricity Initiative, and to discuss issues that could help guide and inform a winning microgrid development strategy. Topics included technology and design issues, regulatory and legal barriers, and market and economic factors influencing deployment.

The Microgrid Workshop and Roundtable featured a combination of formal presentations and facilitated discussion in which participants exchanged experiences, posed questions, and collectively developed lists of issues and recommended actions to spur the microgrid industry.

This report summarizes presentations from the workshops and describes key outcomes of facilitated sessions.

Results and Findings

The workshop results provide information on the Galvin Electricity Initiative work, a microgrid developer's experiences, and a collectively developed list of key issues facing microgrid developers.

Those involved in development of microgrid technologies or markets, including utility professionals involved in research and development and strategic planning, will find information in this report on the challenges that professionals in the microgrid industry face, as well as information and data on resources that can help address these challenges. The report will also benefit executives interested in learning more generally about microgrid development.

Applications, Value, and Use

The most important outcome of this workshop was sharing of information summarized in the presentations and facilitated, interactive sessions. The workshop participants identified the following as prime issues that must be addressed to boost microgrid development:

- Demonstrations are needed to show the value of microgrids. Possible locations are areas where the advantages of a microgrid are greatest, such as locations with transmission and distribution constraints.
- Several regulatory and legal issues are barriers that need to be addressed, including the ability to obtain access to the conventional power system, as well as the ability to run private wires across public streets so that multiple buildings can be incorporated into a microgrid.
- Charges such as standby fees, which are charged for the privilege of having access to the conventional power system, need to be calculated in a fair and accurate matter, because if too high they can reduce the economic viability of microgrids significantly.
- The convergence of connectivity and computational ability in technology enable the modern microgrid when they are integrated into systems with generation and storage. Performance can be optimized for both efficiency and participation in markets and load management programs.
- Although technology development is needed, particularly as it relates to reducing the initial costs of generation and energy storage systems, the human factor is a major component of microgrid development. Considerable communication and education is needed.
- The value of microgrids includes factors that are not strictly related to the price of electricity. These include the desire for green power, enhanced security and energy independence, greater convenience, and better quality of life. These are real values to customers and should be assessed and exploited when developing the business case for microgrids.

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Citations

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The Galvin Electricity Initiative Microgrid Workshop

June 27 and 28, 2006, Chicago, Illinois

1 Workshop Background

The impetus for the June 2006 *Microgrid Workshop and Roundtable* was the Galvin Electricity Initiative. This privately funded effort, launched by former Motorola chief and Six Sigma Quality Control founder Bob Galvin, is creating strategies to transform the nation's outdated electric power system. With blackouts and outages costing the American economy at least $150 billion a year, the Galvin Electricity Initiative seeks to create a power system that will boost the economic vitality of the country by proactively identifying the business and technological path to what Bob Galvin has dubbed the Perfect Power System. This is a system that is "trouble-free to the customer and does not fail."

The technical and economic analyses performed for the Galvin Electricity Initiative reveal that the *microgrid* is a cornerstone of reaching the robust reliability and performance needed to perfect the nation's power system. The microgrid is a design concept based on distributed power generation and energy storage that is networked and populated with intelligent sensors and controls. An individual building-scale power system can be connected with one or more additional distributed power systems to take advantage of shared generation and storage, creating a microgrid. Such systems can be interconnected with the conventional power grid and operate independently or in parallel to the main power delivery system, affording flexible and reliable operation under all conditions.

Why are distributed power systems and microgrids important to achieving the Perfect Power System? As one group of microgrid industry professionals and enthusiasts once published, "Two Grids Are Better than One." Redundancy of supply offers greater reliability. A working premise of the Galvin Electricity Initiative is that the Perfect Power System, from the consumer's point of view, does not fail. Reliability is essential.

Other characteristics of the microgrid concept meet the criteria for perfection. These include superior power quality, which is increasingly important in a digital age, and a number of non-monetized but important societal factors such as quality of life, security, and environmental benefit.

The distributed microgrids that are the means of creating Perfect Power are being demonstrated and used worldwide, but affordability and wide-scale adoption within a

15- to 20-year timeframe will require investment now. The Galvin Electricity Initiative is developing data and that can help guide the business and policy decisions that will help accelerate microgrid demonstration and deployment. To help share and develop that data, the Galvin Electricity Initiative convened key Initiative technical staff and consultants and designers, manufacturers, researchers, policymakers, and others with a stake in microgrid development with the goal of sharing information on Initiative results and obtaining guidance on important gaps and key opportunities for addressing technical, market, regulatory and legal issues facing the microgrid industry.

Approach

A 1½-day workshop was held in Chicago, Illinois in June 2006. This meeting involved presentations by representatives of the Galvin Electricity Initiative, microgrid developers, and researchers and academicians involved in microgrid development as well as in quality leadership. During the workshop, participants and facilitators discussed specific technology design issues, market trends, and barriers to microgrid development on a mass scale.

Attendees

The workshop was attended by 34 participants from the power and manufacturing sector, academia, research organizations and other stakeholder groups.

Workshop Participants

Caren Benjamin	Vanguard Communications
Kevin Best	RealEnergy
David Bodde	Clemson University
Sumit Bose	GE Global Research
Jim Buckman	Joseph M. Juran Center for Leadership in Quality, University of Minnesota
David Cohen	Infotility
Clint Coleman	Distributed Energy Systems
Dave Crudele	EPRI Solutions
David Cuttica	University of Illinois at Chicago
Alexander Flueck	Illinois Institute of Technology

Karen Forsten	EPRI Solutions
Susan Freedman	San Diego Regional Energy Office
Roger Gale	GF Energy
Clark Gellings	EPRI
Karen George	EPRI Solutions
Mack Grady	University of Texas at Austin
Terrence Heng	Software engineer
John Kelly	Gas Technology Institute
John Kerecman	PJM-Environmental Information Services
Lynne Kiesling	Northwestern University
Robin Luke	RealEnergy
John Marshall	Kansas City Power &Light
Patrick McLafferty	The Rutland Group
Mark Nobili	Mark Nobili & Associates
Gene Oatman	Strategic Decisions Group
Jean-Louis Poirier	GF Energy
Maria Rodriguez	Vanguard Communications
Mohammad Shahidehpour	Illinois Institute of Technology
Thomas Smith	Endurant Energy
Jay Stuller	Stuller Communications
Ann Trowbridge	Downey Brand Attorneys
Eric Wong	Cummins Power Generation
Marios Zenios	Alto Consulting
Kurt Yeager	EPRI

Agenda

The workshop was conducted over 1½ days and included discussions, question and answer sessions, and presentations. The following describes the agenda for the workshop.

