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Smart Grid Strategy:
How Can State Commission Procedures Produce the Necessary Utility Performance?

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Executive Summary

All around the U.S. and in many foreign countries, utility companies are in various stages of readiness and eagerness both to invest in and deploy smart grid facilities. In growing numbers, they are asking state public utility commissions to approve smart grid pilot projects and even full-blown smart grid implementation plans. Drawing on experience from several states that have already embarked on smart grid procedures, this paper explores smart grid's status today and describes a systematic approach by which commissions can address utility smart grid applications.

The paper, in Part I, identifies several major sources of complexity that affect smart grid decisionmaking. Part II describes the seven major missions that smart grid's supporters advance. Part III describes the nine major smart grid components. The discussions of each mission and each component, in Parts II and III, include three topics: (1) ***examples***, (2) ***uncertainties and concerns***, and (3) ***advice to commissions***. The ***examples*** and reviews of ***uncertainties and concerns*** are drawn from early experiences in several states and from the smart grid literature. Two appendixes include brief summaries of commission orders from three states where utilities have already filed smart grid applications (Hawaii, Maryland, and Oklahoma) and three states where commission proceedings are underway to establish utility smart grid filing standards (California, Colorado, and Illinois). Part IV provides guidance for commission positioning and procedures for steering smart grid deployment to best serve the public interest.

Decisionmaking complexities: Part I of this paper describes smart grid complexities. These include differing definitions of smart grid and the broad range of missions it could serve (not all of which are mutually consistent). Individual smart grid communications and control system components can serve multiple functions in multiple domains and can be used by multiple actors. Also, smart grid functions and components will affect the entire electric utility industry: generation, transmission, distribution, and customer service. Thus, there is a need for coordination among a variety of actors and interested parties.

Another complexity is that smart grid is being implemented at the same time that electricity markets are changing. For example, demand response (DR) is an important smart grid function, but the country's various regional transmission organizations (RTOs) are at different stages in the process of creating and managing DR markets.

Another source of decisionmaking complexity is that utilities can achieve some smart grid missions, at least partially, without full smart grid implementation. One common example is load-control and demand-response programs. Many utilities have successfully managed them without implementing all of the related smart grid components.

Smart grid decisionmaking is also complex because of the rapid changes in and continuing evolution of smart grid technology. Operational standards are still being developed, and various technologies continue to compete against one another. Business cases for smart grid deployment continue to develop as experience provides more and better information. Each new deployment provides additional details about the many efficiencies achievable through smart grid technologies and smart grid-enabled consumer behavioral changes.

Finally, the U.S. Department of Energy (DOE) is presently allocating $3.4 billion in American Recovery and Reinvestment Act (ARRA) funds to projects related to smart grid investment. Much of the grant funding is going to utility companies, which has already prompted some utilities to seek commission preapproval for smart grid investments in order to meet DOE grant timelines.

Smart grid missions: Part II of this paper identifies and describes seven major smart grid missions. Commission attention to smart grid expenditures should begin with clarity about missions. ***Examples*** are drawn from implementation efforts that are already underway in certain states. The major ***uncertainties and concerns*** associated with each mission are described. Part II also presents ***advice to commissions*** about how best to mitigate or avoid problems inherent in attempts to achieve smart grid purposes. Table 8 briefly summarizes for each major smart grid purpose the associated uncertainties and concerns and offers related advice to commissions.

Smart grid components: Part III of this paper reviews the nine major smart grid components (hardware and software). Part III presents ***examples*** from implementation efforts that are already underway in certain states and describes ***uncertainties and concerns*** associated with each component. Descriptions include listings of the purposes each major component will serve. For each component, Part III includes advice to commissions about how best to mitigate or avoid problems. Table 17 briefly summarizes for each major smart grid component the uncertainties and concerns and offers related advice to commissions.

Along with basic information about the "what" of smart grid technology, in terms of both ends (the missions, in Part II) and means (the components, in Part III), the paper advises how commissions can best orchestrate the "who, when, where, and how" of smart grid implementation. The major recommendations include:

1. Establish performance metrics and targets (see Part II.A.3);
2. Assign costs and allocate risks and benefits to the appropriate parties (Part II.A.3);
3. Advice to commissions for three special issues: multi-jurisdictional utilities, combination utilities, and allocating smart grid costs to competitive choice customers (Part II.A.3);
4. Ensure appropriate protections for vulnerable populations (Part II.A.3);
5. Ensure cyber security (Part II.B.3);
6. Ensure interoperability and allow access for third-party service providers (Part II.E.3); and
7. Rely on integrated resource planning to guide decisionmaking on missions and priorities (Part II.H).

Performance expectations: Utility personnel need clear, consistent signals about performance expectations, which will ensure resolute focus on achieving performance goals and maintaining acceptable performance over time. For many smart grid missions and components, commissions can establish at least preliminary performance measures and targets. For others, performance information is so preliminary that experience from pilot programs (and from utility service territories where full deployment has already started) is needed before realistic performance targets can be set.

For several of the missions and components, it is important to consider how smart grid capabilities relate to preexisting performance targets. Examples of performance targets include standards for reliability, power and service quality, outages and outage response, customer service, demand response, energy efficiency, load management, distributed resources interconnection and renewable energy standards, and meter-reading accuracy and timeliness. Over time, if smart grid does produce the expected benefits, then it will be necessary to revisit and revise targets to reflect improved, smart grid-enabled performance benchmarks.

Assigning costs and allocating risks and benefits: Before ratepayer cost recovery is approved, the utility's plan must fully explain cost recovery, including descriptions of who pays, who gets paid, when, how much, and through what mechanisms. To the extent practical, customer charges for smart grid costs should be timed to coincide with customer opportunities to utilize smart grid capabilities in ways that will reduce their utility bills.

As with any major utility capital expenditures, cost-recovery mechanisms should assign risks to the parties most capable of addressing them. Similarly, parties should earn smart grid benefits through the actions under their control. Cost recovery should clearly link to performance measures and targets. Linking cost recovery to performance targets means establishing clear goals. Independent performance measurement and verification will be needed to evaluate performance. Appropriate financial consequences should result from failing to meet, meeting, or exceeding expected performance.

Should commissions determine costs only after the fact, or might some costs be predetermined? Will smart grid plans result in adverse effects on vulnerable customers, and what means can utilities make available for mitigating adverse effects? Should cost recovery include utility financial incentives, that is, payments that produce supra-normal returns? If so, what performance targets will trigger the incentives? Will the efficiency gains from smart grid implementation result in adverse financial effects on the utility because of reduced electricity sales? If yes, how does the cost recovery proposal address that fact? These are all examples of the kinds of questions that a commission must ask, and utilities must adequately answer, prior to the commission's granting smart grid plan approval.

Commission guidelines for addressing three special issues: In addition to these basic principles, the paper reviews three special issues, relevant to some service territories: (1) multi-jurisdictional utilities; (2) combination utilities (e.g., gas and electric, or water and electric); and (3) allocating smart grid costs to competitive-choice customers (see Part II.A.2).

Multi-jurisdictional and combination utilities should avoid program designs that necessitate duplicate or triplicate infrastructures. At a minimum, commissions will need to prevent double counting. In addition, there may be opportunities to coordinate and cooperate with neighboring jurisdictions and multiple regulatory agencies (possibly including federal, state, and municipal) to achieve economies of scale and scope in regulation.

Some commissions will also need to consider how to allocate smart grid costs to competitive-choice customers. Commissions should conscientiously avoid cost allocation that creates cross-subsidies, either way, between competitive-choice and full-service customers.

Depending on the market structure in each service territory, it will be necessary to allocate smart grid costs separately to generation, transmission, distribution, and customer-service functions.

Vulnerable populations: Commissions should ensure that utility smart grid plans consider potential negative effects on vulnerable customer groups and possible mitigation strategies. A separate NRRI report (Brockway, 2008) provides more detail about the effects of smart grid implementation on residential customers, including low-use and low-income customers.

Cyber security: Commissions should insist that utilities produce adequate smart grid system security plans. The prospect of reviewing security plans is challenging, though, in the absence of established cyber security standards and accompanying practices. Related to cyber security is the need to ensure that private customer data will remain private. A separate NRRI report (Lichtenberg, 2010) explores smart grid privacy issues, including reviews of existing federal and state privacy standards.

Interoperability and access for third-party service providers: Utilities should not inadvertently be granted a first-mover advantage for (or even worse, monopoly control of) customer-side systems. At this early stage of smart grid development, there is no telling which companies will develop the best customer-side systems and smart grid applications. To bring their products and services to the market, competitive suppliers will need access to smart grid facilities, at cost. Competitive suppliers should not have to duplicate smart grid infrastructure. Commissions, therefore, must ensure both functional interoperability and open access to relevant smart grid components. A forthcoming paper from Germany (Kranz, available on request) explores these issues in detail.

Guidelines for commission positioning and procedures: Part IV presents ideas to help commissions craft decisions for the next steps in smart grid development. Here the paper addresses three important questions commissions are likely to face: (1) Should commissions establish principles and expectations in advance (as opposed to waiting for and then reacting to utility proposals)?, (2) Is an experimental or pilot project needed, or should full deployment proceed?, and (3) How can the appropriate scope for each project or proposal be determined?

It is preferable for commissions to establish principles and expectations prior to utilities' developing smart grid implementation plans and submitting applications for cost recovery. As already demonstrated in Hawaii and Maryland, absent prior guidance from regulators utilities will not necessarily anticipate and incorporate into their smart grid implementation plans all of the attributes necessary to ensure meeting public-interest requirements.

Smart grid pilot projects can serve a variety of purposes. These include determining feasibility, practicing and verifying implementation procedures and utility management systems, verifying assumptions about customer behaviors, and demonstrating cost effectiveness. Pilot projects can be beneficial and their costs reasonably assigned to ratepayers, whether or not they confirm all prior assumptions and predictions. One important clue that pilot programs are needed is if a utility is not willing or able to provide assurances regarding benefits and costs. To the extent that smart grid investment justifications rely on cost savings due to uncertain or unknown benefits, more information is needed and pilot programs should be employed to verify assumptions and demonstrate feasibility.

Commissions will also find themselves having to make determinations about the appropriate scope for each step toward full smart grid development. Important considerations include technological economies of scale and interdependence. Some smart grid components can be incorporated piecemeal. Transmission enhancements, distribution automation, and demand response capabilities are generally amenable to incremental implementation. Other components will be much more costly if not installed utility-wide or at least for large portions of a utility service territory or customer base. Examples include system-wide communications and information integration and some elements of AMI. Also, pilot programs need to be large enough and must include sufficient sampling procedures to make sure the participants are representative of the population at large.

One more concern, last but not least, is that commissions need to deploy their own resources to provide adequate oversight for smart-grid projects. When a commission establishes principles and expectations in advance, it can provide directions regarding the timing and sequence of smart grid work.

Conclusions: Part V presents conclusions. Smart grid represents a major new area of utility infrastructure development. In the big picture, there is widespread optimism that smart grid deployment will prove cost-effective. Some researchers estimate that smart grid benefit-to-cost ratios will total four or five to one. Yet-to-be-discovered smart grid applications would provide even more benefits. One theory holds that smart grid capabilities will result in entrepreneurs' conveying new vitality to what has been a rather stodgy public utility sector. But early experiences have identified many areas of uncertainty and concern and few easy answers. Though smart grid may eventually achieve all of its promise, smart grid benefits will not materialize automatically. During the early stages of smart grid deployment, protecting the public interest requires effective commission oversight.

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Table of General Recommendations for Regulators

Seven parts of this paper provide general guidance to commissions on themes common to many smart grid missions and components. This guidance is presented in the gray-shaded areas.

I. Introduction: Smart Grid Complexities Will Challenge Commission Decisionmakers

In an ideal world, smart grid capabilities would be implemented through sequential investments, with benefits in excess of costs produced each step of the way from the not-so-smart grid of today to the fully capable smart grid of tomorrow. The reality, though, is seldom so clear-cut and definite. Commissions are being pressed by utilities to make decisions about utility smart grid investments based on imperfect information about benefits and costs.

Commissions' smart grid decisionmaking is difficult because of several complexities. For starters, there is no universally accepted definition of smart grid.[1] What is generally understood, though, is that smart grid development involves applying modern hardware and software for monitoring, sensing, communicating about, and controlling the various devices that comprise the existing electricity grid. In its comprehensive form, smart grid enables more efficient and reliable operations throughout the entire electricity system. Complexity results, though, because individual smart grid components can serve multiple functions in multiple domains (e.g., generation, transmission, distribution, and customer-side systems) and can be used by multiple actors. Figure 1 depicts the broad scope of smart grid components and actors.[2]

Added complexity arises because utility industry structures vary from state to state, ranging from traditional vertically integrated monopoly utilities to open competitive markets for wholesale electric power generation and retail customer services with delivery provided by regulated wires companies. Because of those differences, appropriate guidelines for commission decisions in one jurisdiction might not be applicable elsewhere (see Part II.A.3).

Another complexity is that smart grid is being implemented at the same time that electricity markets are changing. For example, one important function for smart grid is to support demand-response (DR) capabilities, but the country's various regional transmission organizations (RTOs) are at different stages in the process of creating and managing DR markets.[3] This is an ongoing source of uncertainty. It necessitates smart grid designs that are

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[1] For smart grid definitions, see: Colorado Public Utilities Commission, September 29, 2010 Order in Docket No. 10I-099EG, Decision No. C10-1077, p. 3; DOE, *The Smart Grid: An Introduction*, U.S. Department of Energy, Office of Electricity Delivery and Energy Reliability, 2008, http://www.oe.energy.gov/SmartGridIntroduction.htm; Illinois Statewide Smart Grid Collaborative, *Collaborative Report*, September 30, 2010, pp. 41-43, www.ilgridplan.org; and Sherry Lichtenberg, *Smart Grid Data: Must There Be Conflict Between Energy Management and Consumer Privacy?*, National Regulatory Research Institute, December 2010, pp. 4-5; http://www.nrri.org/pubs/telecommunications/NRRI_smart_grid_privacy_dec10-17.pdf.

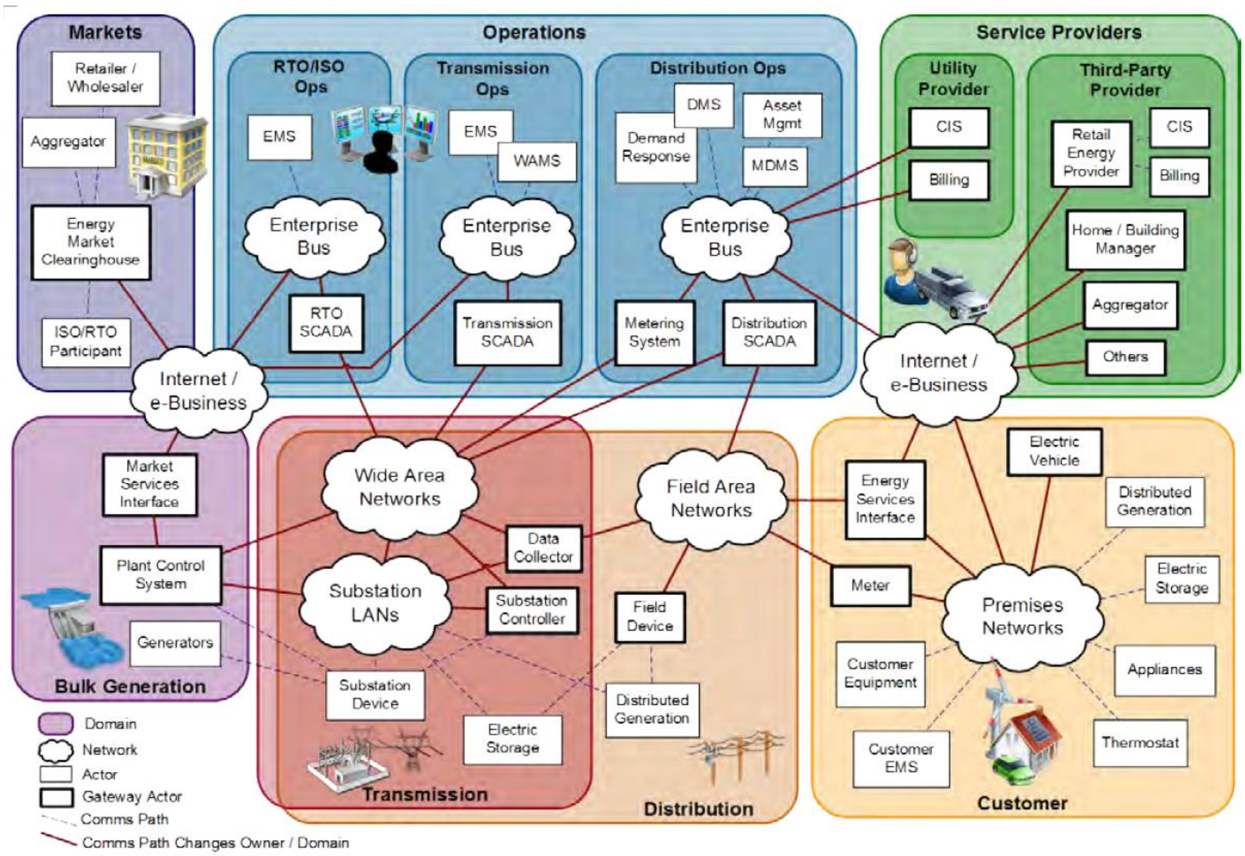
[2] Figure 1 does not elucidate smart grid's expected efficiency improvements and cost savings in each domain. The Illinois *Collaborative Report* separately identifies smart grid's potential "benefits and beneficiaries." Illinois Statewide Smart Grid Collaborative, *Collaborative Report*, September 30, 2010, pp. 17, 46, 48-54, www.ilgridplan.org.

[3] See Krishna, 2010.

flexible enough to enable DR implementation under a variety of possible market structures and in response to a variety of possible market instructions.

Further complexity results because utilities can satisfy some smart grid purposes, at least partially, without full smart grid implementation. One common example is load control and demand response programs. Many utilities have successfully managed them without implementing all of the related smart grid components. There is also considerable uncertainty about the load-control and demand-response benefits achievable through customer responses to new time-differentiated rates and yet-to-be-developed smart grid products and services.

Figure 1: Smart Grid Domains, Networks, and Actors



Source: Illinois Statewide Smart Grid Collaborative, September 30, 2010, *Collaborative Report, p. 47.*

Smart grid decisionmaking is also complex because of the rapid changes in and continuing evolution of smart grid technology. Both the hardware and software are subject to change. The pace of technology change in this area is rapid, operational standards are still being developed,[4] and various technologies continue to compete against one another. Business cases

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[4] The U.S. National Institute of Standards and Technology is in the process of developing Smart Grid Interoperability Standards. See http://www.nist.gov/smartgrid/. The Federal Energy Regulatory Commission is also charged with adopting "interoperability standards and protocols necessary to ensure smart-grid functionality and interoperability in the interstate transmission of electric power and in regional and wholesale electricity markets." See

for smart grid deployment continue to develop as experience provides more and better information. Each new deployment provides additional details about the many efficiencies achievable through smart grid technologies and smart grid-enabled consumer behavioral changes.[5]

Further influencing commission decisionmaking procedures is the American Recovery and Reinvestment Act (ARRA) smart grid deployment funding administered by the U.S. Department of Energy (DOE). The DOE is allocating $3.4 billion in ARRA grants to utilities for smart grid project implementation.[6] Then, to comply with DOE grant requirements, several recipient utilities made applications to their regulatory commissions seeking preapproval for smart grid investments.[7]

This paper will help commissions sort through these complexities. It explores smart grid's status today, taking into account the learning thus far from related activities in several states, and describes how commissions can protect the public interest by systematically managing utility smart grid proposals.

