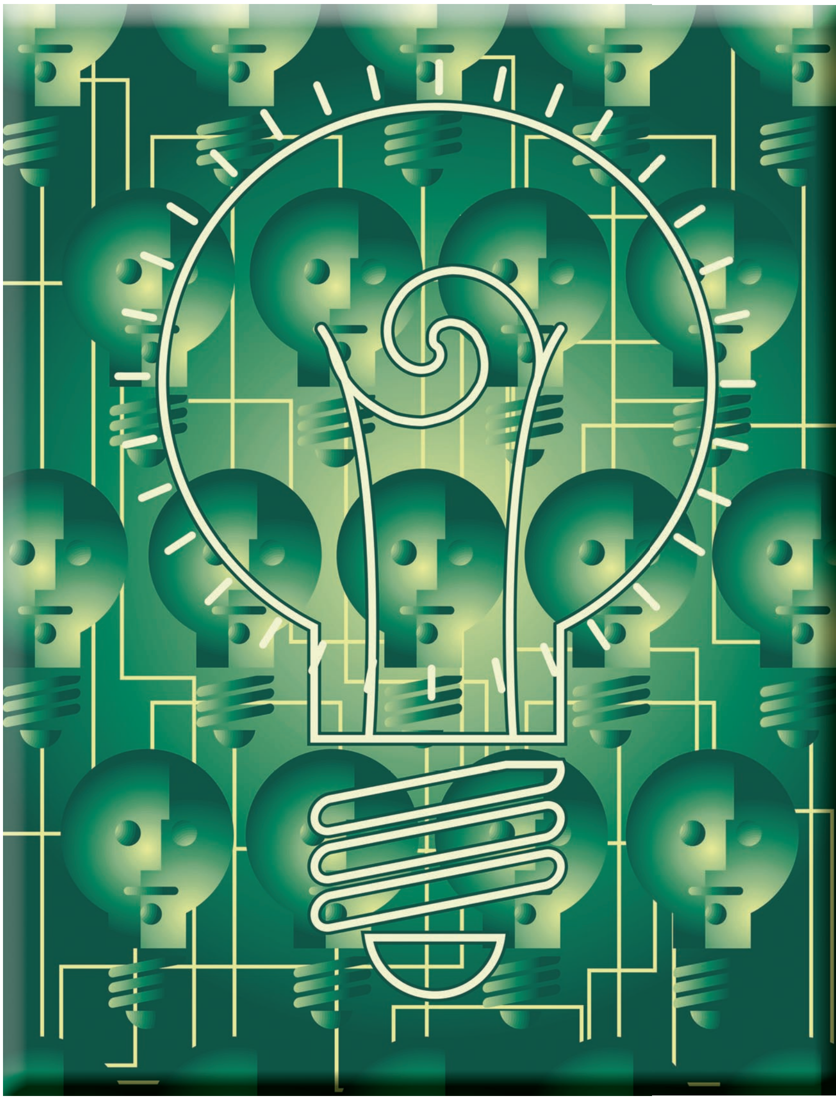
Smart Integration

The Smart Grid Needs Infrastructure That Is Dynamic and Flexible

By Ali Vojdani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ELECTRIC UTILITIES IN THE UNITED States and globally are heavily investing to upgrade their antiquated delivery, pricing, and service networks including investments in the following areas:

- ✔ smart grid, which generally includes improvements upward of the meters all the way to the transmission network and beyond
- ✔ smart metering, sometimes called advanced metering infrastructure (AMI), which usually includes control and monitoring of devices and appliances inside customer premises
- ✔ smart pricing including real-time pricing (RTP) or, more broadly, time-variable pricing, sometimes including differentiated pricing
- ✔ smart devices and in-home energy management systems such as programmable controllable thermostats (PCTs) capable of making intelligent decisions based on smart prices
- ✔ peak load curtailment, demand-side management (DSM), and demand response (DR)
- ✔ distributed generation, which allows customers to be net buyers or sellers of electricity at different times and with different tariffs, for example, plug-in hybrid electric vehicles (PHEVs), which can be charged under differentiated prices during off-peak hours.

The main drivers of change include:

- ✔ insufficient central generation capacity planned to meet the growing demand coupled with the increasing costs of traditional supply-side options
- ✔ rising price of primary fuels including oil, natural gas, and coal

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- ✔ increased concerns about global climate change associated with conventional means of power generation
- ✔ demand for higher power quality in the digital age.

At the same time, continuous improvements in technology accompanied by rapidly falling costs make smart grid, smart metering, and smart pricing investments attractive and cost justified. Moreover, regulators and policy makers at both the state and federal levels have become receptive since they see these investments as a necessary prerequisite to improve energy efficiency and manage peak demand while reducing overall costs of service delivery.

table 1. Penetration of advanced metering technology by state.