Tuesday, June 27		
7:30 am	Continental Breakfast Available	
8:30 am	*Workshop Welcome*	*Bob Galvin*
8:45 am	Participant Introductions	*All*
9:00 am	Workshop Goals & Agenda	*Kurt Yeager & Kevin Best*
	Comments & Suggestions	*All*
9:30 am	Microgrid Commercialization Opportunities & Issues	*Kevin Best, et al*
10:15 am	*Break*	
10:30 am	Roundtable Discussion	*All*
11:15 am	Galvin Electricity Initiative – Technical Development	*Clark Gellings*
12:00 pm	*Lunch*	
1:00 pm	Roundtable Discussion	*All*
1:45 pm	Galvin Electricity Initiative – Business Template Development	*Roger Gale*
2:30 pm	Roundtable Discussion	*All*
3:00 pm	*Break*	
3:15 pm	Galvin Electricity Initiative – Quality Management	*Jim Buckman*
3:45 pm	Roundtable Discussion	*All*
4:15 pm	Summary of Technical & Policy Implications for the Galvin Initiative	*Kevin Best & Kurt Yeager*
4:45 pm	Wrap-Up & Day Two Agenda	*All*
5:00 pm	Close Day One	
5:30 – 7:00 pm	*Reception*	*All*

Wednesday, June 28		
7:30 am	Continental Breakfast Available	
8:30 am	Overnight Reflections on Day One	All
9:00 am	Technical & Policy Breakouts	All
10:30 am	*Break*	
10:45 am	Breakout Advisory Reports & Discussion	Breakout Spokespersons
11:45 am	Galvin Electricity Initiative Response & Next Steps – Close Workshop	Bob Galvin, Kurt Yeager, et al.
12:15 pm	*Lunch*	
1:00 pm	**Depart**	

2 Session Summaries

Introduction and Comments
Bob Galvin

Initiative funder, Bob Galvin, opened the workshop with brief remarks regarding the reason for the Initiative and the importance of improving the power system. He also commented at critical points during the course of the workshop to steer discussion and clarify objectives.

Galvin noted that the reason underlying the Initiative to perfect the power system is to enhance the economic vitality of the United States. "It is a necessity that we have an energy system that cannot fail. By "cannot fail" I mean perfect."

Galvin also stressed the importance of applying a well-thought-out strategy, and defined strategy as the "application of resources that achieve benefit for the customer." It has to be tangible; you have to pick up a tool and do something, per Galvin.

The Path to Perfect Power
Kurt Yeager, President Emeritus, EPRI

Kurt Yeager provided participants with an introduction to the Galvin Electricity Initiative.

Yeager kicked off his presentation by noting that the U.S. National Academy of Engineering reported that "The vast networks of electrification are the greatest engineering achievement of the 20th century." Per Yeager, "it is not just the light bulbs or the computers or any other devices, but the networks that did so much to shape our world."

Reasons for updating the electricity system

These electricity networks have been in a period of extended technical stasis. "It enabled the mechanical industrial revolution, but it is not for digital times," said Yeager. "Now we must take the next step."

The reasons are numerous, including the fact that the cost of unreliable power in the U.S. is estimated to be $150 billion annually. "If invested in modernizing the nation's power system, that amount could lead to perfect performance," asserted Yeager, "but because the economic window around the power system does not account for these losses, it is difficult to make investments." He also quoted Bob Galvin on the investment required: "Quality does not cost—quality saves."

Transforming the grid

To transform the grid will require technological changes:

1. **Electronically control the power systems**. To move from the vestiges of the past will require moving away from electric-mechanical control systems. Pointing to just how outdated the electric system is compared to other industries, Yeager posited an analogy to the railroad: "What if it took 10 days to change a switch on the railroad; we would all recognize that there would be a huge problem."

2. **Integrate electricity and communications**. A smart system is needed that is not simply about more kilowatt hours, but about deriving the value added to each electron and the information content of the system.

3. **Transform meters to two-way.** The iron curtain of the industry—the meter—must be transformed to a gateway. An advanced meter is needed that enables electricity suppliers and customers to communicate with each other automatically and in real time. That way customers are not held hostage to a single level of quality and a single supplier.

4. **Incorporate combined heat and power (CHP) systems and distributed resources into the system.** CHP systems that enable production of both electricity and heat are efficient systems that can augment a central system to improve quality of service. Likewise local distributed power production is a key to a high-reliability, high-quality system.

5. **Reintroduce direct current (DC) into microgrids**. Edison's original concept of a power system that generates, delivers and uses direct current may be revived in microgrids. Such systems can be more efficient and reliable in today's digital economy and society.