This paper has three major sections:

In Part II, smart grid ***missions*** are described. Seven major missions—that is, functions or purposes for smart grid achievement—are identified and described, drawing on ***examples*** from

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http://www.ferc.gov/industries/electric/indus-act/smart-grid.asp.

[5] See, for example, *Prepared Direct Testimony of Mark D. Case on Behalf of Baltimore Gas and Electric Company*, July 13, 2009, Maryland PSC Case No. 9208, p. 12.

[6] For these implementation projects, cost-sharing contributions made by the grant recipients will add $4.6 billion, for a total of over $8 billion. See http://www.oe.energy.gov/recovery/1249.htm, retrieved January 24, 2011. See also http://www.oe.energy.gov/american_recovery_reinvestment_act.htm and http://www.smartgrid.gov/projects/investment_grant. The total DOE ARRA smart grid funding is over $20 billion, representing over 300 grants to date.

[7] As the Maryland PSC explained in its initial order regarding BGE's smart grid application:

> It is clear that the timing of BGE's Proposal was motivated in no small measure by "[t]he availability of funding for smart grid investments from the American Recovery and Reinvestment Act ('ARRA')." We are mindful that during the pendency of its Proposal, BGE has received approval from the U.S. Department of Energy ('DOE') for $136 million in federal taxpayer funds that would partially offset the cost of the Proposal to BGE ratepayers. We are equally mindful, however, that a $136 million "discount" on an $835 million ratepayer investment cannot dictate the outcome here. Rather, in order to approve the Proposal, we must determine that it is a cost-effective means of reducing consumption and peak demand of electricity by BGE customers.

Maryland PSC, June 21, 2010 Order No. 83410, p. 4, footnotes omitted.

early implementation efforts and smart grid literature. The primary ***uncertainties***[8] ***and concerns*** that could interfere with achieving those missions are described. The descriptions of the seven major missions also include ***advice to commissions*** for guiding development.

Part III includes descriptions of nine major smart grid ***components***, including the role each component plays in achieving one or more of the missions. The nine major hardware and software components are described using ***examples*** from early implementation efforts and smart grid literature. Associated ***uncertainties and concerns*** are identified for each of the nine components, including financial, technical, and behavioral concerns. Then, Part III includes ***advice to commissions***, for the dual purposes of: (1) reducing the uncertainties and mitigating the concerns associated with each of the nine components, and (2) eliciting from utilities the performance necessary to deploy each component successfully.

Part IV presents options for ***commission positioning and procedures***. Commissions will advance the utility performance necessary to achieve each mission by following the recommended approaches. The information in Part IV will help commissions decide how quickly to move and how big each step should be along the path to smart grid implementation.

[8] In this context, uncertainty is defined according to economic choice theory. An uncertainty is a situation with variable outcomes where the probability of a given outcome is not known. A risk is a situation with variable outcomes where the probability of a given outcome is known. See: The New School, History of Economic Thought Website, "Choice Under Risk and Uncertainty – General Introduction," http://homepage.newschool.edu/het//essays/uncert/intrisk.htm, retrieved January 4, 2011.

II. Missions: What Are the Possible Missions for Smart Grid?

This Part II sets the stage for commission decisionmaking by reviewing the various missions, promises, and hopes for a fully functioning smart grid. It arrives at answers in part by reviewing how various smart grid proponents, utilities, state legislatures, and state commissions have already decided on smart grid missions.

Smart grid has been proposed as a solution to many different problems and a means to achieve a wide variety of missions.[9] There are seven major missions for smart grid capabilities. They are:

1. Increase efficiency in utility operations;
2. Increase system reliability;
3. Reduce fossil fuel use and emissions;
4. Enhance customer choices;
5. Induce customers to produce system benefits by modifying usage patterns;
6. Improve utility planning; and
7. Develop the economy and grow jobs.

These missions are frequently mutually reinforcing and intersect with and overlap one another. For example, improved utility planning supports increased efficiency in utility operations, increases system reliability, and helps to reduce fossil fuel use and emissions. Enhancing customer choices can lead to modified customer usage patterns, which result in increased efficiency and reduced fossil fuel use and emissions. The mission to develop the economy and grow jobs is supported through direct expenditures and efficiency improvements that result from the efforts made to achieve all of the other missions.

The California Public Utilities Commission (California PUC) has memorialized some of these benefits:

> [M]odernizing the electric grid with additional two-way communications, sensors and control technologies, key components of a Smart Grid, can lead to substantial benefits for consumers. A Smart Grid can enable the integration of higher levels of renewable energy, energy storage, and, eventually, electric vehicles, at a lower cost to consumers. A Smart Grid can also empower consumers by helping them understand and control their energy use, thereby facilitating their participation in demand response programs and helping them to use energy more efficiently. Greater monitoring and automated controls can also reduce the frequency and duration of outages. Many of the advantages of a Smart Grid will contribute to reducing greenhouse gas emissions. It is

[9] See, for example, the U.S. Energy Independence and Security Act (EISA) of 2007, Public Law 110-140, December 19, 2007. Title VIII in that law is about smart grid. Section 1301, Statement of Policy on Modernization of Electricity Grid, lists smart grid characteristics. Section 1306(d) lists "smart grid functions." http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=110_cong_public_laws&docid=f:publ140.110.pdf.

imperative that Smart Grid investments deliver these benefits to the utilities' customers.[10]

System benefits and ratepayer cost savings can be achieved through improvements in any of the first six of seven smart grid missions. Improvements in the seventh smart grid mission—develop the economy and grow jobs—might also lead to reductions in utility system or customer costs or both. Improved models are needed for exploring the complex relationships between utility system modernization, service-territory economic development, and the effects of such development on utility system and customer costs.

Smart grid benefits generally fall into two different categories: (1) utility operating cost savings and (2) supply-side effects. There are also potential indirect benefits from smart meters in the form of more positive customer experiences and reduced emissions. Examples of benefits of the first category include (a) operational savings from remote meter-reading capabilities; (b) more efficient response to outages; (c) more efficient detection of theft, broken meters, and leakage (for gas and water utilities); (d) improvements in customer service; and (e) avoided capital costs (for generation, transmission, and distribution infrastructure). The second category includes reduced expenditures for capacity and energy and downward pressure on wholesale prices resulting from gains in energy efficiency and particularly peak load reductions. These supply-side benefits depend, at least in large part, on the introduction of new utility rates and related consumer responses.[11] Estimates of supply-side benefits rely on predictions about customer responses.[12]

The following sections review each of the seven major smart grid missions in turn, providing examples and exploring inherent uncertainties and concerns associated with the attempts to achieve each mission. Each section also introduces advice to commissions for addressing the uncertainties and concerns.

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[10] California PUC, June 24, 2010, Decision 10-06-047, p. 2; http://docs.cpuc.ca.gov/WORD_PDF/AGENDA_DECISION/119685.pdf. See also http://www.cpuc.ca.gov/puc/energy/smartgrid and http://docs.cpuc.ca.gov/published/proceedings/R0812009.htm.

[11] In addition to price-driven consumer responses, behavioral researchers are studying consumer energy use changes as a result of improved information feedback, consumer education, advertising and marketing strategies including social marketing, and targeted persuasive techniques. See, for example, National Research Council (Stern, Paul C. and Kasperson, Roger E., Editors), *Panel on Addressing the Challenges of Climate Change Through the Behavioral and Social Sciences*, 2010, http://www.nap.edu/catalog.php?record_id=12996.

[12] Results from pilot projects can be helpful in estimating the effects of full deployment. See the discussion about pilot programs in Part IV.B. Information about estimating effects due to the introduction of new rates, including sensitivity analysis techniques, can be found in Adam Pollock and Evgenia Shumilkina, *How to Induce Customers to Consume Energy Efficiently: Rate Design Options and Methods*, National Regulatory Research Institute, January 2010, http://www.nrri.org/pubs/electricity/NRRI_inducing_energy_efficiency_jan10-03.pdf.

A. Increase efficiency in utility operations

Increasing operational efficiency is supported through two major sets of smart grid capabilities. One is through the improved abilities to monitor and control various utility assets. The other is through smart grid's more rapid and comprehensive communications between the utility and customer meters. Both are related to the promise that smart grid can provide utilities with tools to improve asset utilization and operations and maintenance (O&M) in all aspects of utility service delivery: generation, transmission, distribution, and customer service. These capabilities are also closely related to smart grid's potential to increase system reliability and improve utility planning.[13]

1. Examples

Efficiency benefits arise as smart grid capabilities provide utility system operators and field workers with timely information to support improved operational decisions. These capabilities will help utilities increase asset utilization, defer capital investment, extend the operational health and lifespan of various assets, and reduce the need to utilize less efficient assets.[14] For example, in its Smart Grid application to the Maryland PSC, BGE cites improvements through "expansion of distribution automation (i.e., electronic reclosers and autorestoration), remote fault location, line loss reduction, and conservation voltage reduction."[15] In particular, accurate and timely data will enable more precise sizing for distribution system equipment, while real-time monitoring will allow operators "to detect (and respond to) impending asset failure or to initiate predictive asset maintenance."[16]

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[13] The U.S. Energy Information Administration defines "reliability" as follows:

> Electric system reliability has two components—adequacy and security. Adequacy is the ability of the electric system to supply to aggregate electrical demand and energy requirements of the customers at all times, taking into account scheduled and unscheduled outages of system facilities. Security is the ability of the electric system to withstand sudden disturbances, such as electric short circuits or unanticipated loss of system facilities. The degree of reliability may be measured by the frequency, duration, and magnitude of adverse effects on consumer services.

http://www.eia.doe.gov/cneaf/electricity/page/glossary.html#op

[14] Illinois Statewide Smart Grid Collaborative, *Collaborative Report*, September 30, 2010, pp. 50-51; www.ilgridplan.org.

[15] *Prepared Direct Testimony of Michael B. Butts on Behalf of Baltimore Gas and Electric Company*, July 13, 2009, Maryland PSC Case No. 9208, p. 4.

[16] Illinois Statewide Smart Grid Collaborative, *Collaborative Report*, September 30, 2010, p. 16; www.ilgridplan.org.

The second set of capabilities, enhanced communications with customer meters, enables utilities to reduce operational costs associated with meter reading and bill presentment, service turn-on and turn-off, and outage identification and response. BGE identifies improvements and associated cost savings through:

1. more efficient and accurate meter reading;
2. more efficient handling of service orders (including the ability to disconnect and reconnect service without the need to dispatch a utility crew to the premises);
3. more efficient outage management and faster restoration of service following outages;
4. enhanced customer service capabilities; and
5. enhanced capabilities to detect meter tampering and prevent utility service theft.[17]

2. Uncertainties and concerns

The primary risk associated with these capabilities is the scope and amount of benefits that will accrue. Cost savings are theoretically accessible via these means, but how much remains to be seen. Obtaining these benefits will depend on the success of utility personnel education and training and on consistent, long-term management designed to achieve (and then maintain achievement of) these benefits.[18]

Consumer advocates are also concerned that utility operator errors could result in customers being improperly disconnected.

3. Advice to commissions

Table 1 summarizes advice to commissions related to this smart grid function. Together, the first three recommendations—to establish performance metrics and targets, link cost recovery to performance targets, and verify performance—will enable a commission to address utility investments and programs systematically. The goal is for utility managers to remain focused squarely on meeting public-interest objectives. The fourth recommendation—to ensure that shut-off procedures will prevent improper service disconnections—arises because smart grid technologies make it easy to connect and disconnect service.

Table 1: Increase Efficiency in Utility Operations: Uncertainties and Concerns, and Advice to Commissions

Purpose	Uncertainties and concerns	Advice to commissions
Increase efficiency in utility operations	• Uncertainty of timing, scope, and amount of potential benefits • Possibility of mistaken service disconnections	• Establish performance metrics and targets • Link cost recovery to performance targets • Verify performance • Ensure that shut-off procedures will prevent improper service disconnections

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[17] *Prepared Direct Testimony of Michael B. Butts on Behalf of Baltimore Gas and Electric Company*, July 13, 2009, Maryland PSC Case No. 9208, pp. 6-15.

[18] Utility personnel training and education is discussed in Part III.F.

General recommendation to regulators: Establish performance metrics and targets

A commission should identify the factors it will evaluate, the metrics used to evaluate them, and the performance required to justify cost recovery.[19] Important questions about performance metrics are: (1) How, when, and by whom should performance measures be established? and (2) What will be the metrics?

It is possible that standards will be developed for smart grid performance measures, as has been done for energy-efficiency programming.[20] Unless and until such standards exist, though, all parties with sufficient expertise should have a voice in developing performance measures. Collaborative processes are likely to achieve the most satisfactory results the most quickly, and with the best opportunity to achieve consensus and obtain participant buy-in.[21] Input from multiple parties, including independent evaluation specialists, is the best means to ensure success in designing measures that will be practical to implement, reliable, valid, and comprehensive.

To establish a complete set of metrics, commissions should review both smart grid investments and the missions they are intended to serve. Because there is overlap in terms of both missions and components, there will be circumstances where a single metric or group of metrics serves multiple purposes. All major missions and components will, however, need appropriate performance measures.

There should be congruence between the benefits a utility uses to justify smart grid expenditures and the measures that will verify and evaluate performance.[22] For example, BGE

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[19] For a general introduction to utility performance measures, see: Ken Costello, *How Performance Measures Can Improve Regulation*, National Regulatory Research Institute, June 2010, http://www.nrri.org/pubs/multiutility/NRRI_utility_performance_measures_jun10-09.pdf.

[20] See *California Standard Practice Manual Economic Analysis of Demand-Side Programs and Projects,* October 2001, pp. 18-22, http://www.energy.ca.gov/greenbuilding/documents/background/07-J_CPUC_STANDARD_PRACTICE_MANUAL.PDF.

[21] California, Illinois, and Maryland are all using collaborative processes to develop smart grid performance measures. California PSC directed its staff to convene a workshop for the purpose of "creating a final list of metrics to present to the Commission for adoption." California PUC, June 24, 2010, Decision 10-06-047, p. 87, http://docs.cpuc.ca.gov/WORD_PDF/AGENDA_DECISION/119685.pdf. The Illinois *Collaborative Report* includes detailed recommendations for benefit cost analysis, monitoring, and evaluation. Illinois Statewide Smart Grid Collaborative, *Collaborative Report,* September 30, 2010, pp. 223-246, www.ilgridplan.org. Maryland PSC directed BGE and the interested parties "to develop, and submit for our approval, a comprehensive set of installation, performance, benefits and budgetary metrics…." Maryland PSC, August 13, 2010 Order No. 83531, p. 48.

[22] For information about specific types of metrics and evaluation techniques, see: Evgenia Shumilkina, *Utility Performance: How Can State Commissions Evaluate It Using*

premised its smart grid proposal on savings from improvements in customer service and reliability, plus energy use and peak demand reductions slated to result in direct ratepayer savings and downward pressure on wholesale prices due to the energy and demand reductions. To the extent that savings will accrue due to improvements in utility operations, the utility should be willing to guarantee that ratepayers will receive credit for predicted savings.[23]

For areas where smart grid performance is uncertain, work can begin on establishing performance metrics. Commissions will, however, need to await results from pilot programs and early smart grid deployment. Those early experiences will demonstrate performance and associated cost savings that can be used to establish performance targets.

Commissions should also be mindful of the possible need to update performance measures, over time, as more is learned about smart grid implementation. For some components, smart grid capabilities will need to be linked to preexisting performance targets. This includes both preexisting programs that support achievement of smart grid missions and those that will be supported or improved upon through smart grid deployment. Examples potentially include standards for: (a) reliability, power and service quality, outages, and outage response; (b) meter reading accuracy and timeliness; (c) energy efficiency, conservation, demand response, and load management; (d) low-income customer support; (e) shut-offs and disconnection of service; (f) renewable energy; and (g) grid interconnection.

The Colorado Public Utilities Commission (Colorado PUC) explicitly directs:

> The Commission previously defined demand-side management as the pursuit of all cost-effective energy and demand reductions.... We find that if smart meters can yield DSM benefits, such benefits need to be evaluated in the same manner as other DSM options to determine if they should be pursued first. We also note that "traditional" DSM (such as rebates) and smart meter-based promotion of energy efficiency behaviors may complement each other well. The net benefit of smart meter technologies to DSM objectives should be quantified in a Total Resource Cost test analysis. It is also important to acknowledge that the customer segments are not homogenous in terms of how they will respond to feedback strategies. Thus, a portfolio of strategies may be necessary,

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Indexing, Econometrics, and Data Envelopment Analysis?, National Regulatory Research Institute, March 2010 (Revised April 26, 2010), http://nrri.org/pubs/multiutility/NRRI_utility_performance_mar10-05.pdf. See also: Evgenia Shumilkina, *Where Does Your Utility Stand? A Regulator's Guide to Defining and Measuring Performance*, National Regulatory Research Institute, August 2010, http://www.nrri.org/pubs/multiutility/NRRI_performance_measures_aug10-12.pdf.

[23] Oklahoma CC June 22, 2010 Order in Cause No. PUD 201000029, Order No. 576595, p. 30 and attached JSSA, p. 3. Utilities in California, Maryland, and Oklahoma guarantee some ratepayer cost savings associated with AMI deployment, based on each utility's estimates of smart grid operational benefits. These utility guarantees cover modest percentages of total expected benefits, though. The amounts guaranteed are insufficient to ensure that customer benefits will exceed total smart grid deployment costs.

along with better information regarding how to target each strategy.[24]

Performance measures should be established prior to or coincident with commission approval of utility investment and cost recovery. Also, the recommended regulatory system is not complete without performance measurement and verification. Performance measurement includes engaging independent program evaluators to collect and report the data. In the same way that commissions can learn from and emulate the best examples for establishing performance measures, early smart grid program evaluations should prove valuable for determining best practices in smart grid performance measurement and verification.

General recommendations to regulators: Assign costs and allocate risks and benefits to the appropriate parties

Utility managers need clear, consistent signals about performance expectations, to ensure resolute focus on achieving performance goals and maintaining performance. Once performance metrics and targets are established, then cost recovery should be linked to specific performance. Cost-recovery approval should depend on performance over sufficient duration to ensure that benefits exceed costs.[25] Commissions should be clear about the specific cost-recovery mechanisms that will be used, and should condition at least some cost recovery on meeting performance targets. In addition, commissions should consider establishing bonuses for exceptionally good performance and penalties for poor performance.[26]

A commission should require cost estimates that, to the extent possible, include all the costs associated with the project and describe all of the assumptions used. For example, in reviewing BGE's first smart grid application, Maryland PSC identified important missing information about costs. The Maryland PSC explains:

> On the projected cost side of the cost-benefit equation, the Company's business case does not include many costs that are inherent in, or will inevitably flow from, the Proposal. It does not include the approximately $100 million in undepreciated value of existing, fully operational meters that would be retired before the end of their useful lives, for example, or the estimated $60 million it will cost the Company for the new billing system

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[24] Colorado PUC, September 29, 2010 Order in Docket No. 10I-099EG, Decision No. C10-1077, pp. 8-9, footnotes omitted.