State	Total Meters	Penetration
Alaska	304,922	0.4%
Alabama	2,408,311	3.1%
Arizona	2,672,810	1.3%
Arkansas	1,418,374	12.9%
California	14,248,449	0.3%
Colorado	2,333,344	4.1%
Connecticut	2,766,367	21.4%
Delaware	416,530	0.0%
District of Columbia	231,715	0.1%
Florida	9,672,651	2.5%
Georgia	4,339,625	2.7%
Hawaii	465,314	0.0%
Idaho	733,549	16.2%
Illinois	5,641,014	1.5%
Indiana	3,333,183	0.7%
Iowa	1,094,178	2.0%
Kansas	1,298,716	20.0%
Kentucky	2,326,745	5.1%
Louisiana	1,359,990	0.0%
Maine	785,301	14.3%
Maryland	2,574,187	0.0%
Massachusetts	3,651,039	0.2%
Michigan	4,694,569	0.6%
Minnesota	2,497,327	0.6%
Mississippi	985,512	0.0%
Missouri	2,996,721	13.4%
Montana	532,669	0.1%
North Carolina	4,528,699	0.2%
North Dakota	423,866	2.4%
Nebraska	949,461	6.8%
Nevada	1,194,018	0.0%
New Hampshire	774,329	2.5%
New Jersey	3,866,650	0.4%
New Mexico	892,062	0.5%
New York	7,995,481	0.1%
Ohio	6,081,421	0.0%
Oklahoma	1,926,928	7.2%
Oregon	1,825,673	0.3%
Pennsylvania	6,055,729	52.5%
Rhode Island	484,598	0.1%
South Carolina	2,052,900	3.2%
South Dakota	562,960	3.2%
Tennessee	3,044,416	0.0%
Texas	13,086,847	4.4%
Utah	1,051,589	0.0%
Vermont	329,967	0.0%
Virginia	3,329,365	4.2%
Washington	3,008,633	1.4%
West Virginia	669,002	0.0%
Wisconsin	2,982,149	40.2%
Wyoming	1,384,871	0.0%

Source: *Assessment of Demand Response & Advanced Metering*, FERC, 8 Aug 06.

The recent rush to invest in smart technology has been stunning. Datamonitor, for example, projects that the installation of smart meters by utilities will grow from the current penetration of 6% of households in North America to 89% by 2012; the corresponding figure for Europe is 41% (Table 1). Another study by Cellnet and Hunt estimates that U.S. utilities will install 30 million smart meters within the next three to four years—roughly a quarter of all U.S. meters. In California, the investor-owned utilities are in the process of a massive changeover of virtually all electromechanical meters to the smart electronic variety by 2012. The Province of Ontario in Canada is doing the same.

Why is so much money going into the smart grid/metering projects? The short answer is that recent fuel price increases and the rapid escalation in the cost of supply-side options have made energy efficiency and DR programs an attractive bargain. For example, Baltimore Gas and Electric Company (BGE) has concluded that DR is the most cost-effective component of ensuring reliability over the next several years. BGE estimates that the capital cost of DR at US$165/kW is three to four times cheaper than the cost of installing new peaking generation, which is around US$600-800/kW (Table 2).

A growing number of utilities are now counting on distributed resources as part of their supply portfolio. There are numerous other examples all pointing to the benefits of demand-side options including energy conservation, DR, and distributed generation:

- ✔ a recent study by the Electric Power Research Institute (EPRI) and the Edison Electric Institute (EEI), for example, concluded that energy efficiency improvements in the U.S. electric power sector could reduce electric consumption by 7–11% over the next two decades if key barriers can be addressed
- ✔ the state of Maryland has set a goal to reduce per-capita energy consumption by 15% in 15 years while reducing state-wide peak load by 15% from the 2007 level by 2015
- ✔ according to Jon Wellinghoff, a DR advocate at the Federal Energy Regulatory Commission, a mere 5% improvement in U.S. electric efficiency would prevent the need for 90 large coal-fired power plants from having to be built over the next 20 years with significant cost and environmental implications
- ✔ Consolidated Edison Company of New York is investing more than US$1.7 billion this year to upgrade and reinforce its electric delivery system while encouraging energy-efficiency programs.

Power and Promise of Price Signal

With rising gasoline prices, filling up the car tank has become a painful experience. As drivers watch the dollars on the pump display, they are made keenly aware of how much money is literally draining out of their pockets into the tank.

For those with big cars and long distances to drive, this is an effective reminder to switch to smaller cars, drive less, car pool, take public transport, or telecommute.

For the average electricity consumer, the bill may be painful when it finally arrives, but they have no idea how fast the dollars are adding up during the month. This, many experts agree, is among the reasons why consumers may be using more electricity than they would if they knew how much it was costing them. Accounting for the fact that electricity costs vary at different times of the day and across the seasons, the problem becomes even more acute. This also explains the sharp system peaks experienced by grid operators on hot summer days, which is something that is not well known to the average consumer.

Over the years, there have been numerous studies that suggest that consumers would use less electricity if they knew how much it was costing them. The effect becomes more pronounced during peak demand periods when prices are significantly higher. The phenomenon is similar to studies that have documented that people walk more if they wear pedometers that count their steps, eat less potato chips once the calories and the fat content are clearly indicated, or talk less when using public phones where the cost of the call is displayed on a monitor. Price signal is a powerful determinant of usage and certainly works as an effective deterrent to wasteful consumption.

In January 2008, the U.S. Department of Energy (DOE) released the results of a year-long experiment in the Seattle area that concluded that when consumers are given the means to track and adjust their energy usage, power consumption declines by an average of 10%, with 15% during peak demand periods. The study, conducted by Pacific Northwest National

table 2. Sample of peak load reduction programs offered by selected U.S. utilities.