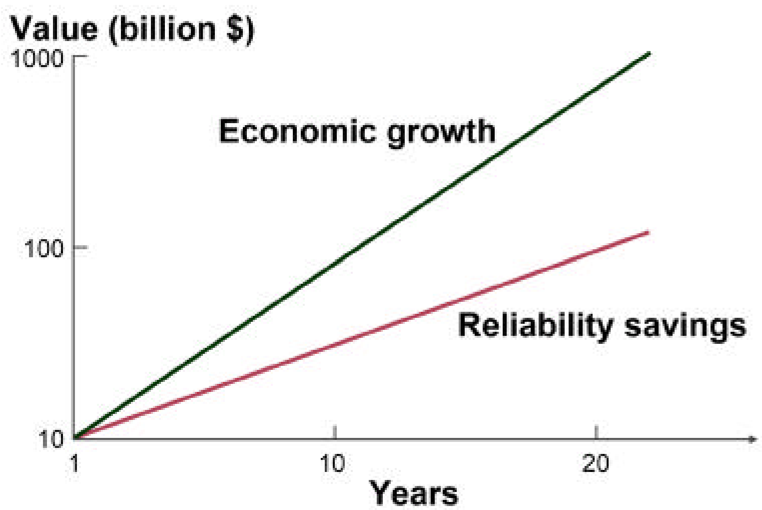
6. **Enable smart, end-use devices**. A Perfect Power System that converges with a communications system will enable the electric system to communicate with microprocessors in all end-use devices, which could automatically optimize their operation.

The value of transformation

Yeager presented two vectors of value related to the electricity system: reliability savings and economic growth, per **Figure 1**. Economic growth is the big payoff.

Yeager contends that if there is not enough work done in electrification to modernize the infrastructure, the nation's economy is not sustainable in a competitive global economy. If we develop the infrastructure, however, Yeager believes 10-20 percent greater growth rates are achievable.

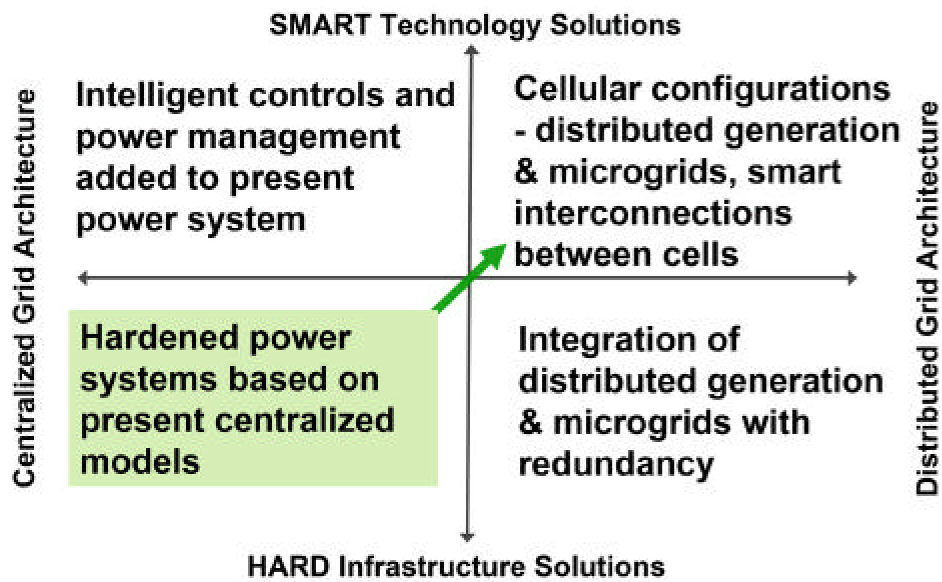
Figure 1. The Value of Transformation



A conceptual framework for alternatives

Referring to quadrants shown in **Figure 2**, Yeager noted that the power industry is not yet moving from the "bigger hammer approach" of the hardening power systems based on centralized models. Utilities are operating in a declining business model, and they are incented to solve the problem by borrowing from the future and not doing the investments needed today.

Figure 2. Conceptual framework for alternatives



A cellular configuration for Perfect Power

The Perfect Power System, which is made up of local distributed power systems and microgrids, will be built from the bottom up, like a series of cells. These cellular configurations, the building systems connected to the microgrid, which are connected to the conventional power grid, will act as "local refineries of bulk power."

The Galvin Electricity Initiative

Catalyzing the transformation needed to create Perfect Power is the goal of the Initiative. In Phase I of the Initiative, an architectural foundation was established. Phase II entails three steps:

1. Technical — Competing engineering assessments and "blueprints" that define Perfect Power configurations

2. Commercial — Defining business templates that facilitate the formation of consortia of key entrepreneurial implementers

3. Operational — Perfect the human dimension with quality management and training

Yeager concluded with the comment that “We can be as perfect as possible with technology, but we must deal with the human dimension. That means we must communicate and educate.”

Local Energy Networks and Microgrids
Commercialization Opportunities and Issues Presentation
Kevin Best, CEO, RealEnergy

Kevin Best shared his experiences as a developer of distributed power systems in a presentation, followed by a roundtable discussion to identify issues related to overcoming barriers to microgrid development.

Best began by noting that he has waited a long time for a serious discussion of the topic of microgrids, and he asked attendees, “Why don’t we get traction on microgrids?” He stated that the he believes private equity is desperate to play in the power system and microgrid game and help refurbish the public electricity system. Ultimately, he stated, investment is needed to bring costs down and bring services up.

Experience as an owner/operator

RealEnergy develops, owns and operates small clean onsite generation systems through the RealEnergy Clean Tech Fleet Opportunity Fund, LP. The company completed 37 interconnections for distributed power systems as of June 2006 employing a number of different fuels and generation technologies, including bio-fuel engines, biogas to pipeline, and bio-waste digesters. A few examples of RealEnergy projects are shown in **Figure 3** below.

Figure 3. Examples of RealEnergy projects

Arden Realty, Long Beach, CA | CommonWealth Partners | Emery Station

Best noted that many of his projects should have been microgrids, such as a project in San Francisco where two buildings across the street from each other could not be interconnected because of rules prohibiting running private wires across the public street. One project, the CalPERS buildings in San Diego, **Figure 4**, has two buildings close by and a private street on which to run wires. The company was able to do one power plant for two buildings.

Figure 4. Two buildings served by a microgrid — the CalPERS buildings, San Diego, California

Designing compatible technology modules

Best reported that development of modules for microgrids could help with "mass customization," which would enable more cost effective design and deployment. They can be factory built and tested, and shipped.