[25] Scott Hempling, *Broadband's Role in Smart Grid's Success: Seven Jurisdictional Challenges*, National Regulatory Research Institute, January 2011, http://www.nrri.org/pubs/multiutility/NRRI_broadband_smart_grid_juris_jan11-1.pdf.

[26] Massachusetts' Green Communities Act of August 2008 directs electric distribution companies to "file a proposed plan with the department of public utilities to establish a smart grid pilot program." The law further prescribes, "Plans which provide for larger numbers of customers and can show higher bill savings than outlined above shall be eligible to earn incentives as outlined in an approved plan." (Massachusetts Acts 2008, Chapter 169, Section 85; http://www.malegislature.gov/Laws/SessionLaws/Acts/2008/Chapter169). Massachusetts DPU, July 27, 2010 Order 09-32 (pp. 75-78) addressed a financial incentive mechanism for National Grid (http://www.env.state.ma.us/dpu/docs/electric/09-32/72710dpuord.pdf).

> necessary to implement the R-SEP rate schedule. Nor does it include the cost of in-home display devices, which easily could exceed another $100 million dollars, or the cost of new customer appliances that the Company projects will one day be able to communicate with the proposed "smart meters." And it does not include the cost of retrofitting or replacing the emerging technology the Company proposes to install—technology that never has been tested in a full-scale deployment—in the event it becomes obsolete far earlier than its projected 10-to-15 year useful life.[27]

The utility should also provide detailed analyses of benefits, and should show that benefits will exceed costs. Similar to the guidance for all utility investments, costs and savings should be allocated between customers and shareholders according to the risks assigned to each.

If a utility cannot provide assurances that ample benefits will accrue to offset costs, then pilot programs are needed to confirm theories and establish baselines for performance metrics and targets. Once a utility has ample confidence that benefits will exceed costs, then a commission can consider approving full deployment (see Part IV).

As the Maryland PSC concluded, cost recovery can be made contingent upon benefits being achieved:

> We find it reasonable to expect that BGE will deliver a cost-effective AMI system before cost recovery will be incorporated into rates, and the Company's customers should not be required to pay in full, with a return, if the system does not meet that essential standard. We recognize that there is inherent uncertainty that the level of benefits projected, particularly the supply-side benefits, will actually be realized. If the final system falls short of being cost-effective, we will hold a fair and appropriate proceeding to determine what cost recovery outcome the public interest requires… .[28]

General recommendations to regulators: Advice to commissions for three special issues: multi-jurisdictional utilities, combination utilities, and allocating smart grid costs to competitive choice customers

Multi-jurisdictional utilities

Commissions that regulate multi-jurisdictional utilities are already familiar with allocating costs between states and avoiding double-counting. These concerns have already been addressed in Oklahoma and Massachusetts.

The Oklahoma Gas & Electric Company (OG&E) smart grid application raised this issue because OG&E also serves customers in Arkansas. In its application to the Oklahoma Corporation Commission (Oklahoma CC), OG&E indicated it planned to submit a smart grid application to the Arkansas Public Service Commission (Arkansas PSC). OG&E proposed to begin assigning 100% of its smart grid deployment costs to Oklahoma, and then promised to

[27] Maryland PSC, June 21, 2010 Order No. 83410, p. 6, fn omitted.

[28] Maryland PSC, August 13, 2010 Order No. 83531, pp. 38-39.

reallocate costs between the two jurisdictions if the Company's smart grid plans were approved by the Arkansas PSC.[29] Oklahoma CC directed OG&E to file an application with Arkansas PSC. If approved by the Arkansas PSC, Oklahoma CC determined to allocate expenditures "between the two jurisdictions, as determined in the OG&E 2013 rate case."[30]

Similarly, the Massachusetts DPU urged National Grid "to take all reasonable steps to receive approval for smart grid-related activities from public utility commissions in other states" and required "quarterly updates on the actions taken by the Company and the other state public utility commissions with regard to the implementation of smart grid pilots in the respective states." The Massachusetts DPU said it "will address issues associated with the allocation of shared pilot-related costs across states at such time as the Company has received approval for a smart grid pilot program from another state."[31]

Rather than duplicating efforts in multiple jurisdictions, state commissions should consider inviting multi-state groups to work together on smart grid deployment plans. Multi-state efforts could be productive in addressing performance metrics and standards, monitoring and evaluation, and the like. This recommendation is not to imply that each state commission must come to the same conclusions or make identical determinations. It simply reflects the opportunity to use limited resources cost-effectively.[32]

Combination utilities

A similar concern arises with respect to combination utilities (e.g., electric and gas companies or electric and water companies). Although most smart grid attention focuses on electric utilities, there are potential smart grid applications for gas and water companies. Coordinating and sharing AMI functions can increase efficiency compared to having multiple companies each creating their own systems.

This is true whether or not gas, water, and electric companies are separately owned. This is also true whether or not the utilities in question are regulated by a single public utility commission. Commissions should direct combination utilities and even multiple utilities to work together to plan AMI and customer-side systems. At a minimum, AMI and customer-side systems should be compatible; or, better yet, interoperable. As well, multiple utilities should share systems when it will reduce costs.

[29] Oklahoma Corporation Commission June 22, 2010 Order in Cause No. PUD 201000029, Order No. 576595, pp. 7, 15.

[30] Oklahoma Corporation Commission June 22, 2010 Order in Cause No. PUD 201000029, Order No. 576595, p. 18.

[31] Massachusetts DPU July 27, 2010 Order 09-32, p. 88.

[32] Scott Hempling, *Broadband's Role in Smart Grid's Success: Seven Jurisdictional Challenges*, National Regulatory Research Institute, January 2011, http://www.nrri.org/pubs/multiutility/NRRI_broadband_smart_grid_juris_jan11-1.pdf.

As with multi-jurisdictional utilities, commissions should also consider the extent to which efficiencies can be gained by working in concert with multiple utility companies and multiple regulatory authorities (e.g., municipal and state regulatory bodies and cooperative, municipal, and investor-owned utilities).

Allocating smart grid costs to competitive-choice customers

States that have authorized retail competition will need to consider whether and how to allocate smart grid costs to competitive choice customers. Depending on the market structure in each service territory, it will be necessary to allocate smart grid costs separately to generation, transmission, distribution, and customer-service functions.

The general principle is for distribution service customers to pay smart grid costs associated with distribution, which would be charged through distribution system rates applicable to all customers. Similarly, costs associated with customer-side systems and services would be charged only to full-service customers.[33] In practice, however, drawing the necessary distinctions requires both art and science. As already noted, smart grid components often support multiple service functions (generation, transmission, distribution, customer service, and aggregation).

Commissions should avoid cost allocation that creates cross-subsidies either way between competitive-choice and full-service customers.

General recommendations to regulators: Ensure appropriate protections for vulnerable populations

Commissions should ensure that utility smart grid plans consider potential negative effects on vulnerable customer groups and possible mitigation strategies. Smart grid customer education plans should use market segmentation techniques to identify specific target audiences with differing needs. Then, utilities should tailor customer education to reflect those different needs. Smart grid plans should also mesh with existing programs and services available to the vulnerable customer groups.

A second concern is that smart meters and AMI infrastructure could make it too easy for utilities to disconnect customers and that erroneous disconnections might result. The National Association of Utility Consumer Advocates (NASUCA) highlights the need for careful adherence to established shut-off protections. NASUCA maintains:

> States and utilities should not be permitted to use advanced meters as a means for reducing consumer protections with regard to electric service in general and termination procedures in particular. The notices and warnings that typically are required prior to service termination provide important protections for low-income and other vulnerable customers and often avoid negative consequences, from misunderstandings to tragedies. Because utility systems, including billing systems, remain imperfect, States should consider increasing consumer protections regarding service terminations as part of the implementation of advanced metering to ensure that mistaken terminations and the

[33] Massachusetts DPU July 27, 2010 Order 09-32, pp. 92-93.

attendant risks and hardships do not occur. This issue is of particular concern on weekends, holidays, and during severe weather conditions, when utility service personnel may not be immediately available to correct a mistaken termination….[34]

Commissions should heed this concern and make sure that utilities implement procedures to prevent improper service disconnections.

B. Increase system reliability

Achieving this smart grid mission will rely on many of the same communications capabilities that will be used to increase utility operational efficiency. Increasing reliability means reducing the number and duration of outages as well as ensuring that power quality is suitable for safely and reliably operating modern electronic equipment.

1. Examples

Communicating directly with equipment deployed throughout a utility's service territory and with individual customer meters will allow a utility to discover and diagnose potentially troublesome situations. An example is stressed assets, such as overloaded transformers and distribution circuits. A utility can then anticipate problems and use preventive maintenance and preemptive equipment replacement to avoid equipment failures. This capability leads to reduced "frequency, duration, and scale of outages."[35] Direct communication with individual meters also enables rapid, targeted emergency response when necessary. If smart grid systems work as planned, a secondary benefit will be exposing utility workers to a minimum of potentially hazardous situations through precise targeting of emergency response.

Smart grid capabilities also include improved monitoring and control of electricity service, leading to improved power quality. Most notably, the smart grid will be capable of sensing and automatically adjusting voltage and reactive power at most if not all service delivery points.[36]

The long-term objective is for the utility grid to become increasingly "resilient" and even "self-healing." The California PUC has determined:

> [A] Smart Grid must… [b]e self-healing and resilient – Using real-time information from embedded sensors and automated controls to anticipate, detect, and

[34] *Resolution 2009-01 on Advanced Electric Metering and Advanced Electric Metering Infrastructure Principles*, June 30, 2009; www.nasuca.org. See also *Resolution 2009-03 on Smart Grid Principles*.

[35] Illinois Statewide Smart Grid Collaborative, *Collaborative Report*, September 30, 2010, p. 52, www.ilgridplan.org.

[36] Illinois Statewide Smart Grid Collaborative, *Collaborative Report*, September 30, 2010, pp. 68-70, www.ilgridplan.org.

respond to system problems, a Smart Grid can automatically avoid or mitigate power outages, power quality problems, and service disruptions.[37]

2. Uncertainties and concerns

Cyber security is a serious concern. The same technologies that will allow a utility company to monitor and control its electric grid assets could be compromised by agents harboring mischievous or malicious intent. Physical security of smart grid equipment is also a concern. Proponents suggest, though, that the overall effect of smart grid deployment will be to enhance the physical security of the electric grid. That is because the smart grid's enhanced communications and automated response capabilities will enable utility operators to identify and quickly alleviate many system problems.[38] As long as adequate physical and cyber protections are deployed, proponents assert, the end result will be improved security against a wide variety of threats, including those related to equipment failure, natural and weather-related disasters, and malevolent behavior.

Technological risks associated with cyber and physical security include:[39] (a) cyber security concerns that inadequate protection of the smart grid system would lead to the loss of control over the system; (b) failure to achieve or maintain compliance with new smart grid standards, as they are still being developed by the National Institute of Standards and Technology (NIST); (c) incompatibility of current technologies with the next generation of technologies, due to rapid developments in the smart grid industry; and (d) security of consumers' private information.[40]

3. Advice to commissions

Table 2 summarizes advice to commissions for the mission of increasing system reliability. The first three areas are discussed below. The last three topics, regarding performance metrics and targets, cost recovery, and performance verification, were already discussed in Part II.A.

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[37] California PUC, June 24, 2010, Decision 10-06-047, p. 31, http://docs.cpuc.ca.gov/WORD_PDF/AGENDA_DECISION/119685.pdf.

[38] Illinois Statewide Smart Grid Collaborative, *Collaborative Report*, September 30, 2010, pp. 140-143, www.ilgridplan.org.

[39] More information on the possible security dangers inherent in smart grid implementation can be found in NIST, *Guidelines for Smart Grid Cyber Security*, U.S. Department of Commerce, National Institute of Standards and Technology, September 2010, www.nist.gov/smartgrid/.

[40] For a review of smart grid privacy issues, see Sherry Lichtenberg, *Smart Grid Data: Must There Be Conflict Between Energy Management and Consumer Privacy?*, National Regulatory Research Institute, December 2010, http://www.nrri.org/pubs/telecommunications/NRRI_smart_grid_privacy_dec10-17.pdf.

Table 2: Increase System Reliability: Uncertainties and Concerns, and Advice to Commissions

Purpose	Uncertainties and concerns	Advice to commissions
Increase system reliability	• Cyber-security and physical-security breaches or failures • Protection of data privacy and confidentiality • Physical security of smart grid equipment	• Require conformance with NIST cyber-security standards, with risks of nonconformance borne by the utility and its vendors, not customers • Consider engaging independent agencies to conduct smart grid security assessments • Protect customer data to ensure privacy and confidentiality • Establish performance metrics and targets for reliability, linking to preexisting reliability standards • Link cost recovery to performance targets • Verify performance

General recommendations to regulators: Ensure cyber security

Commissions should insist that utilities produce adequate smart grid system security plans. Cyber-security concerns are being addressed through major efforts by the U.S. Department of Homeland Security, the North American Electric Reliability Corporation (NERC, December 2010),[41] and the National Institute of Standards and Technology (NIST, September 2010). Under the U.S. Energy Independence and Security Act of 2007 (EISA), FERC also has "responsibilities related to coordinating the development and adoption of smart grid guidelines and standards."[42]

The California and Illinois documents provide guidance about the contents of such plans and procedures to ensure adequate implementation. The Illinois State Wide Smart Grid Collaborative provides guidelines for meeting cyber security, physical security, and privacy concerns.[43] The Maryland PSC recognizes cyber security as a critical issue remaining to be addressed and something the Commission and interested parties "will need to work through… together carefully."[44]

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[41] NERC coordinates cyber-security efforts through its Critical Infrastructure Protection Program. See http://www.nerc.com/page.php?cid=6|69.

[42] GAO, *Electricity Grid Modernization: Progress Being Made on Cybersecurity Guidelines, but Key Challenges Remain to be Addressed*, U.S. Government Accountability Office, January 2011, http://www.gao.gov/products/GAO-11-117. See also U.S. Energy Independence and Security Act (EISA) of 2007, Public Law 110-140, December 19, 2007, http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=110_cong_public_laws&docid=f:publ140.110.pdf.

[43] Illinois Statewide Smart Grid Collaborative, *Collaborative Report*, September 30, 2010, pp. 6-7, 13-14, 27, 79-80, 140-143, 146-149, www.ilgridplan.org.

[44] Maryland PSC, August 13, 2010 Order No. 83531, p. 32.

The California PUC addresses cyber security in its order on smart grid policy.[45] The California PUC requests that deployment plan filings include "an assessment of privacy and grid security issues… [and] discuss how [the utility] plans to incorporate NIST requirements and guidelines...." The California PUC also explicitly recognizes that "the risk assessment should include both the utility and its communications providers." The California PUC provides that utilities may request to keep confidential security plan details, but the Commission will also require access to "a security audit based on industry best practices."[46] The California PUC explains:

> The security strategy should be based on a systematic risk assessment… that addresses the prevention of, preparation for, protection against, mitigation of, response to, and recovery from security threats for the utilities' advanced meter and communications infrastructure, distribution grid management, and distribution grid management with implementation of other Smart Grid technologies and infrastructure, including all major subsystems and utility storage of customer information.[47]

The prospect of reviewing security plans is challenging, though, in the absence of established cyber security standards and accompanying practices. For determining cyber-security efficacy, utility regulators need the functional equivalent of best available control technology (BACT) determinations,[48] but such dependable cyber security standards may be a long time in coming.[49]

Commissions should insist that utilities prepare to meet the NIST standards when they are finalized.[50] If utilities buy hardware and software prior to the completion of interoperability

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[45] California PUC, June 24, 2010, Decision 10-06-047, pp. 42-44, 51-64, 129, http://docs.cpuc.ca.gov/WORD_PDF/AGENDA_DECISION/119685.pdf.

[46] California PUC, June 24, 2010, Decision 10-06-047, pp. 63-64, http://docs.cpuc.ca.gov/WORD_PDF/AGENDA_DECISION/119685.pdf. The California PUC also directs utilities to discuss whether the utility will "audit its security and privacy practices, both internally and by independent outside entities."

[47] California PUC, June 24, 2010, Decision 10-06-047, pp. 62-63, http://docs.cpuc.ca.gov/WORD_PDF/AGENDA_DECISION/119685.pdf.

[48] Best Available Control Technology (BACT) is a program requirement for certain facilities under the federal Clean Air Act. For any given pollutant, air quality regulators determine BACT. See http://www.epa.gov/ttn/catc/rblc/htm/welcome_eg.html, retrieved January 31, 2011.

[49] GAO, *Electricity Grid Modernization: Progress Being Made on Cybersecurity Guidelines, but Key Challenges Remain to be Addressed*, U.S. Government Accountability Office, January 2011, http://www.gao.gov/products/GAO-11-117. The recent GAO report identifies several remaining "key challenges…to securing smart grid systems." Both NIST (Appendix V) and FERC (Appendix VI) indicate general concurrence with GAO's recommendations.

[50] Utilities should also check to make sure that their smart grid communications

and cyber-security standards, then the vendor contracts should explicitly describe the responsibility for meeting future standards. It is reasonable for the vendors to accept the risk associated with making certain that their systems will meet the future standards. At this point, it is unreasonable to burden ratepayers with the risk that smart grid assets could be made prematurely obsolete or become stranded when forthcoming standards are established. Also, smart grid system vendors should absorb risks associated with equipment performance. Acquiring smart meters and the related AMI infrastructure represents an opportunity for the utility and its ratepayers to benefit from performance-based or fee-for-service contracts. These types of agreements focus on the delivery of the desired service, as opposed to the simple purchase of equipment, and thus better align risks and rewards.[51]

Another issue related to cyber security is the security of customers' private data. An NRRI publication explains:

> [W]ith [smart grid's] promise comes the potential for harm from loss of privacy due to poorly implemented policies governing the sharing of energy consumption data with energy providers, their suppliers, product developers, advertisers, and others who can mine this data to target and influence buying behavior.[52]

Commissions need to ensure that existing provisions for maintaining confidentiality of customer data are not compromised by smart grid implementation.

C. Reduce fossil fuel use and emissions

This capability is associated with both the ability of the utility to increase its overall operating efficiency and consumer responses to enhanced customer choices, including modifications in usage patterns.

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networks will comply with Communications Assistance for Law Enforcement Act (CALEA, Pub. L. No. 103-414, 108 Stat. 4279, codified at 47 USC 1001-1010) and any other applicable standards.