State	Utility or Agency	Program Type	Homepage Website
AL	Alabama Power	Loan Control Rate Rider	www.southernco.com/alpower
AR	AEP SWEPCO	Curtailable Service Rider	www.aepcustomer.com
CA	California Power Authority	Curtailment-Demand Response	www.caldrp.com/
CA	Los Angeles Dept. of Water & Pwr	Customer Generation	www.lawdp.com
CA	Pacific Gas & Electric	Demand Response Programs	www.pge.com/
CA	Sacramento Municipal Utility Dist.	AC Cycling Credit	www.smud.org
CO	Platte River Power Authority	Custom Load Shifting	www.prpa.org
CO	Southeast Colorado Pwr Assoc.	TOU Rate–Thermal Storage	www.secpa.com
CT	Connecticut Light & Power	Peak Reduction/Curtailment	www.cl-p.com
CT	United Illuminating Company	Peak Load Reduction	www.uinet.com
FL	Florida Keys Electric Coop	Peak Reduction HVAC Cycling	www.fkec.com
FL	Florida Power & Light	Load Shifting/Curtailment	www.fpl.com
FL	Progress Energy	Curtailment Service Credit	www.progress-energy.com
FL	Tampa Electric Company	Standby Generation Credit	www.tampaelectric.com
IA	Alliant Energy–IP&L	Interruptible Service Credit	www.alliantenergy.com
IA	MidAmerican Energy	Curtailment	www.midamericaneergy.com
IL	Ameren	Voluntary Curtailment	www.ameren.com
IL	ComEd (Excelon)	Load Response Curtailment	www.exeloncorp.com
IN	Cincergy/PSI	PowerShare Curtailment	www.cinergypsi.com
IN	Indianapolis Power & Light Co.	Load Displacement Credit	ww.ipalco.com
IN	Cinergy/UHL&P	PowerShare Curtailment	www.cinergyulhp.com
LA	Entergy Louisiana	Curtailment Options	www.entergy.louisiana.com/LA
MA	ISO New England	Curtailment Credit	www.iso-ne.com
MD	Potomac Electric Power Co.	Curtailable Load Program	ww.pepco.com
MD	Baltimore Gas & Electric	Curtailment Options	www.bge.com
MN	Southern MN Muni. Pwr Agency	Summer Peak Curtailment	www.smmpa.org
MN	Dakota Electric	AC Cycling Credit	www.dakotoelectric.com
MN	Otter Tail Power Company	Thermal Energy Storage	www.otpco.com
MN	Xcel Energy	Load Control/Curtailment	www.xcelenergy.com
MO	Kansas City Power & Light	Summer Curtailment Credit	www.kcpl.com
NC	Progress Energy	Curtailment Options	www.progress.energy.com
NE	Omaha Public Power District	Standby Generation Credit	www.oppd.com
NJ	PJM Interconnection	Load Response Programs	www.pjm.com
NY	ConEd (New York)	Load Reduction Incentives	www.coned.com
NY	NYSERDA	Summer Peak Load Reduction	www.nyserda.org
NY	Long Island Power Authority	Summer Peak Reduction	www.lipower.org
OH	Cinergy/CG&E	PowerShare Curtailment	www.cinergycge.com
OR	Bonneville Power Administration	Demand Exchange Program	www.bpa.gov
OR	PacifiCorp	Voluntary Curtailment	www.pacificpower.net
PA	PECO Energy (Exelon)	Curtailment Options	www.exeloncorp.com
SC	Progress Energy	Curtailment Options	www.pgress-energy.com
TX	Austin Energy	Thermal Energy Storage	www.austinergy.com
TX	TXU ED (Oncor)	Emergency Load Management	www.oncorgroup.com
WA	Puget Sound Energy	Voluntary Load Curtailment	www.pse.com
WI	WE Energies	Load Management Options	www.we-energies.com
WI	Wisconsin Public Service Corp.	Voluntary Curtailment	www.wisconsinpublicservice.com

Source: *Energy & Power Management*, July 2005.

Laboratory (PNNL), estimated that smart grid technology, if used nationwide, could save some US$120 billion in unneeded infrastructure investments, displacing the need for the equivalent of 30 large coal-fired power plants. Cost savings aside, that would be a large reduction in CO_2 emissions.

"As demand for electricity continues to grow, smart grid technologies such as those demonstrated in the Olympic Peninsula area will play an important role in ensuring a continued delivery of safe and reliable power to all Americans," said Kevin Kolevar, DOE's assistant secretary for electricity delivery and energy reliability.

Given such promising results, what is holding back widespread use of smart meters and programmable smart devices?

- ✔ The first hurdle is the lack of enabling technology—the gadgets that enable the sorts of applications in the Seattle experiment.
- ✔ The second, and more serious, hurdle is that simply installing lots of sophisticated gadgets upstream and downstream of a smart meter capable of two-way communication and remote control is not going to do any good unless all the parts of the system are integrated and work in unison, as was apparently done in the PNNL experiment at great expense not visible to consumers.
- ✔ The third hurdle is behavioral, namely getting large numbers of consumers to use what is still complicated for most of us—remember the programmable video recorder?
- ✔ The fourth hurdle is that, by and large, investor-owned utilities in the United States have strong incentives to sell more—not less—electricity, which means energy conservation may not be a top priority for them.