RealEnergy has a contract to design 300-1500 kW combined heat and power (CHP) modules that are price and performance focused. We are "technology agnostic," said Best, and can use reciprocating engines, microturbines and other types of generation. Fuels can be natural gas or "opportunity fuels" that are not as susceptible to volatile prices and supply limitations (like site-produced biogas).

A question they are trying to answer is "Can small-scale distributed generation be mass produced with minimal customization to achieve the price and performance demands of Wall Street?"

In addition, he reported on the need for creating open-protocol intelligent agents for optimization of microgrid operation. These agents can enable automated response to market (price) and grid conditions.

Design standards

"We absolutely need to develop standards for CHP [combined heat and power] systems," contended Best. "We need to talk to each other and get serious about this." He reported that design standards would enable greater development of microgrids, reducing capital costs and enabling capture of load diversity opportunities. Larger, less expensive microgrids would be possible. Also, standards are needed to open opportunities such as greater use of direct current back-to-back systems (that connect an asynchronous device to synchronous systems).

Benefits of microgrids

Best reviewed a number of benefits of microgrids and distributed generation, including:

- Improve reliability by sitting near the load
- New generation, no new transmission and distribution (T&D)
- Increase local ownership and control
- Match load growth more cost effectively
- Hedge price volatility in the power markets
- Provide rate stability
- Overcome T&D constraints
- Improve asset utilization
- Manage shoulders of daily/seasonal peaks
- Easy to permit, fast construction
- Less 'lumpy' replacement costs of aging equipment

Opportunities and Issues Roundtable
Facilitated by Kevin Best, CEO, RealEnergy

Best's presentation led into a discussion session focused on issues related to "getting to the smart microgrid." What are the barriers and how can they be surmounted? The group collaboratively produced a list of important items.

- "Private wires" can't be used
    - Illegal to cross public street to serve adjacent buildings
- Enable DC back-to-back to link
    - Use asynchronous device to connect two asynchronous systems
- Being put in the same regulatory bucket as utilities
    - What is the definition of a utility? Selling electricity?
- Monetize ancillary benefits
    - Microgrid owners want fair valuation for what is produced; They don't get T&D deferrals and environmental credits

- Willingness to pay utility charges if they are fair
- Define market rules for "legalized" microgrids
- Leverage demand-side innovation opportunities
- Open access to distribution system
- Design technology based on market factors (what consumers/utilities want)
- Market rules for "legalized" microgrids
- Monetize externalities, social benefits; create new tools, models for this
    - Greater use of renewables
    - Environmental benefits
    - Security and resilience to disasters
- Capture trends of digital era
    - Younger workforce that is more savvy with digital technology
    - Digital metering enables data on energy use—see results of removing artificial cap on residential customers
    - C&I customers will have a better case for microgrids.
- Quantify level of value creation for customers
- Possible to devise small demonstrations and experiments?
- Address existing cultures
    - Utilities
    - Commissions
    - Consumers
- Define what customers and utilities want from the microgrid and design technologies to address these factors
    - Controls are a good example
- Quantify value to stakeholders
    - Inherent business models need to be understood
    - Create transparency of value streams
    - Transparency to regulators especially crucial
    - Where are microgrids worth capital investment? (Short term, long term)
    - Honor all stakeholders

- Utilities ability to work with private equity
    - How can utilities make money on this?
    - What business structures work?
    - How to work within regulations: workarounds
- Change leadership
    - Need to radically elevate quality
- Communications and control link
    - Interface between control centers and individual facilities crucial
- Open access to distribution system
    - Goes to utility definition: does not include energy, just wires

The Galvin Electricity Initiative
Clark Gellings, Vice President, Innovation, EPRI

Clark Gellings reviewed the work being performed by the Galvin Electricity Initiative.

Gellings first noted that "You can't approach the Perfect Power System in a traditional way." He also defined a Perfect Power System as one that "will ensure absolute and universal availability of energy in the quantity and quality necessary to meet consumer needs." He stated that systems must:

- Be smart, self-sensing, secure, self-correcting and self-healing
- Sustain failure of individual components without interrupting service
- Be able to focus on regional, specific area needs
- Be able to meet consumer needs at a reasonable cost with optimal resource use and minimal environmental impact. Needs to include functionality, portability and intelligence.
- Enhance the quality of life and improve economic productivity

Innovation nodes

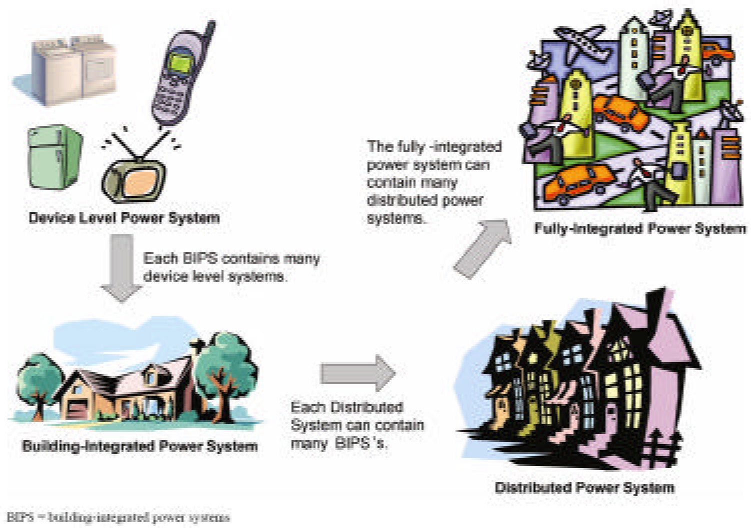
Gellings reviewed the first phase of Galvin Electricity Initiative work, which entailed an assessment of how society will evolve and how this will influence the functionality and needs for systems that consume energy. Part of the approach was to "think of the ends before the means." The technologies that could meet needs were assessed, as well as their potential effect on power system capabilities. Key "innovation nodes" were identified, which are the technologies and systems that would be essential for creating Perfect Power System configurations. They include:

- Distributed generation
- Storage
- Sensors
- Integrated communications
- Computational ability
- Smart appliances and devices
- Advanced building systems
- Power electronic controls