[51] See Paul Hawken, Amory B. Lovins, and L. Hunter Lovins, *Natural Capitalism: Creating the Next Industrial Revolution*, 1999, Chapter 7, http://www.natcap.org. Hawkens, Lovins, and Lovins explain:

> [A] relationship that provides a continuous flow of services to meet the customer's ever-changing needs automatically aligns the parties' interests, creating mutual advantage. The form of compensation for the flow of service can be a sale… or a lease with a fixed or continuing term, or perhaps some other arrangement. But whatever its contractual form, such a relationship, by focusing on ends rather than means, can reward both parties for cost-minimizing choices of means.

[52] Sherry Lichtenberg, *Smart Grid Data: Must There Be Conflict Between Energy Management and Consumer Privacy?*, National Regulatory Research Institute, December 2010, p. iii, http://www.nrri.org/pubs/telecommunications/NRRI_smart_grid_privacy_dec10-17.pdf.

1. Examples

Utilities expect to use smart grid monitoring capabilities to manage the continuous matching of supply and demand. Improved monitoring should lead to improved efficiency and reduced O&M costs for power plants through better scheduling. These operational improvements are related to the mission of generally increasing efficiency in utility operations. Depending on the amount of customer response and its interplay with power plant dispatch, customer efficiency increases and conservation may lead to reductions in fossil fuel use and emissions. Customer demand response may also lead to reduced needs for peaking plant construction and operations.

2. Uncertainties and concerns

Before utility operations managers can predict fossil fuel and emissions savings accurately, they will need more information, both from actual smart grid deployments and operations and from detailed utility system modeling. The amount and types of both utility operating efficiency improvements and customer response changes remain areas of uncertainty. Fossil fuel savings and emissions reductions will, however, also vary from place to place. Savings will depend on: (a) the fuel mix used to serve base, intermediate, and peak loads and the extent to which additional low- or zero-emissions power supplies become available and can be successfully integrated into the utility grid; (b) regional climate and weather patterns, which affect the use of energy for space heating and cooling; and (c) the extent to which customer responses result in increased end-use efficiency, conservation, and improved load management. Savings will also depend on procedures that utility system operators use to determine the dispatch order for power plants. Many state commissions lack jurisdiction over the generation decisionmakers in wholesale markets: Dispatch decisions are made through interactions between regional system operators, independent power producers, and load-serving entities like the incumbent utilities. In those markets, utilities will have difficulty predicting fossil fuel savings and emissions reductions, compared to markets in which a vertically integrated utility company directly manages its own generation assets.

3. Advice to commissions

Because of uncertainty regarding smart grid's effects on fossil fuel use and emissions, recommendations regarding this purpose are preliminary. For now, the first recommendation is to establish performance metrics. In addition, commissions should consider how to allocate costs and savings related to this mission. Customers will obtain savings through rates when they reduce energy use and peak demands. As utilities gain experience with smart grid operations, there will be a basis for commissions to convert performance metrics to performance targets. When that happens, commissions can consider establishing bonuses for exceptionally good performance and penalties for poor performance with respect to this mission.

Table 3: Reduce Fossil Fuel Use and Emissions: Uncertainties and Concerns, and Advice to Commissions

Purpose	Uncertainties and concerns	Advice to commissions
Reduce fossil fuel use and emissions	• Uncertainty of both production and consumption efficiency improvements and consumption demand response results • Uncertainty of generation dispatch changes	• Establish performance metrics • Prepare to allocate costs and savings between customers and shareholders, according to the risks assigned to each

D. Enhance customer choices, including rate offerings to shape customer behavior and load

Until the 1970s, electric service providers offered consumers few choices of rates that varied by time of use. Although some differentiated rates by customer class (e.g., residential, commercial, and industrial), utilities typically provided all similarly situated customers with the same quality of service under the same terms and conditions. Since the 1990s, more providers have begun offering time-of-use or hourly rates to at least some customer groups, but even under those circumstances individual consumers typically had only a few choices.

1. Examples

Achieving this mission requires the effective combination of smart meter capabilities and rate and tariff offerings that will reward consumers for changing energy use behavior to reduce peak loads. Smart meters capable of recording and communicating details about time of use, and eventually in-premise energy management systems coupled with smart appliances, will enable services to be further differentiated. In addition to the general objective of influencing customers to save energy, reduce peaks, and fill valleys, such smart grid capabilities will enable economical and expedient system integration for (a) secure, reliable interconnections for distributed generation, distributed electricity storage facilities, and net metering; (b) widespread, cost-effective energy management and smart appliance management options; and (c) plug-in electric vehicles. All of these smart grid features could represent opportunities for additional or enhanced consumer choices and rate offerings, too.

2. Uncertainties and concerns

At this time, there is no conclusive proof of smart grid efficacy with respect to this mission. Many pilot programs have shown promise, through consumer energy-efficiency improvements and peak-load reductions. Customers in a BGE pilot program averaged double-digit reductions in peak power use and 0.5 to 0.8 percent energy savings.[53] Residential customers in over a dozen pilot programs in the U.S., Canada, and Australia achieved significant peak reductions, and a few of the evaluations also identified significant energy conservation responses.[54] Commissions should use

[53] Maryland PSC, June 21, 2010 Order No. 83410, pp. 11-15.

[54] Conservation responses were noted in pilot programs from Illinois; New South Wales,

caution, though, in extrapolating from smart grid pilot programs, because results can be influenced by participant self-selection bias and limited program duration.[55]

Consumers' long-term experience and comfort with average electricity rates will make difficult the transitions to new smart grid choices. Obstacles include lack of customer awareness, apathy, and fear.[56] Customer education and engagement will be necessary.

Consumer advocates are concerned, too, that more costs and fewer benefits will accrue to especially vulnerable customers (e.g., low-income customers, senior citizens, homebound consumers, and consumers who lack internet access).[57] Some customers are unlikely to change their usage patterns, and are thus at risk of paying more for service in a smart grid regime.[58]

Australia; Ontario, Canada; and Washington State. Ahmad Faruqui and Sanem Sergici, "Household Response to Dynamic Pricing of Electricity: A Survey of 15 Experiments," *Journal of Regulatory Economics*, no. 2, 2010.

[55] In its initial order regarding the BGE proposal, Maryland PSC pointed out:

> [D]espite the existence of a control group, participants in the pilot programs were more likely than the typical ratepayer to own their own home, a swimming pool, a dishwasher, programmable thermostats; to possess a college education; to earn over $75,000; and to use central air conditioning.
>
> By definition, those customers who chose to participate in BGE's pilot programs knew the structure of the program and the advantage of shifting peak time energy consumption. Having received compensation for their efforts, these participants likely felt obligated to actively respond… .

Maryland PSC, June 21, 2010 Order No. 83410, pp. 47-48, fn omitted.

[56] A recent article quotes Terri Flora, AEP Ohio director of corporate communications, as saying "the utility's customers 'were very scared' when initially contacted about smart meters being deployed … ."

> "[C]ustomers were very scared… about electricity and decisions and change," Terri Flora said during an online discussion on empowering consumers. "They became alarmed when we talked to them about what it is we wanted them to do."

Doan, Lynn, "AEP Ohio Exec: Consumers 'Very Scared' of Choices that Smart Grid Brings," *Electric Utility Report*, vol. 7, no. 49, December 13, 2010, pp. 12-13. For a summary of AEP's customer education plans, see: http://www.smartgridnews.com/artman/uploads/1/Terri-Flora-8441.pdf.

[57] See Michael McGann and Jeremy Moss, *Smart Meters, Smart Justice?: Energy, Poverty and the Smart Meter Rollout*, University of Melbourne's Social Justice Initiative, 2010, http://www.advocacypanel.com.au/documents/Finalreport.PDF.

[58] Nancy Brockway and Rick Hornby, November 10, 2010, *The Impact of Dynamic Pricing on Low-Income Customers: An Analysis of the IEE Whitepaper*, Report to the Maryland

Also, some utility programs have achieved positive energy savings and peak load reductions without AMI equipment and smart grid communications systems.[59] Those programs call into question whether smart grid infrastructure is necessary for achieving this mission, or whether smart grid opportunity costs are too high to warrant planned expenditures.

Promoters have embraced smart grid functions for interconnection, energy management and smart appliances, and plug-in vehicles enthusiastically, but achieving the benefits associated with those functions is uncertain. Digital smart meters and distribution management system (DMS) facilities will make it easier to interconnect distributed generation and storage facilities and net metering equipment. Additional changes to rules and requirements will be required, though, before the long-desired goal can be reached of plug-and-play interconnections for distributed energy resources.[60] Appliance and plug-in-vehicle manufacturers are fully engaged in developing the necessary hardware and software to allow smart appliances and plug-in vehicles to be actively or automatically managed as integral smart grid components. New rate and tariff offerings may be needed, though, to encourage customers to take advantage of those capabilities. Third parties are also engaged in developing innovative product and service offerings to take advantage of smart grid data availability.

What is still unknown, however, is the extent to which consumers will accept and adopt those capabilities, new utility rates and tariffs, and new third-party products and services. If widely adopted, then what remains for consumers to demonstrate is the extent to which they will manage energy use according to designers' intentions, thus reducing consumption and peak demands. An apt analogy could be the Energy Star® features incorporated in personal computing equipment. Those energy-saving features are not always implemented, which reduces energy savings compared to what is theoretically possible. The lesson is that in similar circumstances, achieving energy savings requires: (a) energy-saving capabilities, (b) consumer knowledge of them, and (c) consumer action to implement them.

Office of the People's Counsel; and, Maryland PSC, June 21, 2010 Order No. 83410, pp. 5, 52. See also Nancy Brockway, *Advanced Metering Infrastructure: What Regulators Need to Know About Its Value to Residential Customers*, National Regulatory Research Institute, February 2008, http://nrri.org/pubs/electricity/advanced meter nrri 2008-03.pdf.

[59] These include studies in Arizona, Florida, and Georgia. See Smart Grid Information Clearinghouse, In-Depth Information, Legislation and Regulation (by State), at www.sgiclearinghouse.org, retrieved January 31, 2011.

[60] The Network for New Energy Choices *Freeing the Grid* report provides annual status reports of state interconnection and net metering programs along with compendia of best and worst practices. Network for New Energy Choices, *Freeing the Grid: Best Practices in State Net Metering Policies and Interconnection Procedures*, December 10, 2010, www.freeingthegrid.org. See also T. Basso and R. DeBlasio, *Advancing Smart Grid Interoperability and Implementing NIST's Interoperability Roadmap*, National Renewable Energy Laboratory, April 2010, http://www.nrel.gov/docs/fy10osti/47000.pdf.

3. Advice to commissions

Table 4 summarizes advice to commissions for two smart grid purposes: enhance customer choices, and induce customers to produce system benefits by modifying their usage patterns. The discussion of advice to commissions for these two purposes is presented in Part II.E, below.

Table 4: Enhance Customer Choices and Induce Customers to Produce System Benefits by Modifying Their Usage Patterns: Uncertainties and Concerns, and Advice to Commissions

Purpose	Uncertainties and concerns	Advice to commissions
Enhance customer choices Induce customers to produce system benefits by modifying their usage patterns	• Uncertainty about the magnitude and duration of consumer end-use efficiency improvements and demand response results • Inequitable or adverse effects on vulnerable customers • Opportunity costs of smart grid investments	• Use pilot programs if necessary to establish performance metrics and targets • Ensure interoperability and access for third-party offerings • Ensure that utility plans consider potential negative effects on vulnerable customer groups and possible mitigation strategies. • Confirm links to customer education plan • Establish performance metrics and targets, coordinating with customer education plan and preexisting customer service, and demand-response standards • Link cost recovery to performance targets • Allocate costs and savings between customers and shareholders, according to the risks assigned to each • Verify performance

E. Induce customers to produce system benefits by modifying usage patterns

Customers' ability to change usage patterns to increase their energy-use efficiency and reduce peak loads is an essential smart grid mission. Such modifications in customer usage must be integrated with enhanced customer choices and rate offerings. The main premise is that large numbers of customers will be motivated, mostly by time-differentiated rates, to manage their electricity use so that end-use efficiency is increased and peak loads are reduced.

1. Examples

In its recent order on smart grid, the Colorado Public Utilities Commission (Colorado PUC) declared:

> The objective of smart grid technologies is to enable demand response via enhanced communication and advanced metering infrastructure that can better integrate "various mechanisms for controlling or influencing load." Smart grid technologies including smart meters, in-home displays, and programmable appliances are expected to encourage consumers to shift their consumption from peak to off-peak periods. Research estimates that time based rates made possible by smart meters have the potential to reduce peak demand by up to 15 percent.…

> Two smart grid technologies enable consumer energy efficiency: feedback to consumers and time-based pricing. Feedback to consumers is provided through enhanced billing detail and in-home displays, offering near real time information about the quantity, cost, and environmental attributes of the electricity consumed. Such feedback is estimated to reduce electricity consumption by 4 to 12 percent. Time-based pricing, in addition to promoting demand response, is estimated to be able to reduce overall electricity consumption by an average of 4 percent. Research indicates that enhanced billing could increase average household electricity savings by 3.8 percent; estimated feedback by 6.8 percent, daily/weekly feedback by 8.4 percent, real time feedback by 9.2 percent and real time "plus" (down to the appliance level) by 12.0 percent.[61]

Smart grid proponents anticipate a growing toolkit of means to accomplish efficiency and load-shape improvements. Load-shape improvements are the expected result from manual demand responses and automated load controls and are initiated by both consumers and service providers. Results will depend on the growing availability and use of smart appliances that offer automated controls triggered by real-time energy prices (sometimes called a "set it and forget it" option).

A 2009 Federal Energy Regulatory Commission Staff report estimated the potential for demand-response programming to reduce peak demand by 4 to 14 percent compared to business as usual.[62] Also, several smart grid pilot programs have demonstrated both efficiency increases and peak-load reductions.[63]

2. Uncertainties and concerns

Uncertainty remains about both the magnitude and long-run staying power of these effects.[64] The initial BGE proposal to the Maryland PSC is instructive. The Maryland PSC

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[61] Colorado PUC, September 29, 2010 Order in Docket No. 10I-099EG, Decision No. C10-1077, pp. 4-5, footnotes omitted.

[62] Federal Energy Regulatory Commission Staff, *A National Assessment of Demand Response Potential*, Federal Energy Regulatory Commission, 2009, pp. xi-xii, http://www.ferc.gov/legal/staff-reports/06-09-demand-response.pdf.

[63] See Ahmad Faruqui and Sanem Sergici, "Household Response to Dynamic Pricing of Electricity—A Survey of the Experimental Evidence," *Journal of Regulatory Economics*, vol. 38, no. 2, October 2010, pp. 192-225, http://www.springerlink.com/content/k82757p01381/.

[64] Behavioral researchers have long postulated a so-called "take-back" or "rebound" associated with consumers' demand-side management efforts. The theory is that energy cost savings from one set of actions can lead consumers to "take back" some of those savings by investing in increased comfort or other consumer spending. See, for example: Karen Ehrhardt-Martinez and John A. "Skip" Laitner, *Rebound, Technology and People: Mitigating the Rebound Effect with Energy-Resource Management and People-Centered Initiatives*, American Council for an Energy Efficient Economy, August 16, 2010, http://www.aceee.org/proceedings-paper/ss10/panel07/paper18; Kenneth Gillingham, Richard G. Newell, and Karen Palmer, *Retrospective Examination of Demand-Side Energy Efficiency Policies*, Resources for the Future, RFF DP 04-19 REV, September 2004, pp. 11-14, http://www.rff.org/RFF/Documents/RFF-DP-

summarizes:

> On the benefits side of the equation, nearly 80% of the anticipated benefits of this Proposal arise not from operational savings, such as those expected to be realized from remote meter-reading capabilities, but from supply-side benefits, such as energy and capacity price mitigation, and monetizing in the PJM markets the value of projected energy and capacity reductions. Those supply-side benefits, in turn, depend upon fundamental changes in residential customers' energy use and the way most residential customers think about energy pricing, upon the operations of relatively new and difficult-to-predict energy and capacity markets, and upon the results of small-scale pilot programs that differed in important respects from the Proposal before us. In summary… the nature and magnitude of the uncertainties underlying the Company's business case raise serious doubts regarding whether the Proposal is, in fact, a cost-effective means of reducing consumption and peak demand of electricity in Maryland.[65]

Another concern related to modified customer usage patterns is that smart grid changes might produce minimal benefits or possibly even higher costs for some specific groups of customers, especially low-income and senior citizens.[66] Thus, a utility should demonstrate both that its plan will result in sufficient efficiency improvements and peak load reductions to ensure benefits in excess of costs, and that potential negative effects on vulnerable customer groups, if any, will be properly mitigated.[67]

04-19REV.pdf; H. Herring and S. Sorrell, *Energy Efficiency and Sustainable Consumption: The Rebound Effect*, Palgrave Macmillan, 2009, http://books.google.com/books?id=FpcoAQAAIAAJ; Steven M. Nadel, *The Take Back Effect: Fact or Fiction*, American Council for an Energy Efficient Economy, 1993, http://www.aceee.org/research-report/u933; Steven Nadel, *Our Perspective on the "Rebound Effect" – Is It True that the More Efficient a Product Becomes, the More Its Owner Will Use It?*, American Council for an Energy Efficient Economy [Blog], January 12, 2011, http://www.aceee.org/blog/2011/01/our-perspective-rebound-effect-it-true-more-efficient-pro; and Maryland PSC, June 21, 2010 Order No. 83410, pp. 49-50.

[65] Maryland PSC, June 21, 2010 Order No. 83410, pp. 6-7, footnotes omitted.

[66] See: *Resolution 2009-01 on Advanced Electric Metering and Advanced Electric Metering Infrastructure Principles*, June 30, 2009, www.nasuca.org; and Nancy Brockway and Rick Hornby, November 10, 2010, *The Impact of Dynamic Pricing on Low-Income Customers: An Analysis of the IEE Whitepaper*, Report to the Maryland Office of the People's Counsel.

[67] Illinois Statewide Smart Grid Collaborative, *Collaborative Report*, September 30, 2010, pp. 55-56; www.ilgridplan.org. The Illinois *Collaborative Report* identifies both potential positive benefits and potential negative impacts for each major smart grid application. Unintended effects are not always identified prior to implementation, though. This difficulty is addressed through the study of decisionmaking under conditions of risk and with imperfect information. See: M. Adler and E.A. Posner, *New Foundations of Cost-Benefit Analysis*, Cambridge, MA, Harvard University, 2006; and Matthew Adler and Eric A. Posner, "New Foundations of Cost–Benefit Analysis," *Regulation & Governance 3*, no. 1, 2009, http://dx.doi.org/10.1111/j.1748-5991.2009.01045.x.

In addition, many commercial and industrial customers already employ computerized energy management systems that incorporate load management and demand-response capabilities (see Part III.G). Thus, there is some question as to whether and how much AMI infrastructure will bring incremental benefits through commercial and industrial efficiency and demand response. If smart grid deployment will not provide incremental benefits for these customers, the argument goes, then why should they pay for it?[68] A related argument is that a service provider could achieve most of the available benefits by facilitating demand response and load management on the part of relatively few large commercial and industrial customers. From this standpoint the relevant question is, why should a service provider engage in full AMI deployment if most of the benefits can be obtained through active energy-use management by only a small percentage of customers?[69] Finally, demand-response programming might be undertaken by various parties in addition to utilities, including both individual customers and aggregators of retail customers (ARCs). The demand response from commercial and industrial customers could be captured by the customers themselves or by third-party aggregators, thus reducing benefits that might otherwise accrue to all ratepayers.