Referring to the Seattle experiment, Rick Nicholson, an energy technology analyst at IDC, a research firm, was quoted in a January 2008 *New York Times* article saying, "What they did in Washington is a great proof of concept, but you're not likely to see this kind of technology widely used anytime soon." What he is referring to goes back to the hurdles mentioned above, particularly the second. If the components of a smart grid/metering project are not effectively integrated, no amount of money or sophisticated gadgetry will do.

What If?

Among the exciting breakthroughs with significant potential impact on the electric power sector are recent advances in PHEVs. These vehicles can run on stored electricity before a smallish, highly efficient gasoline engine kicks in once you have exhausted the battery's range. Assuming that the batteries will get better, lighter, and less expensive over time and given that most commutes for passenger cars fall in the 10–40-mile range or less, on most trips you will need little if any gasoline since the batteries can carry you to your destination where they can be recharged. Now imagine that a growing percentage of the 1.1 billion cars projected to be on the road globally by 2020 are gradually converted to PHEVs and you begin to get the picture.

A scenario such as this means that, over time, utility companies providing the juice will become as important as oil companies are today. While major oil companies will still have plenty of business, they may gradually lose market share to utilities in the all-too-important transportation sector.

The first question that comes to mind is when would the cars be charged? If they are primarily charged at night, when most grid operators have ample low-cost capacity, there will be little extra strain on the system. Utilities can benefit from extra revenues during off-peak hours, potentially allowing them to adjust their average rates downward. The analogy would be for an airline filling empty seats on red-eye flights. The increased revenues from otherwise under-utilized capacity may be enough to allow overall ticket prices to decline.

Charging lots of PHEVs during peak demand hours would have the opposite effect, with potentially adverse effects on rates as well as straining an already over-stretched and fragile grid. For obvious reasons, utilities would want to encourage charging during off-peak hours by offering low off-peak rates while discouraging the reverse.

The next question is to what extent can the existing grid handle the new PHEVs? Based on a study conducted by PNNL, a significant percentage of U.S. light vehicles can be supported by the existing infrastructure, provided the batteries are charged during off-peak hours. Under such a scenario, there might be a noticeable reduction in the U.S. oil consumption—perhaps as much as 6 million barrels a day.

Challenges of Rapid Evolution

While the new attention focused on smart grid/metering projects highlighted above is a welcomed development with significant promise, the industry is facing considerable challenges that, if not heeded, may result in potentially massive project cost overruns and possible new stranded costs in under-performing or obsolete technologies.

The most daunting challenge facing utilities during their rapid migration to a smart grid/metering business environment is that they are entering essentially uncharted territory with a number of serious pitfalls—and no one can predict how this fast moving business environment will evolve. Some analysts believe that the impact of distributed resources on central generation would be akin to the impact of personal computers on mainframe computing. While we can argue with the validity of the analogy, the only safe bet is that things will change, and will change rapidly and in ways that are hard to predict.

This should be cause for concern because most managers, planners, and engineers in the utility industry are used to moving incrementally and deliberately along a predictable path. Their traditional business model is to migrate from state A to B, C, and D linearly. They are adapted to this type of transformation [Figure 1(a)].

This article argues that the transition to smart grid/metering environment will require flexible design, agility, and improvization necessitated by frequent and dramatic changes that are ill-suited for traditional utility-style projects. In this new environment, people, systems, solutions, and business processes must be dynamic and flexible, able to bend, shrink, or stretch in response to changes in technology, customer needs, prices, standards, policies, or other requirements. The need for flexibility is schematically shown in Figure 1(b), where transition from each state to the next is uncertain and may take one of many multiple paths.

Static design and rigid, hard-wired, coded solutions—the traditional hallmarks of utility industry projects—could be obsolete before they are finished, essentially dated the day they are implemented. Some utilities are already experiencing rapid technological obsolescence and are trying to negotiate with the regulators to shorten the life of assets in AMI projects. Trying to upgrade and integrate old legacy systems in the dynamic and uncertain new environment will be futile technically, functionally, and economically.

This article suggests that we should position our systems and solutions for a dynamic future, where products, services, and business processes frequently change, as is the case in many other industries such as telecommunications. We must also be mindful that as an industry, we are still building fixed, static, inflexible computer applications and interfaces that will be costly in such a dynamic future. It advocates a smarter approach to infrastructure upgrades where we would architect and integrate business processes in a flexible manner so that they can be agile and can dynamically adapt to changes. It advises the utilities to make "flexibility" a key requirement in their specifications as they procure new applications. It introduces a new framework, "smart integration," that creates flexibility by integrating "dynamic applications" with "dynamic interfaces." Finally, the article introduces the novel concept of a "flexibility test," akin to performing seismic tests in the construction industry, that utilities could use to screen inflexible applications and interfaces. Some examples of dynamic applications and dynamic interfaces are presented.

From Static to Dynamic

To describe the serious challenge facing today's utility managers, IT specialists, and business process professionals, take the case of the California independent system operator (CAISO). Significant sums went into designing its basic infrastructure from the ground up when California passed its restructuring law in 1996. These sophisticated systems were hard-wired and coded to perform specific tasks as envisioned by the original designers of the California market. The following quote from the Federal Energy Regulatory Commission (FERC) Technical Conference on CAISO MD02 Implementation (9 December 2002) captures the essence of the problem:

> Most of CAISO's current market functions reside in a black box we call our scheduling application (SA). This black box is welded to the scheduling infrastructure (SI) making it difficult to change, or add to, the existing functionality. The design of these systems is monolithic (that is the complex interdependent elements of the systems make changes to one element impact others, there is a high degree of shared data elements and interfaces and data interactions are not open.) Monolithic design, although not inherently poor, is intended for systems that will not undergo significant change. In general, the systems development industry has evolved away from monolithic design toward open and component type design principles to drive flexibility and economies in system development and operations.