A multi-level system with a microgrid

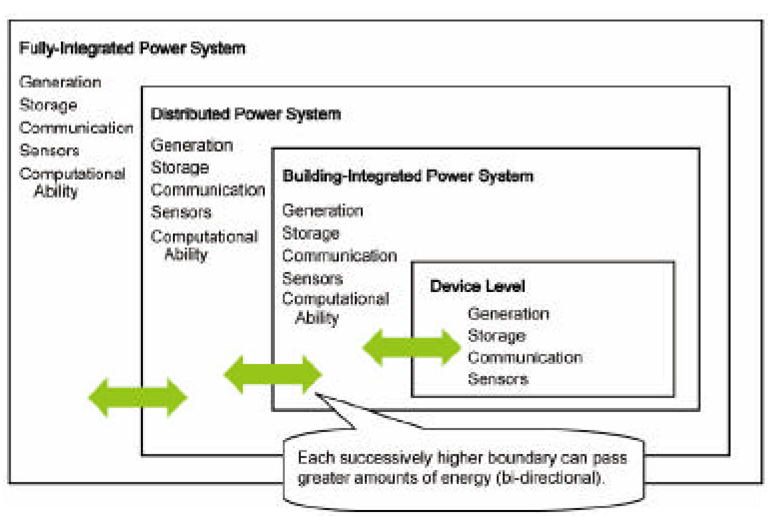
The configuration for the Perfect Power System was identified as not being a single architecture, but rather multiple architectures that could be interconnected. Since these frequently differ in scale, not technology, the Galvin Electricity Initiative research team hit upon the idea of using a "nested" system approach for creating the Perfect Power System. Like Russian dolls, smaller units can be encompassed or integrated, within larger systems. The basic philosophy in developing the Perfect Power System is to first increase independence, flexibility, and intelligence to optimize energy use and energy management at the device and individual building level, then to aggregate and connect buildings and facilities at a neighborhood or local level. Integration of local systems–the nesting—can be done as necessary or justified for delivering Perfect Power supply and services. The nested approach divides up the power system into four interconnected, or nested, levels, as shown in **Figure 5.**

Figure 5. Each level of the Galvin Perfect Power System is comprised of one or more of the lower levels



The development path to perfect power is shown in **Figure 6.**

Figure 6. The nested philosophy of development creates the path to Perfect Power



Phase II of the Galvin Electricity Initiative is to evaluate the design configurations and identify where investments can be most productive in creating a Perfect Power

System. Of course, per Gellings, when designing the power systems, the phrase “it depends” applies, but the team made assumptions about likely cases and circumstances when doing engineering analyses. Also, to assess the business case, modeling was performed that accounts for value inputs that can be readily measured, such as the economic value of electricity. Other values that are not typically in accounting systems but provide value include factors such as convenience and quality of life. Showing how certain capabilities and attributes can enhance value, Gellings noted that AA batteries sell for $108 per kilowatt hour (kWh), compared to about 8¢ per kWh or more paid for residential power. “We value portability, so we’re willing to pay for this.”

Preliminary findings

Gellings reviewed objectives that if they could be reached could enable a winning microgrid strategy:

- **Reduce capital costs of distributed generation and energy efficiency.** “When examining technology research issues, if you focus on bringing down the costs it can make a big difference,” said Gellings. While this is intuitive, the modeling done for various configurations and cases can offer some guidance on the extent of cost reduction that is needed and where to put the emphasis. Also, installing devices and end-use equipment that is as efficient as possible is the first thing to be done when rolling out a microgrid. The systems serviced by microgrids have to be efficient to minimize the size of generation and storage systems--and therefore their cost.
- **Enhance the reliability and performance of distributed resources.**
- **Need practical, large-scale energy storage.**
- **Need micro-scale CO_2 management.** This can be of some concern. At some point an estimated value of carbon--somewhere between $7-$50 per metric ton—will be charged to someone. And the consumer will eventually pay. Emissions tariffs could impact microgrid development, as they can significant affect the economics of the system, degrading value.
- **Develop master controller and software.** “This is a huge opportunity, and software development is the most important part,” commented Gellings.
- **Enable demand-response.** Many of the benefits of microgrids are non-traditional, and Perfect Power Systems would be more valuable because they allow participation in programs that provide time-varying costs of electricity.

- **Need plug-and-play technologies for combined heat and power systems.** "You can't engineer it every time or it will be too costly," said Gellings.

Developing Microgrids Roundtable
Facilitated by Clark Gellings, Vice President, Innovation, EPRI

Clark Gellings' presentation on the findings of the Galvin Electricity Initiative set the stage for a discussion on business and technical development of microgrids. Several different topics were addressed, ranging from new construction (green field) vs. retrofit applications to stand by charges and CO_2 tariffs.

Green field vs. retrofits

John Kelly of the Gas Technology Institute noted that green field development makes sense since according to the American Institute of Architects, 50 percent of the buildings to be occupied by the year 2030 have not been built yet. Even when doing redevelopment, a lot of projects involve building new.

According to Kevin Best of Real Power, investors look at retrofits as there are more opportunities there. For example, he said that as an investor there is not a whole lot of non-combustion generation that is reasonable for investors, so "you are back to combustion; back to heat." For example, a hospital is an ideal core microgrid host as a user of both electricity and heat.

Dave Bodde of Clemson University asked why, if models show there is value creation and value is captured by consumers using microgrids, why doesn't it happen in practice? He said we have invented most of what we need, and we should be on the brink of action. But we are hung up on something. Could it be some of the regulatory barriers we heard about? What else? He noted an example of an old air conditioning system at Clemson that hasn't been replaced, despite its age. The reason is that there is no reward system in doing so. We must ensure that we have all market barriers identified.

John Cuttica of the University of Illinois at Chicago commented that if you go after the end-user for investment you will not get it now. Varying predictions and uncertain energy futures make investments stop.