Thus, the present state of knowledge leaves questions unanswered regarding the extent to which smart grid cost savings may be dependent upon consumer behavioral changes and how much uncertainty exists regarding such consumer behavior. And, if benefits depend to any significant extent on behavioral changes, what proofs or assurances should a commission require prior to approving a smart grid deployment plan?

3. Advice to commissions

Projected cost savings that depend on customer responses to new rates and tariffs deserve special scrutiny. A utility's application should contain a detailed plan for when and how the new rates will be implemented, how customers are expected to react to them, and how customers will benefit. Many of the benefits will require customer participation and changes in customer energy-use patterns. Commissions should ensure that rates and tariffs will provide customers with ample opportunity to achieve cost savings by adopting recommended changes in end-use efficiency and demand response. And the utility should confirm that customer education plans will provide the information customers need to take advantage of the cost-saving opportunities (see Part III.I).

In addition, the utility should explain any effects that can be specifically attributed to various customer groups. Relevant groups might include, for example: low-income, seniors, and other "stay-at-home" customers; customers whose utility bills are paid by taxpayers, like government and school facilities; and small, medium, and large commercial and industrial

[68] The business case BGE presented to the Maryland PSC did not cite any benefits from commercial customer demand response. The Commission reports, "BGE has presented no evidence to support any projected demand response from its commercial customers and has testified that it does not yet know what that response might be, but that it expects it to be 'relatively minor.'" Maryland PSC, June 21, 2010 Order No. 83410, p. 25.

[69] Colorado PUC, September 29, 2010 Order in Docket No. 10I-099EG, Decision No. C10-1077, p. 8. The Colorado PUC explicitly identifies this issue.

customers. It will also be important to distinguish between institutional, commercial, and industrial customers who have ample opportunity for efficiency improvements, load shifting, and demand response, as opposed to those customers who have little, if any, opportunity to make changes in response to new rates and tariffs. Another important distinction could be between effects on preexisting customers as opposed to new customers. As long as means are available to prevent or mitigate inequitable or adverse effects on vulnerable customers, then customers can take responsibility for managing their energy use so that benefits will accrue to them through utility bill cost savings (see Part II.A.3).

General recommendations for regulators: Ensure interoperability and allow access for third-party service providers

Commissions should ensure that smart grid deployments will meet requirements for interoperability and provide access for third-party offerings. At this early stage of smart grid development, there is no telling what companies will develop the best customer-side systems and smart grid applications. At least some smart grid benefit cost analyses demonstrate reliance on cost savings from yet-to-be-developed third-party applications. But competitive suppliers should not have to create their own complete, duplicate smart grid infrastructure. Competitive suppliers will need the opportunity to utilize smart grid capabilities to meet the smart grid missions, both for themselves and their customers.

Commissions also must recognize the nature of smart grid itself as a network industry subject to potential monopoly abuses. Commissions will need to ensure open access to relevant smart grid components by competitive suppliers, at cost. Utility smart grid components paid for by choice customers should be available for third parties that want to offer DR and customer-side products and services. To make this possible, commissions will need to ensure both functional interoperability and open access to relevant smart grid components.[70] Commissions should not inadvertently grant a first-mover advantage for (or even worse, monopoly control of) customer-side systems.[71]

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[70] Utilities have both motivation and opportunity to use smart grid to leverage legitimate monopolies to stifle competition in potentially competitive markets. For a comprehensive discussion, see J. Kranz and A. Picot, "Toward an End-to-End Smart Grid: Overcoming Bottlenecks to Ensure Competition and Innovation in Future Energy Markets," Munich, Germany: Ludwig Maximilians University, Institute for Information, Organization and Management working paper (forthcoming, available on request: kranz@lmu.de).

[71] California law (SB 17) explicitly provides that a "smart grid deployment plan may provide for deployment of cost-effective smart grid products, technologies, and services by entities other than electrical corporations." The California PUC has ordered that utility deployment plans should "address how the Smart Grid will enable consumers to capture the benefits of a wide range of energy technologies and management services that may, or may not, be offered by the utility, while protecting consumers' privacy, and promote innovation and competition among companies developing new products and services." The California PUC avers:

> It will…be the policy of this Commission to ensure that no utility gets an unfair competitive advantage from a regulatory decision and that the Smart Grid implementation proceed in ways that do not discourage the participation of third parties

F. Improve utility planning

Embedded sensors, communications capabilities, and controls throughout the transmission and distribution grid will provide utility operational managers and planners with more detailed, accurate, and timely data. Planning benefits will result to the extent utilities are able to utilize that data to improve planning quality and accuracy, and then succeed in implementing their improved plans.

1. Examples

Planning benefits will result from an "increase in system visibility" that will enable accurate determinations of load, and how load interacts with "operational attributes of distribution system components."[72]

2. Uncertainties and concerns

These capabilities apply to both transmission and distribution, but they have long been applied to transmission, at least to some extent. They have been much less prevalent in the distribution system.[73] Achieving significantly improved utility planning capabilities does not necessarily require a fully deployed smart grid infrastructure, though. The lion's share of planning benefits can be obtained without AMI, real-time communications, or hourly data. And, no matter what data can be provided, utility planners must be capable of receiving, processing, and acting wisely on the data they do receive. Cost savings from utility planning benefits, therefore, are not as automatic as they might first appear.

3. Advice to commissions

The recommendations for this mission mirror those for other areas where uncertainty prevails regarding the scope and amount of potential benefits. As shown in Table 5, the recommendations include: (1) establishing performance metrics, coordinating with preexisting standards where practical; and (2) monitoring and evaluating performance. Eventually, as utilities gain experience, commissions can establish performance targets and associate them with cost recovery and utility financial incentives.

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in Smart Grid deployment, investment, and marketing.

California PUC, June 24, 2010, Decision 10-06-047, pp. 11, 37, 118, http://docs.cpuc.ca.gov/WORD_PDF/AGENDA_DECISION/119685.pdf.

[72] Illinois Statewide Smart Grid Collaborative, *Collaborative Report,* September 30, 2010, p. 210, www.ilgridplan.org. See also Maryland PSC, June 21, 2010 Order No. 83410, p. 23. BGE predicts "capital savings through better capital planning as a result of increased knowledge of its electric load."

[73] Illinois Statewide Smart Grid Collaborative, *Collaborative Report,* September 30, 2010, p. 211, www.ilgridplan.org.

Table 5: Improve Utility Planning Quality and Accuracy: Uncertainties and Concerns and Advice to Commissions

Purpose	Uncertainties and concerns	Advice to commissions
Improve utility planning quality and accuracy	• Uncertainty of scope and amount of potential benefits • Opportunity costs of smart grid investments	• Establish performance metrics, coordinating with preexisting standards • Monitor and evaluate performance • Long-term: Adjust performance metrics and targets to reflect smart grid norms

G. Enhance economic development and job growth

Smart grid deployment will be a source of economic development and job growth. This is generally true for all kinds of infrastructure investments, where construction spending results in direct, indirect, and induced economic activity.[74] Economic development and job growth will also occur in those areas where smart grid vendor companies are engaged in service delivery and to an even greater extent in equipment manufacturing. To the extent that smart grid investments result in reductions in energy expenditures, even more economic development and employment will be supported. This is particularly true for those areas of the country that are net importers of the fuels used for electricity generation.[75]

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[74] In economic impact studies, direct impacts are those that result from a particular economic activity. In the case of smart grid deployment, these would be impacts associated with the purchase and build-out of smart grid equipment. Indirect impacts are associated with all of the suppliers and providers of the materials and activities that support the direct impacts. This would include, for example, all of the raw material and component part inputs that go into the development of an AMI system. Induced impacts are the result of discretionary spending of income on the part of the direct and indirect beneficiaries. See: Max Wei, Shana Patadia, and Daniel M. Kammen, "Putting Renewables and Energy Efficiency to Work: How Many Jobs Can the Clean Energy Industry Generate in the US?," *Energy Policy*, v38, n2, 2010, http://www.sciencedirect.com/science/article/B6V2W-4XP8TBH-2/2/6e2ca2787c7fa7f01b7c90dfa53d7bb1; and M. Goldberg, K. Sinclair, and M. Milligan, *Job and Economic Development Impact (JEDI) Model: A User-Friendly Tool to Calculate Economic Impacts from Wind Projects*, National Renewable Energy Laboratory, March 2004, p. 3, http://www.windpoweringamerica.gov/pdfs/35953_jedi.pdf.

[75] For a review of recent relevant economic impacts studies and methodologies, see Max Wei, Shana Patadia, and Daniel M. Kammen, "Putting Renewables and Energy Efficiency to Work: How Many Jobs Can the Clean Energy Industry Generate in the U.S.?," *Energy Policy*, vol. 38, no. 2, 2010, http://www.sciencedirect.com/science/article/B6V2W-4XP8TBH-2/2/6e2ca2787c7fa7f01b7c90dfa53d7bb1.

1. Examples

According to one study, U.S. smart grid "projects which are already planned and 'shovel ready'" are slated to support a total of about 275,000 net jobs during deployment, from 2009 through 2012, and about 140,000 jobs during "steady state" operations, from 2013 to 2018.[76]

2. Uncertainties and concerns

How does smart grid deployment compare to other investments for its ability to support and sustain economic development and job creation? What opportunity costs are associated with smart grid investments? Might similar economic and employment benefits be achieved at lower cost using a smaller smart grid investment or none at all? As with all utility investments, commissions must be wary of acting on the basis of tentative, provisional information. The long-standing concern about gold-plating applies.[77] With smart grid investments, commissions need to be vigilant to require utility assurances of cost effectiveness and should consider whether particular investments need to pass muster as least-cost options.

3. Advice to commissions

Economic and employment development is seldom an explicit public utility commission mission, but it is currently a pressing concern for all levels of government. Commissions should consider the extent to which information about economic and employment development will be useful, both to the commission itself and to other policymakers. Utilities and their vendors can be asked to provide data on the economic and employment development effects that result from smart grid deployment. Commissions should consider whether it is appropriate for a utility to link benefit cost analyses to broader economic development considerations regarding industry attraction and retention, job creation and retention, capital formation, and the like. If a utility's smart grid benefit-cost analysis includes positive economic and employment impacts, then those impacts and this smart grid purpose should be incorporated into the utility's integrated resource planning and then into smart grid performance metrics and targets.

Table 6: Enhance Economic Development and Job Growth: Uncertainties and Concerns, and Suggested Commission Approaches

Purpose	Uncertainties and concerns	Advice to commissions
Enhance economic development and job growth	• Opportunity costs of smart grid investments	• Establish performance metrics • Monitor and evaluate performance

[76] KEMA, January 13, 2009, pp. 1-1 and 1-2.

[77] This is known as the Averch-Johnson effect, where a firm invests more than necessary in order to take advantage of regulatory incentives. See Harvey Averch and L.L. Johnson, "Behavior of the Firm Under Regulatory Constraint," *American Economic Review*, n52, December 1962, pp. 1052-1069.

H. Summary: smart grid missions and priorities and their attendant risks

The multiplicity of missions and possible benefits requires a commission to determine their relative importance, then set priorities, goals, and objectives based on local circumstances. This task need not be tackled by a commission alone, though. Some commissions are already receiving priorities from state smart grid legislation.

Table 7 summarizes the uncertainties and concerns associated with each major smart grid purpose. Because smart grid is still in the early stages of conception and implementation, uncertainty is a consistent theme. Another frequent concern is opportunity costs: The same missions might be achieved at lower cost, without smart grid investment or at least without full smart grid deployment. The presence of these concerns, though, does not necessarily imply that smart grid investment and development should cease. The sensible approach for the time being is for commissions to exercise caution, gather all necessary data, resist general claims, and allocate the risks and benefits properly among interested parties.

General recommendations for regulators: Rely on integrated resource planning to guide decisionmaking on missions and priorities

Where the priority-setting is the commission's job, integrated resource planning (IRP) techniques are necessary to produce the information and identify the tradeoffs. IRP should link the investments to a utility's particular circumstances, demonstrating how the proposed smart grid investments will meet specific resource needs, explaining which of the seven major missions will be served and how. A utility—or whoever else is proposing smart grid expenditures—should produce a benefit-to-cost justification for all planned expenditures.[78] A commission should require a showing that specific local priorities, goals, and objectives will be met and that the proposed smart grid investment is a least cost means of achieving the desired ends.[79] For

[78] A comprehensive discussion of procedures for analyzing the benefits and costs associated with smart grid investments is beyond the scope of this paper. For a detailed discussion, including references to recent studies and reports on this subject, see: Illinois Statewide Smart Grid Collaborative, *Collaborative Report,* September 30, 2010, pp. 28-30, 223-246, www.ilgridplan.org. Also, for a review and brief summaries of smart grid cost recovery issues and decisions in recent state commission procedures, see Institute for Electric Efficiency, *Edison Electric Institute State Regulatory Update: Smart Grid Cost Recovery,* October 2009, http://www.edisonfoundation.net/IEE/reports/IEE_State_Update_SG_Cost_Recov.pdf.

[79] The California PUC determined that different benefit-cost tests can be used for mandated as opposed to voluntary investments. California PUC explains:

> [C]ost estimates provided as part of a [smart grid] deployment plan will be preliminary and conceptual.… In those cases, where the investment in a Smart Grid is necessary to achieve a policy requirement, then a least-cost analysis may be appropriate. However, in cases where the Smart Grid investment will produce benefits beyond simple compliance with a regulatory requirement, we believe a cost-benefit analysis is appropriate.

California PUC, June 24, 2010, Decision 10-06-047, pp. 70-76; http://docs.cpuc.ca.gov/WORD_PDF/AGENDA_DECISION/119685.pdf.

investments that meet one or both of these tests, as a condition of approving cost recovery a commission should insist on a fair allocation of risk among interested parties.[80]

This approach to justifying smart grid investments is no different from what commissions should require prior to approving cost recovery for any utility expenditure.[81] One important difference for smart grid expenditures, though, is that smart grid deployment and evolution is just beginning: Estimating smart grid benefits and costs is a challenge for utilities, regulators, and other interested parties. Some expected benefits are yet to be proven. Also, compared to smart grid costs, benefits are more difficult to identify and quantify, and uncertain, and will occur in the future. Benefits are more uncertain, in part, because of the lack of clarity regarding the interaction of smart grid functions with wholesale and retail markets. Benefits are also difficult to quantify because of uncertainty about the future availability and functions of (and, therefore, benefits that may accrue due to the use of) customer-side systems, smart appliances, and smart grid-enabled energy management systems and services, especially third-party applications. Because of these uncertainties, utilities should clearly state the assumptions used to calculate costs and benefits. Utilities should use sensitivity analysis techniques to explore how the results are likely to vary depending on reasonable changes in the assumptions.

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[80] BGE's original smart grid proposal is an instructive example of several means by which too much risk can be shifted onto customers. Maryland PSC, June 21, 2010 Order 83410, pp. 1, 35-36, 39-41, 44, 49-50, 53-54. See also: Scott Hempling, "'Smart Grid' Spending: A Commission's Pitch-Perfect Response to a Utility's Seven Errors," National Regulatory Research Institute, July 2010; http://www.nrri2.org/index.php?option=com_content&task=view&id=279&Itemid=38.

[81] See Scott Hempling and Scott H. Strauss, *Pre-Approval Commitments: When and Under What Conditions Should Regulators Commit Ratepayer Dollars to Utility-Proposed Capital Projects?*, National Regulatory Research Institute, November 2008; http://nrri.org/pubs/electricity/nrri_preapproval_commitments_08-12.pdf.

Table 7: Smart Grid Purposes, Uncertainties and Concerns, and Suggested Commission Approaches

Purpose	Uncertainties and concerns	Advice to commissions
Increase efficiency in utility operations	• Uncertainty of timing, scope, and amount of potential benefits • Possibility of mistaken service disconnections	• Establish performance metrics and targets • Link cost recovery to performance targets • Verify performance • Ensure that shut-off procedures will prevent improper service disconnections
Increase system reliability	• Cyber-security and physical-security breaches or failures • Protection of data privacy and confidentiality • Physical security of smart grid equipment	• Require conformance with NIST cyber-security standards, with risks of nonconformance borne by the utility and its vendors, not customers • Consider engaging independent agencies to conduct smart grid security assessments • Protect customer data to ensure privacy and confidentiality • Establish performance metrics and targets for reliability, linking to preexisting reliability standards • Link cost recovery to performance targets • Verify performance
Reduce fossil fuel use and emissions	• Uncertainty of both production and consumption efficiency improvements and consumption demand-response results • Uncertainty of generation dispatch changes	• Establish performance metrics • Prepare to allocate costs and savings between customers and shareholders, according to the risks assigned to each
Enhance customer choices Induce customers to produce system benefits by modifying their usage patterns	• Uncertainty about the magnitude and duration of consumer end-use efficiency improvements and demand response results • Inequitable or adverse effects on vulnerable customers • Opportunity costs of smart grid investments	• Use pilot programs if necessary to establish performance metrics and targets • Ensure interoperability and access for third-party offerings • Ensure utility plans consider potential negative effects on vulnerable customer groups and possible mitigation strategies. • Confirm links to customer education plan • Establish performance metrics and targets, coordinating with customer education plan and preexisting customer service, and demand-response standards • Link cost recovery to performance targets • Allocate costs and savings between customers and shareholders, according to the risks assigned to each • Verify performance
Improve utility planning quality and accuracy	• Uncertainty of scope and amount of potential benefits • Opportunity costs of smart grid investments	• Establish performance metrics, coordinating with preexisting standards • Monitor and evaluate performance • Long-term: Adjust performance metrics and targets to reflect smart grid norms
Enhance economic development and job growth	• Opportunity costs of smart grid investments	• Establish performance metrics • Monitor and evaluate performance

III. Components: To Achieve Smart Grid's Missions, What Are the Major Hardware and Software Components?

To achieve smart grid missions, utilities will invest in smart grid components. For this report, nine major components of smart grid hardware and software are identified.[82] The components (arranged in order, proceeding from the bulk transmission system and central station generators toward the end-use customer) are:

1. Transmission enhancements;
2. Distribution automation and distribution management systems;
3. Advanced capabilities for integrating distributed resources;
4. Advanced Meter Infrastructure (AMI);
5. System-wide communications and information integration;
6. Utility personnel education and training (about the purposes for changes and how best to manage smart grid capabilities to maximize cost savings and consumer benefits)
7. Meaningful demand response capabilities;
8. Customer-side systems (e.g., customer web portals, in-premise energy use displays, smart thermostats, energy management systems); and
9. Customer education (both about what changes are taking place and why, and how customers can best utilize smart grid capabilities to reduce their utility costs).

The following sections review each of the nine major components. Each component is described, including listing the component's role in achieving one or more of the smart grid missions. ***Examples*** are included from selected states and smart grid literature. ***Uncertainties and concerns*** about each component are listed, including financial, technical, and behavioral concerns. ***Advice to commissions*** follows for each component.