Following the electricity crisis of 2000–2001, it became clear that the original market design was deficient in a number of dimensions. Moreover, to prevent a recurrence of many of the problems associated with gaming, market power abuse, and other issues, market rules, settlement procedures, and a host of other requirements were changed, including switching from zonal to nodal prices. These changes were to be incorporated in a massive undertaking called a market redesign technology upgrade (MRTU).

The MRTU set out an ambitious plan to upgrade the technology and address the new requirements over a set period of time with a set budget. But the environment under which CAISO operates and the world beyond did not remain static for the MRTU project to be completed. The requirements evolved as the implementation progressed and the simulation results compelled the need tochange the MRTU tariff and the new software applications.

Confronted by frequent and unpredictable change, the MRTU project is behind schedule and over budget. While the new enterprise is likely to be more flexible than the original, it is not clear if it would be flexible enough to easily incorporate significant future changes such as those that may be driven by the increasing need for DR in California.

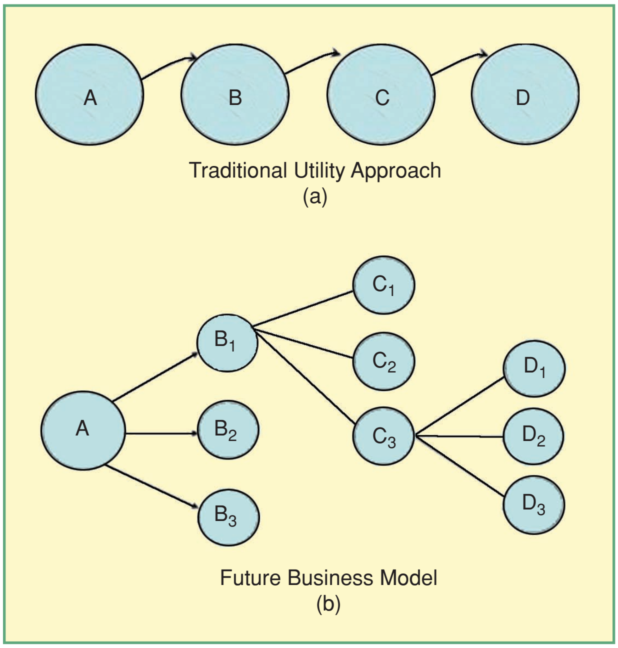

figure 1. (a) From linear and static to (b) nonlinear and dynamic.

There are numerous examples from other ISOs and utility IT projects confronting essentially the same problem. Rigid, hard-wired systems that are difficult, if not impossible, to change do not work well in rapidly changing business, regulatory, and technical environments. The outcome is projects that are late, function marginally or poorly (if at all), and exceed their original budgets by wide margins. Moreover, even if they are made to work by the sheer tenacity of IT developers and vendors, they will face a similar challenge the next time a new requirement or change has to be incorporated, keeping the management, the customers, and the regulators perpetually frustrated.

Winning When You Don't Know the Game

For the sake of trivializing the problem, let's say that an experienced football coach is told to prepare his team for a challenging game. He goes through the routine of getting the team ready and gets them the best uniforms and equipment. But when the team shows up at the field, he realizes that they must play a soccer match, not football. His players, all experts in passing, receiving, and carrying the football, will be penalized if they touch the ball in soccer. Moreover, their shoulder pads and helmets hamper their mobility on the field. Their practiced routines of passing and carrying are useless. In today's business environment, the coach needs players who are agile and flexible—so they can play soccer, football or any other ball game—with versatility.

An Example: A Dynamic Computer Application

But how would this work in practice? That was the challenge posed by a recent research project funded by the California Institute for Energy & Environment (CIEE). Referring to the game analogy, the DRBizNet Project (for a DR business network), did not specify the exact nature of the game to be played, the specific rules of the game, the players, or other details (for more information on DRBizNet, see the "For Further Reading" section). It only described a conceptual scheme for developing, sending, receiving, verifying, and implementing signals in a fast, secure, and error-free environment among a number of participants in a DR program in California.

It was a challenging project precisely because so many of the critical details were intentionally unspecified. It was essentially asking the coach to prepare a team to play a ball game without saying what the game would be. Faced with this seemingly insurmountable challenge, the team was forced to define the requirements of the project at the highest level of abstraction so that the end product would be able to function under virtually any specific set of rules or specifications. The result was the definition of basic functionalities required in any DR project no matter who the participants were, how many, what specific systems or needs they had, or any other constraints. A great deal of flexibility was built into DRBizNet by building on top of flexible foundational technologies such as the standards-based service-oriented architecture (SOA), business process management, and intelligent agents (Figure 2).