Jean-Louis Poirier of GF Energy stated that the issue is that we must build the plant ahead of the load, and only utilities have been in a position to do this. Therefore the brown field developer may be more attractive.

Tom Smith of Endurant Energy said that green field is great, but saturation of buildings is so much of a driver that you need to come up with something for existing buildings. You also need to get credit for being efficient, and for lower emissions. He said there is not a level playing field right now.

CO_2 issue

When asked about how RealEnergy sequesters carbon, Kevin Best noted that he does a green house at each dairy project he does for sequestration. When asked what he would do if a high carbon tax was imposed, he responded "You can decide not to build."

One of the assumptions of the Galvin Electricity Initiative value model is that all regulations will tighten. Lynne Kiesling of Northwestern University commented that the incidence of carbon tax will be higher on the central generator vs. the developer, which gives the developer the advantage. Also you have to consider that the modeling makes an assumption about something that doesn't exist yet—customers being able to take a price risk. Retail competition or lack of it needs to be modeled.

Kurt Yeager of EPRI noted that a pivotal issue is getting credits for carbon control.

David Bodde of Clemson posed the question that "If we don't have competitive markets are we really assessing legitimate opportunities? Or are we really at a tipping point?"

The Galvin Model

In response to a question about the assumptions used in the Galvin model, which assesses the value of various distributed power and microgrid configurations, Clark Gellings noted that the model was not yet ready for release but we are looking for volunteers that have data sets to validate and exercise the model. [The Galvin Model will be made available on www.galvinelectricity.org in early 2007.]

Standby charges/demand charges

A standby charge is a fee charged to commercial and industrial customers for the capability to use power from the grid when onsite generation is unavailable. A demand charge is a portion of the electricity charge based upon the electrical capacity that is billed or consumed.

"Pick one" said Kevin Best of RealEnergy. "I would be happy to pay a demand or standby charge, but not both."

Kurt Yeager contended that if you have a perfect system, you don't need standby charges.

In response to a query about the causation for setting standby fees, Clark Gellings noted that this additional charge is based on the extreme situation that one day all of the standby customers might all need power from the utility at the same time. "But this is not realistic," per Gellings, and standby fees should be based on actual cost.

Eric Wong of Cummins Power suggested that microgrids could essentially cover those costs for each other.

Tom Smith of Endurant stated that he believed that distributed generation is not treated fairly since it offers peak demand offset advantages yet also has to pay standby charges.

The Galvin Electricity Initiative Business Design Template
Roger Gale, Partner, GF Energy

Roger Gale reviewed the GF Energy work for the Galvin Electricity Initiative, which focuses on new business opportunities, new entrants, and new applications.

Much of the discussion in the workshop related to supply-side issues. Roger Gale reported that he focused on what is demand driven. "Most industries, as they become competitive and innovative, look to customer pull," reported Gale.

He noted that he believes it is unfair to focus on regulatory constraints, as real as they are. "We are in a transformational state, but utilities are a mature industry and protective of 'legacy' systems." He doesn't see them as the change agents.

The task that GF Energy is conducting in the second phase of the Galvin Electricity Initiative is to examine market trends and business opportunities. "We are not looking at a world that starts fresh. We have to build, in this case, literally, the buildings," reported Gale.

Overall findings

- The pervasive digital world is challenging the slow-thinking, low-risk, low-innovation electricity world. We will reach a tipping point within a decade.
- Internet protocol (IP) standardization combined with ubiquitous communications, wireless and wired, and cheap mesh sensor network technology make precise, real-time and on-demand electricity management a low-cost increment to investments already being made to serve other needs (e.g., security, Web connectivity).
- Customers will start having control over power and they will use that control.
- New entrants are eager to offer new customer-centric products and services (we found several potential business opportunities).

- The result will be a "customer pull" which will be helped by regulator's desires to adopt new electricity rates that will incent utilities to invest in advanced metering infrastructure and smart grid technologies.
- We envision a system that is managed increasingly by customer demand response but also relies on an improved real-time central grid backbone progressively supplemented by distributed generation and microgrids.
- The result will be a real-time managed electricity system that assures higher levels of reliability, efficiency, and environmental performance. Huge benefits (in the tens of billions/year) are at stake.

Trends identified

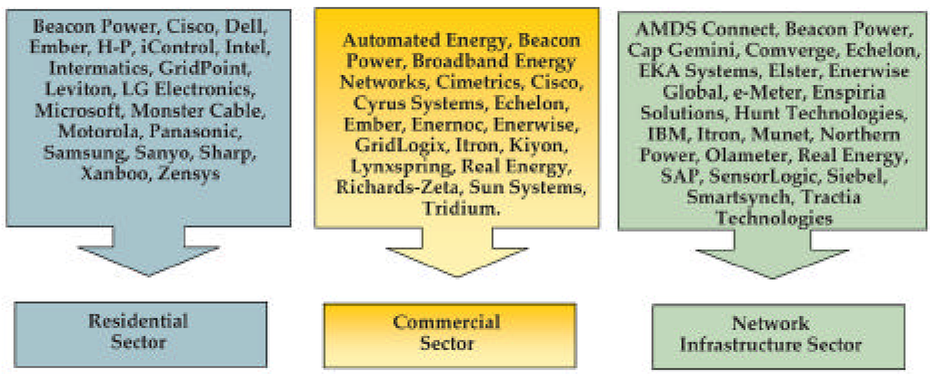
- Web-enabled homes are becoming common. (And green field vs. brown doesn't make that much difference)
- Installation and financing of remote management and interactive storage is now beginning to become available.
- Everything is going IP (Internet protocol). Now we need to look at open protocols.
- In six to nine months more utilities will be moving to advanced meter infrastructure. For example, EDF in France is going to replace 40 million meters. Many utilities in the U.S. have cut spending on meters in the last 10 years. Where they may have spent in the single digits before they are now looking at up to 155 percent spending for meters.
- The roll-out time for building intelligence is 10 years. We have got to get this done and get the customer in control of his or her energy destiny.
- Technologies enabling demand response (in which customers can receive price signals from a utility and manage energy in response) are being developed, including in-home displays that show the customer what he or she is paying for and how much each function costs. For example, 9 percent for lighting is typical. Who knows that? Once an inexpensive data display is available, people will act on it. Issue is how many and how much, but critical line to cross is getting capability.