Table 8 provides a summary review of how the various smart grid components help to achieve the major smart grid missions. The ideas presented in Table 8 are illustrative and preliminary, and are not intended to be all-inclusive. There is no direct, one-to-one correspondence between smart grid components and missions. As is the case with smart grid missions, the components are interrelated with and overlap one another. Some components can be worked on in isolation, though, without being fully integrated into a comprehensive smart grid

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[82] The National Energy Technology Laboratory provides a detailed listing and status report for over 200 smart grid technologies, classified by major function: integrated communications; advanced components; advanced control methods; sensing and measurement; and improved interfaces and decision support. Many are already existing technologies that are not fully deployed. NETL expects that a large majority of the others will be commercially available not later than the middle of this decade. NETL, *A Compendium of Smart Grid Technologies*, U.S. Department of Energy, National Energy Technology Laboratory, July 2009, http://www.smartgrid.gov/sites/default/files/pdfs/a_compendium_of_smart_grid_technologies_06-2009.pdf.

program. Specific components may be amenable to incremental development without the creation of lost opportunities[83] and without inflating costs due to backtracking.[84]

[83] The concept of lost opportunity arises in the field of energy efficiency programming. An opportunity is said to be "lost" if it is not completed during initial construction or when a major replacement or renovation takes place. If completing a particular investment makes it more difficult or expensive to complete a subsequent improvement, then that subsequent improvement can be thought of as a "lost opportunity." See James A. Dirks et al., *Lost Opportunities in the Buildings Sector: Energy-Efficiency Analysis and Results*, U.S. Department of Energy, Pacific Northwest National Laboratory, 2008, http://www.osti.gov/bridge/servlets/purl/938573-LqMAh9/.

[84] The concept of backtracking is similar to lost opportunity. Backtracking is a possible problem in any development process, whenever "step B… forces one to undo the results of the previously taken step A." Christopher Alexander, *The Nature of Order: Book Two – The Process of Creating Life*, Center for Environmental Structure, 2002, p. 306.

Table 8: How Smart Grid Missions Are Advanced by Major Smart Grid Components

Missions→ ↓Components↓	**Increase efficiency in utility operations**	**Increase system security, reliability, and power quality**	**Reduce fossil fuel use and emissions**	**Enhance customer choices, including rate offerings**	**Induce customers to produce system benefits by modifying usage patterns**	**Improve utility planning quality and accuracy**	**Develop the economy and grow jobs**
Transmission Enhancement	Decrease congestion and line losses	Reduce forced outages Prevent cascading outages	Facilitate integrating wind and solar	Minimize bottlenecks to improve market efficiency	Match loads with output of non-dispatchable generation	Allow better matching of supply and demand	Expand green power portfolio & supply diversity
Distribution Automation	Reduce system losses Improve asset utilization	Enable dynamic optimizing	Improve asset use efficiency		Facilitate smart charging of electric vehicles	Produce disaggregated data for improved asset utilization	Reduce system losses Improve asset use efficiency
Distributed Resources	Integrate variable output generation; storage	Enable smart microgrid operations	Integrate variable output generation; storage	Enable more green power choices	Optimize use of wind and solar	Improve short-term forecasting and scheduling	Diversify supply
AMI	Enable operational efficiencies; efficient outage management	Detect and diagnose problems early Respond quickly to outages	Minimize vehicle miles driven for meter reading and customer service	Enable variable rates that better reflect market prices	Make possible the use of in-premise displays and smart thermostats	Provide detailed knowledge of service territory loads and growth	Reduce theft and fraud Improve cash flow
System-Wide Information & Communications Integration	Improve forecasting	Manage assets to avoid reliability problems	Integrate weather & air quality data	Broadcast real time prices to induce demand response	Utilize web portals and in-premise displays to communicate with customers	Get the right data to the right people in time to be helpful	Provide accurate price signals Support timely bill settlement
Utility Personnel Education and Training	Improve employee productivity	Detect problems early to avoid emergencies				Make sure utility workers are ready to use the best available data	
Meaningful Demand-Response Capabilities	Enable efficient EV charging	Shift loads and reduce peaks	Improve environmental dispatch	Shift loads and reduce peaks to decrease bills	Foster "set it and forget it" convenience	Supply detailed data on demand response	Put downward pressure on supply costs
Customer-Side Systems	Foster "set it and forget it" convenience	Support preventive maintenance	Advance efficient energy use and conservation	Make possible new products and services	Improve HVAC and appliance management	Present detailed data on usage patterns	Put downward pressure on prices and bills
Customer Education and Training			Increase end-use efficiency through smarter customer choices	Promote new rate offerings to help customers achieve cost savings	Teach customers about load management and demand response		

Sources: Table adapted from *Understanding the Benefits of the Smart Grid*, June 2010, National Energy Technology Laboratory, DOE/NETL-2010/1413, www.netl.doe.gov/smartgrid/, incorporating additional information from Ashley Brown and Roya Salter, September 2010, *Smart Grid Issues in State Law and Regulation*, Galvin Electricity Initiative, www.galvinpower.org.

A. Transmission enhancements

1. Examples

The National Energy Technology Laboratory identifies nearly two dozen smart grid technologies for transmission grid improvements. These include technologies to increase transmission system operating efficiency and reliability, and to improve planning.[85] Taken as a whole, they will improve power flow, voltage support, and power quality while reducing congestion and system line losses. Smart grid technologies will monitor and alert grid managers to a variety of transmission line conditions, including thermal ratings, vibration, line clearance, and icing. They can even help reduce costs associated with vegetation management. They will provide transmission system planners with high-quality data that can provide better prediction and more accurate modeling and analysis. Some of the technologies will enable specific transmission system components to automatically sense and appropriately respond to changes in status (such as loss of generation or loss of a transmission line) by implementing a pre-programmed set of actions (such as load shedding, generator redispatch, separation of interties, and islanding).[86]

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[85] The jurisdiction over cost recovery for transmission enhancements relating to smart grid needs clarification. For states that have not authorized retail competition and whose utilities have not joined a regional transmission organization, transmission costs are recovered through state-jurisdictional rates for bundled retail service. For states that have either (a) authorized retail competition or (b) allowed their utilities to join RTOs, transmission costs are recovered through FERC-jurisdictional tariffs. This distinction arises from Federal Power Act Section 201(b)(1), as interpreted by FERC in Order 888 and Order 2000, and by the U.S. Supreme Court. FERC adopted a "seven-factor test" for determining whether wires should be classified as transmission or distribution. See *Promoting Wholesale Competition Through Open Access Non-discriminatory Transmission Services by Public Utilities; Recovery of Stranded Costs by Public Utilities and Transmitting Utilities*, Order No. 888, FERC Stats & Regs & 31,036 (1996), on reh Order No. 888-A, FERC Stats and Regs & 31,048, at pp. 30,181-82, 30,335-46 (1997), *aff'd in relevant part sub nom. Transmission Access Policy Study Group v FERC*, 343 US App DC 151; 225 F3d 667 (2000), *aff'd sub nom.* New York v FERC, 535 US 1; 122 S Ct 1012; 152 L Ed 2d 47 (2002).

That bright line becomes blurry if the reasons for transmission enhancements are related to the reliability of the bulk power system. In that situation, both FERC and states have concurrent jurisdiction provided the state's action is not "inconsistent" with federal decisions. See Federal Power Act Section 215(i).

See Scott Hempling, *Broadband's Role in Smart Grid's Success: Seven Jurisdictional Challenges*, National Regulatory Research Institute, January 2011, http://www.nrri.org/pubs/multiutility/NRRI_broadband_smart_grid_juris_jan11-1.pdf.

[86] NETL, *A Compendium of Smart Grid Technologies*, U.S. Department of Energy, National Energy Technology Laboratory, July 2009, pp. 12-17, 19, 21, 24-25, 28, 34-35, 38;

These components will help support the smart grid missions of: increasing operational efficiency; increasing system reliability; reducing fossil fuel use and emissions; and improving utility planning.

2. Uncertainties and concerns

The major concerns associated with transmission enhancements are uncertainty regarding the benefits to be achieved; physical- and cyber-security risks; dependence on utility personnel education and training; and dependence on the ability to intelligently manage the increased flow of data and information and use it to improve asset utilization, planning, and system operations.

3. Advice to commissions

The recommendations related to transmission enhancement are presented below, along with those for distribution automation and distribution management systems.

B. Distribution automation and distribution management systems

1. Examples

Distribution automation and distribution management systems (DMS) facilitate real-time or near-real-time sensing and communications of grid operations. These operations will improve fault location identification, dynamic system protection for two-way power flows, dynamic volt-VAR management, and conservation voltage optimization. These same systems will improve monitoring of utility assets, "to detect (and respond to) impending asset failure or to initiate predictive asset maintenance."[87] An important attribute of distribution automation and DMS projects is their "potential to deliver tangible benefits without requiring intensive consumer engagement or behavior change."[88]

Distribution automation and DMS will help achieve the missions of increasing efficiency in utility operations and increasing system reliability. They will also support improved utility planning and accuracy.

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http://www.smartgrid.gov/sites/default/files/pdfs/a_compendium_of_smart_grid_technologies_06-2009.pdf.

[87] Illinois Statewide Smart Grid Collaborative, *Collaborative Report*, September 30, 2010, p. 16; www.ilgridplan.org.

[88] Bob Gohn and Clint Wheelock, 2010, *Smart Grid: Ten Trends to Watch in 2011 and Beyond*, Pike Research, LLC, http://www.pikeresearch.com/research/smart-grid-ten-trends-to-watch-in-2011-and-beyond, pp. 3-4.

2. Uncertainties and concerns

These components face physical- and cyber-security risks. DMS success depends on utility personnel education and training. Gains from distribution automation and DMS depend on the ability of utility personnel to manage the increased flow of data and information and use that information to achieve improvements in asset utilization and planning and system operations.

3. Advice to commissions

The recommendations for these two smart grid components—transmission enhancements and distribution automation and DMS, as shown in Table 9—provide the means for commissions to match performance metrics and targets to cost allocation and utility performance (see Parts II.A.1 and II.A.2).

Table 9: Transmission Enhancements and Distribution Automation and Distribution Management Systems: Uncertainties and Concerns, and Advice to Commissions

Component	Uncertainties and concerns	Advice to commissions
Transmission enhancements Distribution automation (DA) and distribution management systems (DMS)	• Uncertainty of timing, scope, and amount of potential benefits • Cyber-security and physical-security breaches or failures • Opportunity costs of smart grid investments	• Establish performance metrics and targets • Link cost recovery to performance targets • Prepare to allocate costs and savings between customers and shareholders, according to the risks assigned to each • Associate exemplary utility performance with financial incentives • Verify performance

C. Advanced capabilities for integrating distributed resources

Implementing this smart grid component will make it simpler and easier for distributed electricity resources, including both generators and storage facilities, to interconnect and operate safely and reliably with the electric grid. Integrating distributed resources will increase efficiency in utility operations (by facilitating the placement of distributed generation close to loads) and reduce fossil fuel use and emissions (by facilitating the use of distributed solar, wind, and other low- or zero-emissions generators). It also enhances customer choices by facilitating options for self-service power and net metering.

1. Examples

One aspect of smart grid improvement that facilitates faster and easier interconnections is meters that are readily capable of measuring, recording, and communicating data about bidirectional flows of electricity (incoming and outgoing) and by time intervals as brief as every five minutes. This data, from a single smart meter, will suffice for many utility net metering programs.

Another aspect is "dynamic system protection for two-way power flows." This capability will allow utility "systems and devices to automatically detect and control output from distributed resources in order to maintain safety and stability."[89] This capability can also allow distributed generation to help reduce the numbers and duration of outages and improve power quality. Furthermore, if electricity storage devices (including plug-in electric vehicles) proliferate, then the ability to easily, simply, and intelligently integrate them will also assist with meeting the smart grid mission to reduce peak loads.

This component supports the smart grid missions of increasing operational efficiency; increasing system reliability; reducing fossil fuel use and emissions; and enhancing customer choices.

2. Uncertainties and concerns

Distributed generators can include both merchant plants and self-service power providers.[90] More than 40 states have already established interconnection guidelines or standards for distributed generators. The Federal Energy Regulatory Commission (FERC) has established standard interconnection agreements and procedures for generators both small (20 MW or less) and large (>20 MW).[91] Smart grid implementation may facilitate generator interconnections, but by how much remains to be seen.

Another important question is whether smart grid implementation will reduce or increase interconnection costs and total system costs. The long-term goal may be an electric distribution system where generation can be interconnected anywhere, but converting the distribution grid from the existing uni-directional system to the bi-directional system of the future will be costly. Smart grid proponents generally believe that smart grid implementation will simultaneously increase the benefits and lower the costs, helping to tip the balance in favor of the greater use of distributed generation. Still, the question remains as to whether the benefits associated with the increased opportunities for and use of distributed generation will exceed the costs associated with interconnecting and reliably managing the bi-directional distribution grid.

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[89] Illinois Statewide Smart Grid Collaborative, *Collaborative Report*, September 30, 2010, p. 16, www.ilgridplan.org.

[90] Generally speaking, a merchant plant is in the business of generating and selling wholesale electricity for profit, and a self-service power generator primarily serves a particular retail customer.

[91] For state interconnection standards and guidelines, see http://www.dsireusa.org/incentives/index.cfm?EE=1&RE=1&SPV=0&ST=0&searchtype=Interconnection&sh=1. For FERC interconnection procedures see http://www.ferc.gov/industries/electric/indus-act/gi.asp.

3. Advice to commissions

Table 10 summarizes recommendations for integrating distributed energy resources. Details about performance metrics and targets and cost allocation are in Parts II.A.1 and II.A.2. For advice on coordination with customer education plans, see Part III.I.

Table 10: Advanced Capabilities for Integrating Distributed Energy Resources: Uncertainties and Concerns and Advice to Commissions

Component	Uncertainties and concerns	Advice to commissions
Advanced capabilities for integrating distributed energy resources	• Cyber-security and physical-security breaches or failures • Opportunity costs of smart grid investments	• Confirm links to customer education plan • Establish performance metrics and targets, coordinating with customer education plan and preexisting interconnection standards • Ensure interoperability and access for third-party offerings • Link cost recovery to performance targets • Allocate costs and savings between customers and shareholders, according to the risks assigned to each • Verify performance

D. Advanced Metering Infrastructure (AMI)

Advanced Metering Infrastructure (AMI) is the name for hardware and software technologies and capabilities that are integral to smart grid development. A large share of total smart grid deployment costs will be for AMI implementation. AMI implementation will support the achievement of all smart grid missions.

AMI can include various combinations of:

- smart meters, capable of two-way communications;
- a communications system or systems which allows a utility (or other service provider) to obtain data from and possibly send data and commands to the smart meters;
- automated meter reading;
- remote connect and disconnect of service;
- outage management support;
- power quality and voltage management at the meter; and
- support of communications to enable customer prepayment for utility service.

Smart meters and at least an elementary meter data communications system are necessary to enable automated meter reading, remote connection and disconnection of service, some improvements in outage management support, power quality and voltage management at the meter, and customer prepayment. Some of these capabilities can be deployed incrementally, though.

1. Examples

Smart meters are solid-state, digital devices. Manufacturers are designing them to be modular, flexible, and customizable. Some changes and upgrades will require the physical installation of optional hardware modules, but most smart meters will also be capable of receiving software changes and upgrades that are sent directly through the smart grid communications network. Some smart meters can enable multiple utilities (e.g., electric, gas, and water) to collect data from multiple meters at a single address. Then, a single communications network can convey each meter's data to the relevant utility. This ability to collect and transfer data from multiple meters can also convey net metering generator data to utilities.

2. Uncertainties and concerns

There are many competing technology choices for achieving AMI functions.[92] There are also concerns about purchasing AMI systems while equipment standards remain unfinished. A related concern is that AMI systems could be subject to rapid obsolescence.[93] AMI equipment also raises concerns regarding cyber security and physical security.[94] Important questions remain regarding the pros and cons of using wired versus wireless technologies, and using existing commercial networks versus proprietary networks.[95] Uncertainty remains about how much AMI is necessary and sufficient to capture how much of the available smart grid improvement. Important questions remain about whether AMI can be developed incrementally, without resulting in lost opportunities[96] or creating needs for backtracking.[97]

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[92] NETL, *A Compendium of Smart Grid Technologies*, U.S. Department of Energy, National Energy Technology Laboratory, July 2009, http://www.smartgrid.gov/sites/default/files/pdfs/a_compendium_of_smart_grid_technologies_06-2009.pdf.

[93] Illinois Statewide Smart Grid Collaborative, *Collaborative Report*, September 30, 2010, p. 179, www.ilgridplan.org. The Illinois *Collaborative Report* also addresses interoperability, which it identifies as a primary goal of technical requirements to help mitigate risks associated with technical maturity, equipment standardization, manageability, and upgradeability.

[94] See Colorado PUC, September 29, 2010 Order in Docket No. 10I-099EG, Decision No. C10-1077, pp. 3-11, and Bob Gohn and Clint Wheelock, *Smart Grid: Ten Trends to Watch in 2011 and Beyond*, Pike Research, LLC, 2010, pp. 13-14; http://www.pikeresearch.com/research/smart-grid-ten-trends-to-watch-in-2011-and-beyond.

[95] Scott Hempling, *Broadband's Role in Smart Grid's Success: Seven Jurisdictional Challenges*, National Regulatory Research Institute, January 2011, http://www.nrri.org/pubs/multiutility/NRRI_broadband_smart_grid_juris_jan11-1.pdf.

[96] See James A. Dirks et al., *Lost Opportunities in the Buildings Sector: Energy-Efficiency Analysis and Results*, U.S. Department of Energy, Pacific Northwest National Laboratory, 2008, http://www.osti.gov/bridge/servlets/purl/938573-LqMAh9/.

3. Advice to commissions

Table 11 includes recommendations for commission approaches to AMI deployment. The only recommendation for AMI not discussed earlier is to prevent double recovery of costs by identifying equipment and functions that smart grid makes redundant.

Table 11: Advanced Metering Infrastructure: Uncertainties and Concerns, and Advice to Commissions

Component	Uncertainties and concerns	Advice to commissions
Advanced Metering Infrastructure (AMI)	• Cyber-security and physical-security breaches or failures • Unfinished standards • Rapid obsolescence • Uncertain consumer response • Inequitable or adverse effects on low-income and vulnerable populations • Opportunity costs of smart grid investments	• Use pilot programs if necessary to establish performance metrics and targets • Confirm links to customer education plan • Ensure that utility plans consider potential negative effects on vulnerable customer groups and possible mitigation strategies. • Link cost recovery to expected performance • Establish performance metrics and targets, coordinating with preexisting standards • Ensure interoperability and access for third-party offerings • Allocate costs and savings between customers and shareholders, according to the risks assigned to each • Prevent double recovery of costs by identifying equipment and functions that smart grid makes redundant. • Ensure that appropriate cost savings will accrue to customers through rates and tariffs • Verify performance

AMI deployment could make it necessary to depreciate for ratemaking purposes (i.e., recover the remaining costs of) equipment and functions that smart grid makes redundant. Costs associated with these strandable assets should be incorporated into benefit-cost analyses. Care should be taken to prevent double recovery of costs. This principle applies equally to hardware, software, and personnel. The Massachusetts DPU states:

> [W]e must determine that … program-related costs are incremental to costs that the company recovers through its base rates and other rate adjustments, in order to prevent double recovery of those costs. … [A] simple demonstration by a company that it will be undertaking new activities associated with its smart grid pilot program will not be sufficient to disprove the double recovery of costs. Instead, to identify costs that are truly incremental to those included in rates, a company must track and clearly identify the labor costs associated with: (1) new employees hired specifically for smart grid pilot

[97] Christopher Alexander, *The Nature of Order: Book Two – The Process of Creating Life*, Center for Environmental Structure, 2002, p. 306.

program implementation; and (2) new employees hired to perform non-smart grid work that was previously performed by employees who have been assigned to the smart grid pilot program on a full- or part-time basis.[98]

E. System-wide communications and information integration

Many smart grid gains will come from more efficiently managing individual system components, but optimizing the system as a whole may require implementing system-wide communications and information integration.