At the conceptual level, this list provides what is needed to implement a DR program not knowing any of the details:

- ✔ an efficient system to register and identify participants in the DR program
- ✔ a standardized set of protocols to send, receive, verify, and acknowledge signals among participants
- ✔ a standard set of protocols to accept, reject, or modify notification signals for demand curtailment
- ✔ a standard set of protocols for incentives offered to participants for engaging in DR programs
- ✔ a standard set of protocols for keeping track of notification signals sent, received, accepted, rejected for record keeping, settlement, billing, auditing, and back-office systems
- ✔ a highly secure and error-free environment for all of the above to take place in real-time and with high speed
- ✔ a flexible underlying IT infrastructure that could support all of the above and is capable of expanding or changing to accommodate frequent changes in the rules, the procedures, the number, and makeup of the participants or virtually anything else.

The DRBizNet Project succeeded precisely because it was designed from the ground up with flexibility in mind. The underlying IT infrastructure and business processes were defined to handle any DR tariff and market structure. The signals could come from CAISO and be sent to participating utilities who could pass it on to their customers, any aggregators, or other intermediaries. But if a different scheme was substituted, DRBizNet could still handle it.

As long as the fundamentals remained the same—number of participants, registering, sending, receiving, verifying, accepting or rejecting standardized DR messages—the project could handle any change by virtue of simple configuration of its flexible building blocks. There was no need to change the computer application.

To make this possible, quite a bit of intellectual capital had to go to thinking in abstract terms, to define the fundamental requirements on a conceptual level, and to provide built-in flexibility. As previously stated, this is in sharp contrast to many utility IT projects where the requirements of the desired end state are usually prespecified and the business environment is assumed to be static.

Operational Challenges

Managing smart grid/metering projects is difficult due to the sheer size and complexity of the number of data points. For example, a typical DR project requires

- ✔ secure and reliable communication and control among a potentially large number of participants
- ✔ ability for participants to register and interact with one another in an error-free environment

- ✔ ability for various participants to bid, iterate, and interact to prices and response of other participants
- ✔ facility to schedule and implement the transactions that parties have agreed to do
- ✔ protocols for measurement and verification of the above
- ✔ automated processes for settlement, billing, collection, bookkeeping, and dispute resolution.

Similarly, managing a smart metering/pricing project requires

- ✔ offering different services and tariffs that vary by time of use and potentially by type of application
- ✔ metering and meter data management services
- ✔ new systems for billing and settlement
- ✔ new customer-service applications capable of supporting the new metering, pricing, and billing schemes.

The traditional approach to design such new systems would be to specify a blueprint that includes a standard architecture for a group of applications that would supposedly provide the needed functionality. Historically, utilities would typically issue RFPs to procure the necessary applications or upgrading existing ones to provide incremental functionality. The vendors or the IT department would design and build static "data bridges" to connect these applications. The main shortcoming of this approach, as already pointed out, is that it represents a static view of a rapidly changing future, namely,

- ✔ systems are built in deterministic ways, satisfying the requirements of the next phase
- ✔ interfaces are built to connect these static systems
- ✔ nowhere in the specifications of the applications or interfaces is there any explicit requirement for flexibility or adaptability to change (even if flexibility is mentioned, the industry does not have any convention or methodology for measuring or testing for flexibility).

Smart Business Integration

How to design, buy, and test flexible infrastructure? As the preceding DRBizNet example illustrated, including flexibility in the original project design is a challenging concept, requiring conceptual thinking at an abstract level. It would be akin to building a skyscraper that can withstand a massive earthquake or a bridge than can sway in the wind without collapsing. Just as such a flexible structure would require more advanced design and more resilience, flexible IT systems require more conceptual thinking up front.

A comparison between the business planning environment in the utility and telco or airline sectors shows the contrast between flexible versus static design. Telcos and airlines can change their entire pricing structure in a matter of hours in response to changing business conditions or an advertising campaign by a competitor. For example, when a major airline announces that it will introduce a fuel surcharge or collect fees for checked luggage or on-board food service, the entire industry typically matches in a matter of hours.