Gale said the cost effectiveness of distributed power systems will be iffy in the next years unless customers have instantaneous information and control. And a fine level of management will be needed to realize value. Wireless technology will take away a lot of the update cost of new communications systems, however, said Gale.

New entrants

New businesses are entering the business of energy-related communications and automation. These are shown in **Figure 7**.

Figure 7. Examples of new entrants



Source: GF Energy

Gale sees a fertile ground for more entrants and new platforms, particularly in the commercial-customer sector. For example, he reported that Cisco is aggressively moving into the Honeywell and Johnson market space.

Reaching the tipping point

GF Energy believes that the tipping point toward perfection is likely to come within 10 years, and will be characterized by the following metrics:

- Home automation systems are a staple offering from hardware retailers, telecom companies or energy retailers
- Building intelligence is accepted in more than 50 percent of the new commercial buildings and a whole new breed of system integrators has proved itself in that sector
- Many Fortune 500 companies have their multi-site facility portfolios fully Web-enabled and have subscribed to extensive demand response (DR) services
- Submetering is a valid option in multi-family and office buildings alike
- About 40 to 45 percent of the load is under AMI and grid interoperability has been mostly achieved

- DR markets have proved themselves for more than five years; there are many reliable and financially sound multi-GW DR providers
- Over 20 percent of new distribution investments are smart-grid related

GF Energy has estimated the annual benefits of smart infrastructure and microgrids:

Source of Benefit	Benefits/year ($B, 2020)
"Smarting up" of customer premises (smart homes, intelligent buildings)	$10-15
Enabling of Demand Response and AMI deployment	$15-20
Investments in smart grid technologies	$10-15
DG and smart grid-interactive storage technologies	$5-10+
Microgrids	?
TOTAL	40-60+?

Huge benefits are at stake in the market. Gale said that the numbers presented are first level, but he believes them to be conservative.

With smart meters at $60 per home (same type of housing, wireless, and assuming an easy installation) the economics of an advanced meter infrastructure are improving. Gale commented that bundling services on basic communications and control systems that are in place is important.

John Marshall of Kansas City Power & Light provided an example of a smart device in which KCP&L is investing. This is an interactive set-back thermostat from Honeywell that can be set via the Internet. In tests in June 2006, the thermostat is estimated to enable the utility to control 1.1 kW per household. The cost of the thermostat is $300, paid by the utility and free to the customer because it is covered in the rate base.

John Cuttica of the University of Illinois pointed out that the homeowners themselves would not have made the $300 investment in the thermostat, so the public utilities commission has figured out a way the utility can make money on this. That is what is missing from the development of combined heat and power systems.

Clark Gellings concluded the discussion by cautioning that there might be barriers to utilities entering the smart system development. For companies currently engaged, it might appear that the utilities will want to use their monopoly power, so current industry members could oppose them. Unions may also oppose this, fearing job loss.

Leadership and Quality in the Galvin Electricity Initiative
Jim Buckman, Joseph M. Juran Center for Leadership Quality

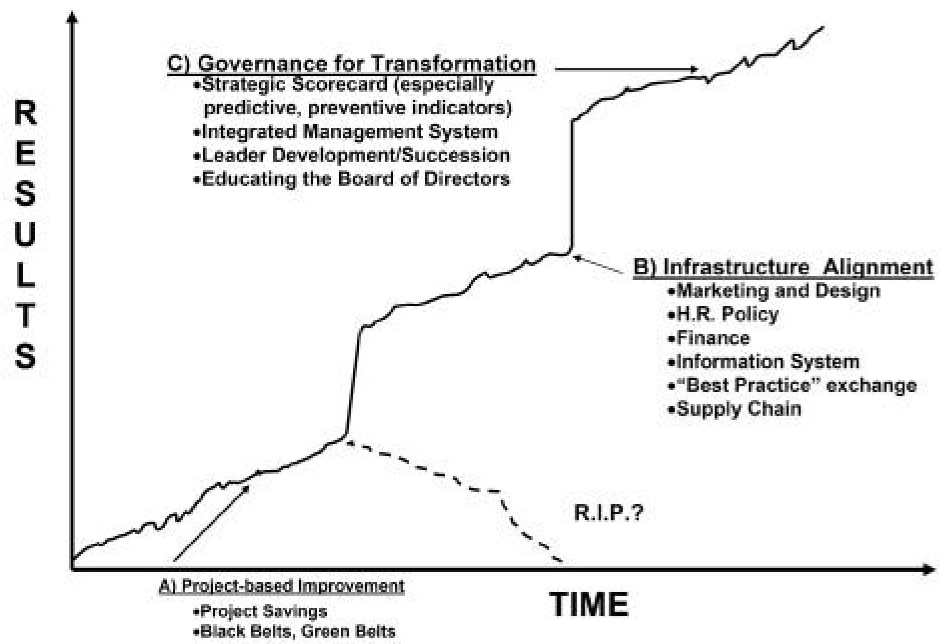
Buckman reviewed the tasks the Juran Center is performing for the Galvin Electricity Initiative to provide quality leadership training to members of the industry. Buckman also offered a basic introduction to the concepts of permanent quality advantage.

The tasks of the Juran Center for the Initiative are to develop a guidebook on creating quality and provide training on quality to the microgrid and power industry. The intent is to complete a superior educational offering and a make it possible "for as many competitors as possible to do well with your help," said Buckman. "This may sound odd, but it works," said Buckman.

Buckman has observed that it is possible—albeit challenging—to develop a quality advantage. "Thousands of businesses have done this. Almost always, it works." The issue is adopting a quality program that yields savings over the long term. He noted that 50 to 60 percent hit a deflection point and run out of steam. The quality activities stop and disappear in about two years.