1. Examples

The Maryland PSC summarizes the BGE proposal for this smart grid component:

> Several network infrastructures and information technology systems would support the new 'smart' meters. The first communication system would connect the utility to the meters. It consists of two different networks. The first network is a local area network ('LAN') that transmits data between the meters and various collection devices throughout BGE's service territory. … The second network is a wide-area network ("WAN") or backhaul, which transmits data between the collection devices and the AMI head-end system. … BGE also proposes to improve its communications networks to allow for the increased flow of data….[99]

These components enable increased efficiency, increased reliability, and improved utility planning. Depending on how directly a utility company is engaged in generation dispatch and managing demand-response resources, successful system-wide communications and information integration could also help to reduce fossil fuel use and emissions.

2. Uncertainties and concerns

The major risks associated with these components are the same as for the distribution and transmission system improvements: physical and cyber security; dependence on utility personnel education and training; and dependence on the ability to manage intelligently the increased flow of data and information and use it to improve asset utilization, planning, and system operations. In addition, until there is more experience with smart grid implementation, it is difficult to differentiate between benefits that require these components and benefits that can be produced without incurring all of the costs associated with system-wide communications and integrated information. Optimizing the system is also likely to require coordinating multiple decisionmakers. Depending on industry structure, the decisionmakers can include some or all of the following: transmission operators, distribution operators, retail service providers, aggregated groups of customers, and individual customers. Communications challenges will proliferate as more players interact in smart grid management.

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[98] Massachusetts DPU July 27, 2010 Order 09-32, p. 86, citing D.P.U. 09-33, at pp. 65-67, fn omitted.

[99] Maryland PSC, June 21, 2010 Order No. 83410, pp. 18-19, fn omitted.

3. Advice to commissions

The recommendations shown in Table 12 are the same as for other smart grid missions and components for which benefits remain uncertain. Experience with smart grid operations will allow commissions to adjust performance metrics and standards to account for improved efficiency resulting from system-wide communications and information integration.

Table 12: System-wide Communications and Information Integration: Uncertainties and Concerns, and Advice to Commissions

Component	Uncertainties and concerns	Advice to commissions
System-wide communications and information integration	• Uncertainty of timing, scope, and amount of potential benefits • Cyber-security and physical-security breaches or failures • Opportunity costs of smart grid investments	• Establish performance metrics and expected performance, coordinating with preexisting service quality standards • Monitor and evaluate long-term performance • Long-term: Adjust performance metrics and standards to reflect smart grid norms

F. Utility personnel education and training

Successful utility personnel education and training is needed. Utility personnel must grasp the purposes for smart grid changes. Utility personnel must learn to manage smart grid capabilities, so that the utility will accomplish the many tasks integral to smart grid success.

1. Examples

All of the major smart grid components will require tasks to be regularly and successfully completed by utility personnel. Successful utility personnel education and training will be necessary for the smart grid to achieve its missions for increasing efficiency in utility operations, increasing system reliability, and improving utility planning. Depending on the market structure and smart grid deployment plans for a particular utility service territory, this component will also prove necessary for reducing fossil fuel use and emissions, enhancing customer choices, and inducing customers to produce system benefits by modifying usage patterns.

2. Uncertainties and concerns

Will the utility be able to manage more information and make more decisions in a faster time frame? The same capabilities that offer opportunities for better management of the system could also be mismanaged or just ignored.

3. Advice to commissions

Achieving the potential improvements in utility operations will require successful training for utility personnel. The recommended approach for commissions is not to establish specific performance metrics and targets for this activity. Commissions should focus on utility performance in achievement of the smart grid missions (see Table 13). Establishing the appropriate linkages between utility performance and cost recovery will provide sufficient incentive for utility managers to ensure a successful education and training program for utility company personnel.

Utilities, though, can learn important lessons from education about the high-quality management of other complex systems. Like other complex environments with high costs associated with mistakes or failures, there is a need for high-quality system simulations so that operators can have the chance to learn and make mistakes in a low-cost simulated environment, rather than a high-cost real environment. Lessons can be learned from the development of simulation software for pilot and driver training, for example. The U.S. armed services have also recently achieved important successes with training based on war-games simulation.[100]

Table 13: Utility Personnel Education and Training: Uncertainties and Concerns, and Advice to Commissions

Component	**Uncertainties and concerns**	**Advice to commissions**
Utility personnel education and training	• Uncertainty of timing, scope, and amount of potential benefits	• Link to all other components' performance metrics, expected performance, and cost recovery

G. Meaningful demand-response capabilities

Meaningful demand-response capabilities are closely related to customer-side systems. Demand response will also depend in part on the efficacy of customer education. For the smart grid to reduce peak demand, consumers must have opportunities to reduce their demand in response to price signals. That means customers need to know what to do and how to do it.

Demand response is the major function of the mission to induce customers to produce system benefits by modifying usage patterns, and it is associated with meeting the missions to increase efficiency in utility operations, increase system reliability, and reduce fossil fuel use and emissions.

1. Examples

FERC defines demand response as "categorized into two groups: incentive-based demand response and time-based rates." FERC states:

> Incentive-based demand response includes direct load control, interruptible/curtailable rates, demand bidding/buyback programs, emergency demand response programs,

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[100] Roger Dean Smith, *Military Simulation & Serious Games: Where We Came From and Where We Are Going*, Orlando, FL: Modelbenders, LLC, 2009, http://www.modelbenders.com. See also http://gamesforchange.org/ and http://www.seriousgames.org/.

capacity market programs, and ancillary services market programs. Time-based rates include time of use rates, critical peak pricing and real time pricing.[101]

Some demand reduction could be the result of individual decisions. For example, customers decide whether to participate in incentive-based demand response programs. More demand response is expected to occur automatically, through the use of major appliances with pre-programmed controls that are designed to reduce demand in response to smart grid price signals and time-based rates. For example, water heaters, air conditioners, clothes washers and dryers, and dishwashers can all be manufactured to be capable of adjusting energy use according to predetermined logic based on both the users' habits and preferences and energy prices and times of peak use.[102] Similar plans are in the works for plug-in electric vehicles to act as intelligent grid storage and distributed generators.[103]

One complicating factor, depending on the market structure in each jurisdiction, is the relationship between wholesale and retail demand response.[104] Even prior to smart grid deployment, demand response (sometimes termed "load management" or "load control") has already been implemented through a variety of programs offered by load-serving entities.[105]

In some states, smart grid efforts are already incorporating demand response (e.g., Maryland and Texas).[106] Many states, including states both with and without emerging smart

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[101] See Scott Hempling, *Demand Response and Aggregators of Retail Customers: Legal, Economic, and Jurisdictional Issues: Materials for the NRRI Teleseminar*, National Regulatory Research Institute, December 15, 2010. See also NRRI Teleseminar [audio CD], *Demand Response, Retail Aggregators, FERC, and the States: Conflict or Cooperation?*, at http://nrrionline.org/index.php?main_page=product_music_info&cPath=62&products_id=199.

[102] The generic name for such devices is "smart appliance" or "grid-responsive equipment." See U.S. Department of Energy, *Smart Grid System Report*, July 2009, http://www.oe.energy.gov/DocumentsandMedia/SGSRMain_090707_lowres.pdf; and U.S. Department of Energy, *Smart Grid System Report Annex A and B*, July 2009, Annex A, pp. 56-61, http://www.oe.energy.gov/DocumentsandMedia/SGSR_Annex_A-B_090707_lowres.pdf.

[103] DOE, *Smart Grid System Report Annex A and B*, July 2009, Annex A, pp. 41-55, http://www.oe.energy.gov/DocumentsandMedia/SGSR_Annex_A-B_090707_lowres.pdf.

[104] U.S. Department of Energy, *Smart Grid System Report*, July 2009, http://www.oe.energy.gov/DocumentsandMedia/SGSRMain_090707_lowres.pdf; and U.S. Department of Energy, July 2009, Smart Grid System Report Annex A and B, http://www.oe.energy.gov/DocumentsandMedia/SGSR_Annex_A-B_090707_lowres.pdf , Annex A, pp. 56-61.

[105] Some of these were started as long as about 35 years ago. In particular, the first utilities initiated direct load control programs for electric water heaters in the middle to late 1970s.

[106] The source for the information about state programs, unless otherwise noted, is:

grid efforts, have also implemented a variety of retail programs provided by utilities under state-regulated rates. Examples include emergency- and reliability-triggered demand response programs in many states (often under the auspices of RTOs) and a variety of voluntary tariff offerings for interruptible and curtailable rates, automated load controls (especially for air conditioners and water heaters), demand and capacity bidding, and even permanent load shifting, including thermal storage (California, Maryland, and Ohio). Also, several states have begun to incorporate demand response into utility-integrated resource plans, energy-efficiency and/or renewable-resource plans, or resource-procurement plans (e.g., Arizona, Connecticut, Delaware, Maryland, Massachusetts, North Carolina, Oklahoma, Virginia, West Virginia, and Wisconsin). In a similar vein, energy storage (electrical, mechanical, and thermal storage) will be incorporated into resource planning and smart grid deployment in several states (including California, Maine, New Jersey, New York, Ohio, and West Virginia). Some states explicitly require evaluation, measurement, and verification of demand response (e.g., California, Oklahoma, and Pennsylvania).

Demand response is also an aspect of wholesale electricity markets, facilitated by regional transmission organizations (RTOs) acting under FERC regulation. The recent North American Electric Reliability Corporation (NERC) long-term reliability assessment of the electricity industry concludes, "DR is increasingly being used to balance system load and relieve resource adequacy and transmission reliability issues."[107] For example, PJM reported demand response in 2010 would provide an expected 8,525 MW, equivalent to about 6% of summer peak demand.[108] Several states have actively encouraged utilities to participate in wholesale-market demand-response programs (e.g., Maryland, New Jersey, and Virginia).[109]

DRCC, *Demand Response & Smart Grid—State Legislative and Regulatory Policy Action Review: October 2008 – May 2010*, Demand Response Coordinating Committee, June 18, 2010, http://www.demandresponsecommittee.org/reports.htm. This compendium is not a complete inventory of state demand response efforts though: It covers only the time period indicated in the title, and not the states' prior and subsequent efforts.

[107] NERC, *2010 Long-Term Reliability Assessment*, North American Electric Reliability Corporation, October 2010, p. 59, www.nerc.com/files/SGTF_Report_Final_posted.pdf. See also pp. 11-12, 26, 60-61, and http://www.nerc.com/page.php?cid=4|53|56.

[108] PJM, May 5, 2010, *Demand Response to Play Significant Role in Meeting PJM's Higher Summer Peak Electricity Use*, PJM Interconnection, News Release, http://www.pjm.com/~/media/about-pjm/newsroom/2010-releases/20100505-summer-2010-outlook.ashx. Demand response in the PJM market is provided by "curtailment service providers," who may be public utilities, large customers, or third-party aggregators. See http://www.pjm.com/markets-and-operations/demand-response/dr-reference-materials.aspx and Krishna, 2010, pp. 19, 20, 33.

[109] DRCC, *Demand Response & Smart Grid—State Legislative and Regulatory Policy Action Review: October 2008 – May 2010*, Demand Response Coordinating Committee, June 18, 2010, pp. 31, 39-40, 82, http://www.demandresponsecommittee.org/reports.htm. In 2009 and 2010, Indiana, Minnesota, and Wisconsin commissions restricted retail customers from directly participating in wholesale (RTO) demand response markets. (Indiana Utility Regulatory

2. Uncertainties and concerns

How will wholesale and retail DR programs interact? Both the enabling technologies and markets are co-evolving. DR program evaluators are still working out measurement and verification protocols. Nevertheless, DR is already growing in importance as a tool for managing electricity supply and demand.[110] Already, efforts are underway to coordinate DR with variable output renewable generation[111] and plug-in electric vehicles.[112] DR could have a role in helping to meet all seven of the smart grid missions.

The most important risks associated with DR involve uncertainty about its reliability and availability as a resource for meeting electricity supply needs. This uncertainty could be reduced as DR spreads over an increasing base of customers, but it could also become even more acute as utility planners grow to rely on it. As NERC explains, "Decreased or insufficient participation could lead to operational challenges where peak demand is not able to be met by current generation or transmission resources."[113]

3. Advice to commissions

Recommendations for commission oversight of this smart grid component are listed in Table 14.

Commission, July 28, 2010 Order in Cause No. 43566; Minnesota Public Utilities Commission, May 18, 2010 Order in Docket No. E-999/CI-09-1449; Wisconsin Public Service Commission, October 9, 2009 Order in Docket 5-UI-116.)

[110] See: Federal Energy Regulatory Commission Staff, *A National Assessment of Demand Response Potential*, Federal Energy Regulatory Commission, 2009; and Charles Goldman et al., *Coordination of Energy Efficiency and Demand Response*, Lawrence Berkeley National Laboratory, January 2010, http://eetd.lbl.gov/ea/ems/reports/lbnl-3044e.pdf.

[111] Friederich Kupzog, Thilo Sauter, and Klaus Pollhammer, "IT-Enabled Integration of Renewables: A Concept for the Smart Power Grid," *EURASIP Journal on Embedded Systems*, 2011, Article ID 737543, www.hindawi.com/journals/es/2011/737543.abs.html.

[112] KEMA and IRC, March 2010, *Assessment of Plug-in Electric Vehicle Integration with ISO/RTO Systems*, ISO/RTO Council, www.iso-rto.org.

[113] NERC, *2010 Long-Term Reliability Assessment*, North American Electric Reliability Corporation, October 2010, p. 59, www.nerc.com/files/SGTF_Report_Final_posted.pdf.

Table 14: Meaningful Demand-Response Capabilities: Uncertainties and Concerns, and Advice to Commissions

Component	Uncertainties and concerns	Advice to commissions
Meaningful demand-response capabilities	• Uncertainty of demand-response results • Changing demand-response programs, both wholesale and retail • Opportunity costs of smart grid investments	• Use pilot programs if necessary to establish performance metrics and targets • Ensure interoperability and access for third-party offerings • Confirm links to customer education plan • Establish performance metrics and targets, coordinating with customer education plan and preexisting demand response program standards • Link cost recovery to performance targets • Allocate costs and savings between customers and shareholders, according to the risks assigned to each • Verify performance

H. Customer-side systems

Customer-side systems are those smart grid components that provide customers with data and information and assist customers with their energy use management. They include "home energy management systems, in-home networks and displays, [and] smart appliances."[114] Customer-side systems are integral components and enablers of the missions to enhance customer choices and induce customers to produce system benefits by modifying usage patterns.

1. Examples

As NETL (2010) explains, these smart grid components

> …will provide the convenience consumers expect when participating with the smart grid – enabling them to "set it and forget it." Although "simple" from the customer's perspective, these systems will enable complex transactions to take place such as demand response, DER [distributed energy resources] operation, and others.[115]

2. Uncertainties and concerns

To the extent that consumers obtain and utilize customer-side systems, they can use the information and energy management capabilities to achieve greater efficiency of use and to reduce peak demand. Although pilot programs have shown promising results, there is still some uncertainty how broad and deep customer use changes will be. Customer-side systems reflect the same uncertainties and concerns as apply to the mission to enhance customer choices (see

[114] NETL, 2010, p. 9.

[115] Ibid.

Part II.D). Customers are likely to display wide variability in interest in and willingness to learn about and utilize customer-side systems. More study is needed to understand clearly the various consumer market segments. Pilot programs have focused mostly on residential customers, too, with little attention to commercial and industrial customers. There are also concerns regarding the costs and benefits of customer-side systems for low-income and other vulnerable customers.

Should customer-side systems be provided by utilities, third parties, or both? Management of and integration with customer-side systems can be important to a large number of possible actors, including transmission and distribution utilities, competitive suppliers, service aggregators, and energy service companies. As long as smart meters are interoperable components of an open system, third parties could provide customer-side systems hardware and software.

3. Advice to commissions

The recommendations for commission actions regarding customer-side systems are summarized in Table 15. There are no new recommendations in Table 15 that have not already been discussed above.

Table 15: Customer-side Systems: Uncertainties and Concerns, and Advice to Commissions

Component	Uncertainties and concerns	Advice to commissions
Customer-side systems	• Cyber-security and physical-security breaches or failures • Protection of data privacy and confidentiality • Evolving interoperability standards • Uncertain consumer response • Inequitable or adverse effects on low-income and vulnerable populations • Market distortions due to utility first-mover advantage or monopoly control • Opportunity costs of smart grid investments	• Require conformance with NIST cyber security standards, with risks of non-conformance borne by utility and vendors, not customers • Ensure protection of data privacy and confidentiality • Use pilot programs if necessary to establish performance metrics and targets • Ensure interoperability and access for third-party offerings • Ensure that utility plans consider potential negative effects on vulnerable customer groups and possible mitigation strategies. • Confirm links to customer education plan • Establish performance metrics and targets, coordinating with customer education plan and customer service standards • Link cost recovery to performance targets • Allocate costs and savings between customers and shareholders, according to the risks assigned to each • Verify performance

I. Customer education

Many smart grid benefits will be obtained only if ample numbers of customers change their energy-use behaviors because they receive and act on helpful information about their energy use. Successful customer education is needed to enable the smart grid mission to induce customers to produce system benefits by modifying usage patterns. Customer education needs to cover (a) performance metrics, targets, and cost recovery; (b) integrating distributed resources; (c) AMI; (d) demand response capabilities and program offerings; and (e) customer-side systems.

1. Examples

Many smart grid benefits will be obtained through the implementation of new pricing options. Smart meter capabilities will allow the timing and amount of customer electricity usage to be determined precisely. Using that capability, a utility can introduce a variety of rates that vary over time to reflect the price of electricity. Those rate options could include inclining block rates, seasonal rates, time-of-use rates, critical peak prices, and real-time prices.[116] For most customers, though, especially most residential customers, these new rate options represent big changes.[117] Customers will need to be educated about proposed smart grid changes—both about what changes are taking place and why, and about how customers can best utilize smart grid capabilities to reduce their utility costs.