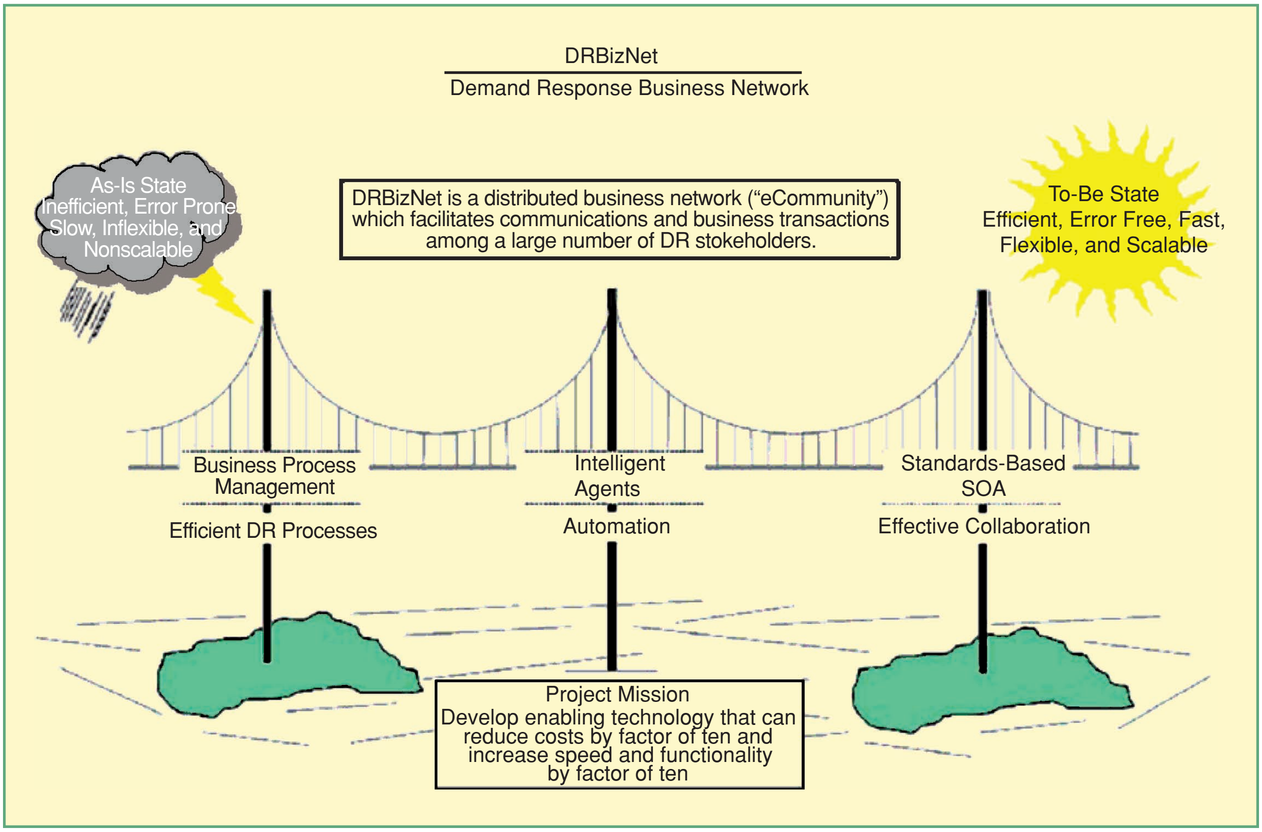

figure 2. Bridging to an uncertain future with a dynamic demand response computer application built on flexible foundational technologies.

The same goes for a promotional fare or other marketing strategies. When one mobile phone company recently introduced a flat rate for mobile service, all others matched the offer instantly. If consumers demand new service options, such as a family plan for mobile phones, for text messaging, or other services, the industry can respond quickly.

Utilities, by contrast, take months, if not longer, to introduce a new tariff or adjust an existing one, and this greatly hampers their ability to respond to consumer demand and changing requirements.

How does one build a flexible infrastructure that can be more responsive to changing business environments and consumer needs? The basic recipe, which we call the "smart business integration" methodology, includes the following steps:

- ✔ Define the basic products and services that consumers need at a conceptual level.
- ✔ Identify the business processes that can support and deliver those products and services.
- ✔ Break down the business processes into a set of services at a higher level of abstraction than is done today.
- ✔ Provide the necessary infrastructure for integrating these services in a flexible way according to best practices in a service oriented architecture (SOA).
- ✔ Buy or build applications for delivering the desired services in a dynamic and flexible way. (Business rules should not be hard coded. This can be accomplished by using business process management engines.)
- ✔ Specify and build flexible interfaces to bridge data transfer among different applications making sure the interfaces are not tightly coupled with the applications. (Interfaces have to be a lot smarter than the dumb bridges of the past. They will be more expensive to build but will be independent of the applications if they are to be replaced.)
- ✔ Manage business processes end-to-end with a business process management (BPM) software that coordinates among different applications.
- ✔ Simplify the connections between applications and minimize coupling through an enterprise application integration (EAI) architecture.
- ✔ Use smart technologies such as complex event processing (CEP) to analyze the events as they occur and use the insight obtained to automatically modify business processes dynamically.

Investing in Dynamic Interfaces

The commercial systems integration (CSI) framework developed by the Electric Reliability Council of Texas (ERCOT) provides an example of flexible interfaces. The CSI framework was designed to bridge the gap between several market applications and the settlement application. In this case, the challenge was to design the interface before the applications were fully designed. To allow for such flexibility, the concepts described above were applied to design a highly configurable interface built for change so that when business rules change, they do not impact the base framework. In the long run, such built-in flexibility is likely to save considerable money in terms of avoided change orders.

The Flexibility Test

Having described what is meant by flexible infrastructure and how to build it, one must focus on testing for flexibility, just as technicians test new cars for crash resistance or engineers test new building designs for withstanding earthquakes. The utility industry needs to define new tests and new standards testing software flexibility. Today we only test software for conformance to prespecified requirements and the ability to take more volume or to work faster. Standards tests currently used include

- ✔ functionality tests
- ✔ availability tests
- ✔ performance tests
- ✔ security tests
- ✔ volume tests
- ✔ integration tests.

We, as an industry, should define new tests to measure how flexible an application is. Can it, for example, handle a different set of requirements or withstand the equivalent of an 8.0 earthquake? Can the vendors of various components of a complicated IT project demonstrate that they can quickly and easily reconfigure the business processes and business rules in a given application? If one application in a chain of applications was changed or replaced, can the remaining applications perform with limited effort? These are among the issues that will make a big difference in how well the overall framework will perform. Ultimately, we must ask each vendor two key questions:

- ✔ How fast and at what cost can you change an application?
- ✔ How fast and at what cost can you change an interface?