A relatively small number achieve infrastructure alignment per **Figure 8**. These include companies such as Ford, Corning, Motorola, and Xerox in the 80s. Even those companies having undergone leadership change, head away from quality management. "If you don't plan to be permanently transformed, then there can be no permanent sustained advantage." Those that succeed, said Buckman, "keep an eye to leadership and governance."

Figure 8. The Path to Greatness



Quality as being trouble-free

There are two critical parts of achieving quality. One is that you satisfy customers' needs at an acceptable cost, which is a subjective measure that changes with markets. The other is that quality means "free from trouble." This is first and foundational and is a tangible, measurable, and timeless definition.

Buckman plans on focusing on the trouble-free component in his training. Clark Gellings noted that the power industry today in 22 states measures power reliability, duration and frequency. But they typically count only outages of five minutes or more. If you assume that the data from other states besides these 22 is equivalent, then on any given day in the U.S., 500,000 people are without electricity for an hour or so.

Raising the bar to 'free from trouble' constitutes a breakthrough for many companies, said Buckman. This is almost always preceded by some breakthrough, as company products that have achieved it attest: the Model T, Sony TVs, Toyota cars. And these products don't cost more.

For what is in effect a new industry (the microgrid industry), then the goal of being perfectly free from trouble will be a breakthrough. This is the type of pursuit that thinkers such as Paul O'Neill, Bob Galvin, and others who have changed entire industries endorse. The philosophy is "It is impossible, but we'll do it anyway."

Bob Galvin added that he thought this was probably the first time Buckman would have an opportunity to teach a new industry about quality. Galvin thought it could be an advantage "to claim that the microgrid industry is one that has trained and founded itself on quality." "This could be a marketing message," he suggested.

Discussion

Asked what "it" is that is trouble-free, Buckman noted that it is not simply the power itself, but it also includes experience at point of usage. It includes great treatment from installers, that the bill is understandable, everything.

Buckman cautioned that if the industry doesn't start with the right culture, it is building on a house of cards. He saw this in the auto industry, which inconvenienced many customers. "You don't want to do this in the electricity industry."

Kevin Best brought up that as an industry, microgrids don't have a trade organization. This can be problematic since there is no group to create standards and set some sort of bar. A challenge in the industry is that if you are an investment banker or have a wrench in your pocket you are an expert. "There has to be some way to earn your way in."

Kurt Yeager noted that sustainable quality is essential, so that the Galvin catalytic investment will be successfully leveraged.

Breakout Session Results, Day Two
Facilitated by John Cuttica, University of Illinois and
Susan Freedman, San Diego Regional Energy Office

The second half-day of the workshop was devoted to sessions in which participants split into two groups to address recommendations for accelerating the development of microgrids and overcoming barriers.

Summary of Breakout Session 1 from John Cuttica:

The business case was the emphasis of discussion in this session, with business case meaning: What is value? Who receives it? And how do you capture it? Several recommendations resulted:

1. **Developing a prototype system will be necessary**. But it is important to define the kind of system we are talking about and be clear about this—and get the right people involved.

2. **Do not get warped by present regulations**. The new ingredient is distributed generation. Keep this in mind when developing the prototype.

3. To test the concept, test the ability to fulfill the value. **The point is to develop the business case**, not to persuade the entity (such as the utility or regulator). If you can show values that are definable and can be reached, then the next step is automatic.

4. **Include all stakeholders.** Also keep in mind the Perfect Power concept and identify all the different players: the entrepreneurs, the partners impacted, and the customer. Work the value proposition and harness public and political will.

5. **For the utility, increase asset utilization.** The bidirectional flow of electricity can increase load factor. Hybrid vehicles may be possible generators. Look for value to the utility. Find a balance for the requirement to serve.

6. **Consumers looking for perfection are not necessarily looking for this from utilities**, who are not set up for perfection.

Summary of Breakout Session 2 by Susan Freedman

This group assessed the concept behind Perfect Power. What are we talking about and looking to achieve? This led to an ‘evolution versus revolution’ discussion. For example, in evolution you move from a desktop computer to a laptop. In the revolutionary mode, you move from a rotary to a cell phone. The group came up with several recommendations and comments.

1. **A revolutionary change is needed.** The microgrid can be defined as a platform for innovation.

2. **Open access to distribution systems is needed.** If focus is on this, it is where all else comes together.

3. **Determine the political level at which this will get done.** This could be the level of government, which Freedman believes is the local level. Look at areas with a strong political will, perhaps caused by a constrained transmission and distribution system, where developments are already happening. This is an entry point.

And the local government will guide the system down to what the customer wants: reliability, green power and the like.

4. **Look to develop in potential target states of New Jersey, California, and Texas, for example.** These tend to have more friendly laws and innovative commissioners.

5. **Spur duplication** and document win-win developments.

6. **Address communication and marketing issues.** Figure out why people would want this. Independence, control, green living, as well as microgrid power that is more reliable than utility power are drivers. An example is the organic food industry. It has a niche because people perceive it is of higher quality. Or the call waiting example. Things like this will come from microgrids.

Ending Discussion

Several suggestions emerged as the workshop wrapped up related to getting out of the laboratory and into the field. The new wave of technology is enabling a new wave of development, and the group agreed that quality management, which has been lacking to date, has to be a focus. The difficulty of this, and of creating a robust business case, was discussed. After all, the regulatory compact with today's utilities was created because serving residential customers is not an advantageous business. $35 a year is the value of a residential customer. There is not a lot of investment that can be justified on that basis. That is why the utility gets a guaranteed rate of return in exchange for a franchise. This economic situation needs to be considered, as do opportunities for other value, such as green power. Several states have already voted to require a renewable energy portfolio (a mandated level of renewable energy resources in the utility's portfolio). The value of such desired changes can be tapped for microgrid development. Alignment of interests with various stakeholders is key. For example, modest modifications regarding bidirectional flow of electricity can increase the value of the current system to the utility.

"Let's get into board rooms and also talk to regulators," was a popular call to action.