This is not an easy thing to achieve, partly because the engineers procuring the systems are not used to specifying and demanding flexible applications, and also because many vendors serving the utility industry are not used to developing and delivering this type of software. But since the most important permanent asset in a complicated IT project is the underlying integrated infrastructure, every effort and every precaution must be taken to end up with such a solution at the end. The extra up-front effort will certainly be worth it if it results in a platform that allows us to offer new products and services and can support new business processes or changes to existing ones.

Smart companies incorporate flexibility in their requirements and test for flexibility. As an example, when the PJM Interconnection decided to replace its existing DR system with one that can keep up with the changing business rules, they identified "architecture flexibility" as a key requirement. They also tested for flexibility by asking vendors to

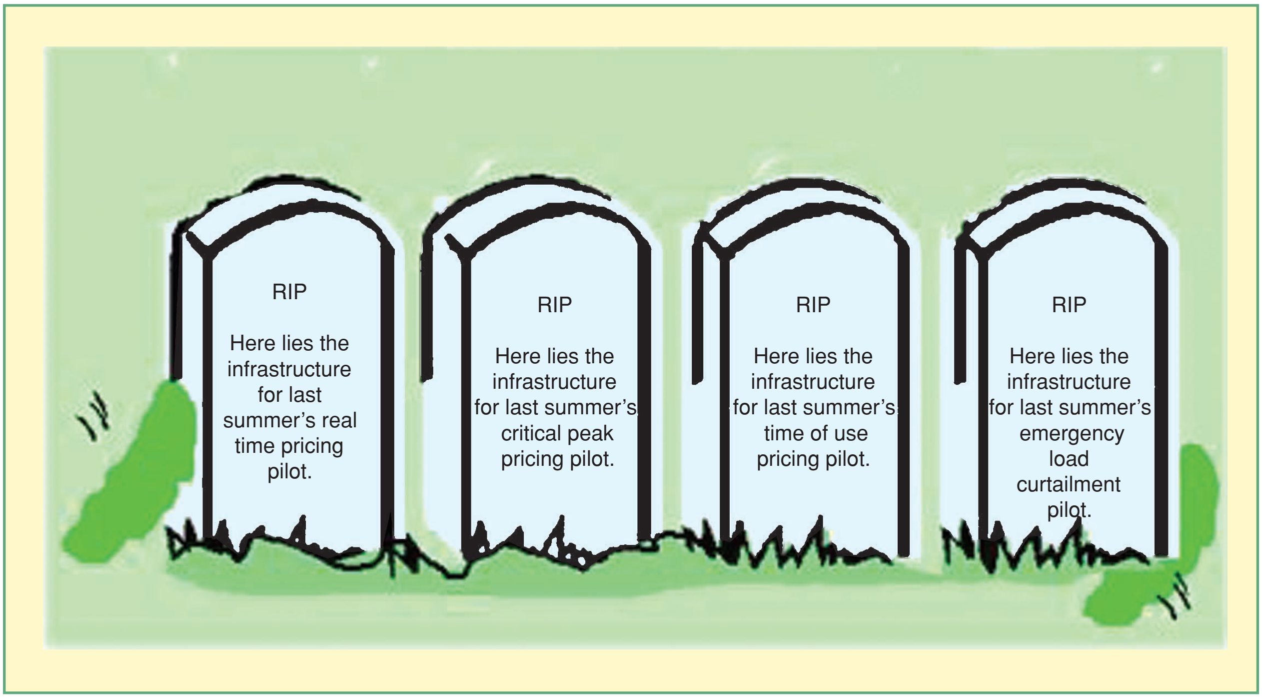

figure 3. The graveyard of inflexible demand response applications.

show that the software can be quickly configured to accommodate major changes to business processes and business rules. Flexibility played a key factor in their procurement process. Smart investment in flexibility is likely to pay off handsomely in the long run.

Moving Away from the Static World of Static Designs

As the utility industry evolves, yesterday's static world where we moved incrementally from the current state to a well-defined future state where new system requirements could be specified with accuracy and certainty has come to an end. We are entering into a dynamic era where the only certainty is change. Under these circumstances, utilities must position themselves to be flexible and agile—being able to react to change quickly, being able to respond to new customer needs, and being able to take advantage of fast evolving technological opportunities and innovations.

In this new era, we need flexible infrastructure—bridges and skyscrapers made from flexible material and not unbending concrete or rigid steel. Components used in new projects must be defined and designed to dynamically adapt to change. As highlighted in this article, inflexible/static components would have a short life at best in a rapidly evolving environment. The transition from static to dynamic will be a difficult one for utilities and vendors that are not used to dealing with rapid change and uncertain design features (not all software used by utilities is inflexible; e.g., many commercial enterprise resource planning systems used by utilities are built for use in multiple industries and are quite flexible). But the alternative is worse: a graveyard of stranded investments—systems and solutions that under-perform and are obsolete faster than they can be replaced (Figure 3). Some utilities are already confronting the problems associated with premature obsolescence in advanced metering projects. Ultimately, customers have to pay for the mistakes.

It will be more expensive to build flexible infrastructures than static ones. But the value proposition will be large. The sooner we start investing in flexibility, the sooner we can start saving and avoiding rapid technological obsolescence.

For Further Reading

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Biography

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