For new pricing options to translate into greater efficiency and reduced peak demands, though, the smart grid requires the presence of intelligent and empowered customers, or, alternatively, customer agents. In this context, a customer agent aggregates customers together and manages the aggregated group's energy use according to a pre-defined agreement. Agents could be either a utility or non-utility entity.

Consumer education has been identified as a primary component of smart grid deployment in California, Colorado, Illinois, and Maryland.

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[116] For more details and related citations, see Adam Pollock and Evgenia Shumilkina, *How to Induce Customers to Consume Energy Efficiently: Rate Design Options and Methods*, National Regulatory Research Institute, January 2010, http://www.nrri2.org/index.php?option=com_content&task=view&id=222&Itemid=48.

[117] The status quo of customer education is telling. According to a recent survey (of 1168 Americans), over 70% report never having heard the term "smart grid" (39%, n=455) or not knowing much about what it means (34%, n=397). Less than a quarter of respondents report having a "basic understanding" (19%, n=222) or "fairly complete understanding" (5%, n=58). Fourteen percent of those surveyed (n=163) report already having a smart meter at their home. Once provided with basic information about smart grid, though, about ¾ of those surveyed indicate that smart grid is a "somewhat" or "very high priority" and nearly the same number either "somewhat" or "strongly support" implementation, even at a cost per household of $6 to $10 per month. Market Strategies International, *E2 (Energy + Environmental) National Survey Results: Understanding the Prospects for Electric Cars and Smart Grid/Smart Meter Technology,* November 18, 2010, pp. 15-30, http://www.marketstrategies.com/papers+_+articles.aspx, retrieved December 15, 2010.

California will require smart grid deployment plans to "demonstrate a proactive approach to consumer education and outreach… ."[118] The California PUC opines:

> The evolution of a utility customer from a recipient of energy and into a participant in the grid must also involve a detailed education and marketing of why Smart Grid is beneficial to the individual consumer.[119]

Colorado PUC concludes that utility smart grid applications should include "[t]he utility's proposal to implement a substantial and comprehensive consumer education program… ."[120]

The Illinois Statewide Smart Grid Collaborative identifies consumer education as "essential to achieving the goals of smart grid deployment." The Illinois Collaborative notes that utility customer education "must be optimized for both cost-effectiveness and success at achieving its goals" and "requires effective and coordinated communications planning and execution."[121]

In its order denying BGE's initial smart grid application, the Maryland PSC stressed the importance of customer education, stating:

> [W]e believe the success of any TOU rate schedule will depend heavily on a significant investment of time and resources in customer education prior to implementation[;] we expect the Company to provide, in any future proposal involving TOU pricing, a detailed education plan that will prepare its ratepayers for the coming changes. … We believe a detailed and comprehensive education plan is essential *before* BGE begins implementation of any AMI system or associated dynamic pricing.[122]

In its second order, offering conditional approval of the BGE revised smart grid plan, the Maryland PSC said:

> [W]e cannot emphasize this strongly enough: *the success of this Initiative, and the likelihood that customers will actually see the benefits this project promises, depend centrally on the success of the Company's customer education and communication effort.*

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[118] California PUC, June 24, 2010, Decision 10-06-047, p. 37, emphasis in original, http://docs.cpuc.ca.gov/WORD_PDF/AGENDA_DECISION/119685.pdf.

[119] Ibid.

[120] Colorado PUC, September 29, 2010 Order in Docket No. 10I-099EG, Decision No. C10-1077, p. 9, ¶19.

[121] Illinois Statewide Smart Grid Collaborative, *Collaborative Report,* September 30, 2010, pp. 24-25, 163-165, www.ilgridplan.org.

[122] Maryland PSC, June 21, 2010 Order No. 83410, pp. 33-34, emphasis in original.

It is not enough just to have a plan—the Company must devote the necessary time and resources to this aspect of the Initiative, education and communication *must* be ready to go *before* each stage of the deployment, and the Company cannot artificially limit the funds and resources available to education and communication by sticking rigidly to predetermined budgets or by diverting resources from education to other tasks."[123]

2. Uncertainties and concerns

After receiving the educational messages, will many customers change their energy use behaviors to reduce energy use and peak demands? Pilot programs have demonstrated some success, but are far from definitive.[124] One concern is about how utilities will educate hard-to-reach populations. Another is how specific customer groups will receive and act on the education they do receive. Will the various populations alter their energy-use behaviors in the desired ways, and thus receive smart grid benefits? Or will there be inequitable or adverse effects on low-income and vulnerable populations? These questions should guide utilities in the development of customer education plans.

3. Advice to commissions

Table 16 summarizes advice to commissions on smart grid customer education. Similar to the recommendation for smart grid education of utility personnel, there is a need to integrate smart grid customer education with the implementation of several smart grid components. Utilities should integrate customer education in their plans for all customer-focused smart grid components: integrating distributed resources, AMI, demand response capabilities, and customer-side systems. Customers should also receive basic education about smart grid's purposes and goals. Commissions should establish performance metrics, performance targets, and cost recovery for customer-facing smart grid components, based in part on the assumption that utilities will prepare and deliver successful customer education.

A separate set of metrics should cover the consumer education function. Maryland PSC found "that BGE's performance in this regard should be measured against specific customer education and communications metrics." Accordingly, Maryland PSC directed the parties "to develop a comprehensive set of metrics and submit them for our approval before implementing any consumer education and communications plans."[125]

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[123] Maryland PSC, August 13, 2010 Order No. 83531, p. 43, emphasis in original.

[124] Ahmad Faruqui and Sanem Sergici, October 2010, "Household Response to Dynamic Pricing of Electricity – A Survey of the Experimental Evidence," *Journal of Regulatory Economics*, vol. 38, no. 2, pp. 192-225, http://www.springerlink.com/content/k82757p01381/.

[125] Maryland PSC, August 13, 2010 Order No. 83531, p. 44.

Table 16: Customer Education: Uncertainties and Concerns, and Advice to Commissions

Component	Uncertainties and concerns	Advice to commissions
Customer education	• Uncertain consumer response • Inequitable or adverse effects on low-income and vulnerable populations	• Link customer education, for performance metrics, targets, and cost recovery, to components for integrating distributed resources, AMI, demand response capabilities, and customer-side systems • Ensure that utility plans consider potential negative effects on vulnerable customer groups and possible mitigation strategies. • Establish customer education performance metrics and targets • Link cost recovery to performance targets • Verify performance

J. Summary: smart grid components

Table 17 presents brief summaries of all nine major smart grid components, their associated uncertainties and concerns, and related advice to commissions. Ultimately, ratepayer costs result when utilities buy, install, operate, and manage smart grid components. To avoid potential problems, commissions need to understand clearly the components and their associated uncertainties and concerns.

Table 17: Smart Grid Components: Uncertainties and Concerns, and Advice to Commissions

Component	Uncertainties and concerns	Advice to commissions
Transmission enhancements	• Uncertainty of timing, scope, and amount of potential benefits • Cyber-security and physical-security breaches or failures • Opportunity costs of smart grid investments	• Establish performance metrics and targets • Link cost recovery to performance targets • Prepare to allocate costs and savings between customers and shareholders, according to the risks assigned to each • Associate exemplary utility performance with financial incentives • Verify performance
Distribution automation (DA) and distribution management systems (DMS)		
Advanced capabilities for integrating distributed energy resources	• Cyber-security and physical-security breaches or failures • Opportunity costs of smart grid investments	• Confirm links to customer education plan • Establish performance metrics and targets, coordinating with customer education plan and preexisting interconnection standards • Ensure interoperability and access for third-party offerings • Link cost recovery to performance targets • Allocate costs and savings between customers and shareholders, according to the risks assigned to each • Verify performance
Advanced Meter Infrastructure (AMI)	• Cyber-security and physical-security breaches or failures • Unfinished standards • Rapid obsolescence • Uncertain consumer response • Inequitable or adverse effects on low-income and vulnerable populations • Opportunity costs of smart grid investments	• Use pilot programs if necessary to establish performance metrics and targets • Confirm links to customer education plan • Ensure that utility plans consider potential negative effects on vulnerable customer groups and possible mitigation strategies. • Link cost recovery to expected performance • Establish performance metrics and targets, coordinating with preexisting standards • Ensure interoperability and access for third-party offerings • Allocate costs and savings between customers and shareholders, according to the risks assigned to each • Prevent double recovery of costs by identifying equipment and functions that smart grid makes redundant. • Ensure that appropriate cost savings will accrue to customers through rates and tariffs • Verify performance
System-wide communications and information integration	• Uncertainty of timing, scope, and amount of potential benefits • Cyber-security and physical-security breaches or failures • Opportunity costs of smart grid investments	• Establish performance metrics and expected performance, coordinating with preexisting service quality standards • Monitor and evaluate long-term performance • Long-term: Adjust performance metrics and standards to reflect smart grid norms

Component	Uncertainties and concerns	Advice to commissions
Utility personnel education and training	• Uncertainty of timing, scope, and amount of potential benefits	• Link to all other components' performance metrics, expected performance, and cost recovery
Meaningful demand-response capabilities	• Uncertainty of demand-response results • Changing demand-response programs, both wholesale and retail • Opportunity costs of smart grid investments	• Use pilot programs if necessary to establish performance metrics and targets • Ensure interoperability and access for third-party offerings • Confirm links to customer education plan • Establish performance metrics and targets, coordinating with customer education plan and preexisting demand response program standards • Link cost recovery to performance targets • Allocate costs and savings between customers and shareholders, according to the risks assigned to each • Verify performance
Customer-side systems	• Cyber-security and physical-security breaches or failures • Protection of data privacy and confidentiality • Evolving interoperability standards • Uncertain consumer response • Inequitable or adverse effects on low-income and vulnerable populations • Market distortions due to utility first-mover advantage or monopoly control • Opportunity costs of smart grid investments	• Require conformance with NIST cyber security standards, with risks of non-conformance borne by utility and vendors, not customers • Ensure protection of data privacy and confidentiality • Use pilot programs if necessary to establish performance metrics and targets • Ensure interoperability and access for third-party offerings • Ensure that utility plans consider potential negative effects on vulnerable customer groups and possible mitigation strategies. • Confirm links to customer education plan • Establish performance metrics and targets, coordinating with customer education plan and customer service standards • Link cost recovery to performance targets • Allocate costs and savings between customers and shareholders, according to the risks assigned to each • Verify performance
Customer education	• Uncertain consumer response • Inequitable or adverse effects on low-income and vulnerable populations	• Link customer education, for performance metrics, targets, and cost recovery, to components for integrating distributed resources, AMI, demand response capabilities, and customer-side systems • Ensure that utility plans consider potential negative effects on vulnerable customer groups and possible mitigation strategies. • Establish customer education performance metrics and targets • Link cost recovery to performance targets • Verify performance

IV. Commission Positioning and Procedures

Parts II and III identified benefits and risks associated with smart grid's many missions and technologies. Commissions must position themselves to gather the necessary information, conduct the benefit-cost analyses, set priorities, make the tradeoffs, determine budgets, assign the risks, and integrate new infrastructure with old, all while educating the consumer and assessing the utility's performance. Careful positioning will avoid having their decisions "framed" by interest groups rather than public-interest prerequisites.[126]

The following parts of this paper review important commission procedural decisions for grappling with smart grid deployment:

- Part IV.A advises that commissions establish principles and expectations in advance of receiving utility proposals.
- Part IV.B recommends how commissions can determine when a utility should employ an experimental or pilot program, rather than embarking on full deployment.
- Part IV.C recommends how a commission can determine the appropriate scope for each utility project.

A few state commissions have already responded to smart grid applications. These include Hawaii, Maryland, and Oklahoma.[127] Brief summaries of the outcomes of those commission proceedings are provided in Appendix A. A few other states have started to develop standards for smart grid applications. These include California, Colorado, and Illinois. Brief summaries of those proceedings are the subject of Appendix B.

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[126] Scott Hempling, *"Framing": Does It Divert Regulatory Attention*, National Regulatory Research Institute, June 2010, http://www.nrri2.org/index.php?option=com_content&task=view&id=270&Itemid=38. This essay quotes psychology professors A. Tversky and D. Kahneman, who state: "[F]raming a discussion appropriately is 'an ethically significant act.'" *Science*, vol. 211, no. 4481, January 30, 1981, pp. 453-458.

[127] It should be noted that the timing of applications and subsequent approvals in both Maryland and Oklahoma was influenced by the availability of ARRA funds for smart grid implementation, distributed by the U.S. DOE. BGE's DOE grant award is approximately $136 million, or about 1/6 of its project total cost. Maryland PSC, June 21, 2010 Order No. 83410, p. 4. OG&E's award is approximately $127 million or a bit more than 1/3 of its project total cost. Oklahoma CC June 22, 2010 Order in Cause No. PUD 201000029, Order No. 576595, p. 9.

A. Should commissions establish principles and expectations in advance of utility filings?

The early experiences in Hawaii and Maryland demonstrate that, without prior guidance from regulators, utilities will not necessarily anticipate all the attributes necessary to meeting public-interest requirements. In particular, the Maryland experience is instructive: Following the Maryland PUC's initial order, BGE revised its proposal as needed to meet the Commission's principles and expectations.

Commissions can learn from one another and coordinate and cooperate to establish appropriate public interest prerequisites. A wealth of relevant information is already available from the states that are developing smart grid procedures.[128] As a recent NRRI paper explains:

> State and federal regulators should agree on public interest prerequisites for the smart grid before utilities make proposals. If regulators do so, they will achieve a higher likelihood of consistency across jurisdictions and a lower likelihood of financial disappointment.[129]

B. Is an experimental or pilot project needed, or should full deployment proceed?

Smart grid pilot projects can serve a variety of purposes. These include determining feasibility, practicing and verifying implementation procedures and utility management practices, verifying assumptions about customer behaviors, and demonstrating cost effectiveness.[130]

Pilot projects to serve all of these purposes are already underway in various jurisdictions. Presently, it is logical to consider scaling back or postponing new pilot programs until evaluation results, including benefit and cost data, are available from already-initiated smart grid pilot programs and full-scale implementation projects. Many lessons will be learned from these early efforts, which will help everyone in shaping future smart grid efforts. Depending on outcomes from the ongoing pilots and full-scale implementation efforts, the need to verify basic feasibility and cost effectiveness could be greatly reduced or even eliminated.

A commission can assign a pilot project's costs to ratepayers, whether or not it confirms all of the underlying assumptions and predictions.[131] Prudent experiments are a reasonable

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[128] See Appendix B.

[129] Scott Hempling, *Broadband's Role in Smart Grid's Success: Seven Jurisdictional Challenges*, National Regulatory Research Institute, January 2011, http://www.nrri.org/pubs/multiutility/NRRI_broadband_smart_grid_juris_jan11-1.pdf.

[130] Ahmad Faruqui, Ryan Hledik, Salem Sergici, "Piloting the Smart Grid," *The Electricity Journal*, vol. 22, no. 7, August-September 2009, pp. 55-69.

[131] Colorado PUC, *Recommended Decision of Administrative Law Judge G. Harris*

ratepayer obligation. In the past, major technological system changes similar in scale and scope to full smart grid deployment have frequently produced what is called a productivity paradox. It often takes many years for such sweeping innovations to deliver on their promised efficiency improvements. That was the case with early electrification and computerization. Pilot programs play a vitally important role in such transitions. As a recent Colorado PUC proposal for decision (PFD) explains, "It is through the construction of an integrated and comprehensive test environment that hypotheses can be thoroughly tested."[132]

One clue that pilot programs are needed is if a utility is unwilling or unable to provide assurances regarding benefits and costs for the full-fledged program. To the extent that a utility's investment justifications rely on cost savings due to uncertain or unknown benefits, then more information is needed and pilot programs should be employed to verify assumptions and demonstrate feasibility. At present, there is a need to reduce uncertainty regarding customer responses to new smart grid rate and service offerings.[133]

C. How can a commission determine the appropriate scope for each smart grid project?

This paper recommended that commissions proceed through sequential investments, with each incremental step resulting in benefits in excess of costs. Reality is not likely to prove quite so hospitable.

Important considerations include technological economies of scale and interdependence. Some smart grid components can be incorporated piecemeal. These include transmission enhancements, distribution automation, and demand-response capabilities. Other components will be much more costly if not installed utility-wide, or at least in large portions of a utility service territory or customer base. Examples include system-wide communications and information integration and some elements of AMI.

Also, pilot programs must be designed to produce reliable and valid results. That means being large enough, and sampling procedures sufficient, that pilot program participants are representative of the full population.

A commission will also want to consider how its own resources will be deployed in providing oversight for smart-grid projects.[134] California is designing its procedures so that

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Adams Granting CPCN Subject to Conditions, October 27, 2010, Decision No. R10-1158, Docket No. 10A-124E, p. 29.

[132] Ibid.

[133] See Sections II.D and II.E.

[134] Scott Hempling, *Broadband's Role in Smart Grid's Success: Seven Jurisdictional Challenges*, National Regulatory Research Institute, January 2011, pp. 11, 12, http://www.nrri.org/pubs/multiutility/NRRI_broadband_smart_grid_juris_jan11-1.pdf.

utilities will provide "visions" or "roadmaps" of their long-term implementation plans, which will help the California PUC to manage its own planning and budgeting.[135]

[135] California PUC, June 24, 2010, Decision 10-06-047, pp. 65-66, http://docs.cpuc.ca.gov/WORD_PDF/AGENDA_DECISION/119685.pdf.

V. Conclusions

In the big picture, there is widespread optimism that smart grid deployment will prove cost-effective. The deployment of computerization and digital systems is already affecting practically all businesses and consumer products and services.[136] This widespread trend makes the eventual deployment of smart grid capabilities seem inevitable. Still, early experiences have identified many areas of uncertainty and concern and few easy answers. Though smart grid may eventually achieve all of its promise, smart grid benefits will not materialize automatically. Much is left to learn and there is much more ground to cover before anyone can craft a precise roadmap for implementing smart grid.

During the early stages of smart grid deployment, protecting the public interest requires effective commission oversight. Public utility regulatory commissions will be grappling with smart grid issues for many years to come. Commissions should use smart grid deliberations as a means to instigate cooperative and collaborative efforts designed to elicit from all participants the best thinking about how to proceed while protecting and furthering the public interest.[137] That path will be the most productive and beneficial in the near term, as work continues to answer the remaining questions about smart grid.

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[136] For example, technologies and capabilities similar to what is required for smart grid implementation are already being applied to automotive consumer accessories (Anderson, 2011; Webb, 2010), and traffic and parking management (Vanderbilt, 2010).

[137] In the Internet age, this ideal is popularly termed "crowd-accelerated innovation." Chris Anderson, curator of TED (Technology, Entertainment, Design) conferences, is credited with coining this term. The idea builds on the work of Chesbrough's "open innovation" (Henry William Chesbrough, *Open Innovation: The New Imperative for Creating and Profiting from Technology*, Harvard Business School Press, 2003); Farrell's "collaborative circles" (Michael P. Farrell, *Collaborative Circles: Friendship Dynamics & Creative Work*, University of Chicago Press, 2001); von Hippel's "democratizing innovation" (Eric von Hippel, *Democratizing Innovation*, MIT Press, 2005); Howe's "crowdsourcing" (Jeff Howe, *Crowdsourcing: Why the Power of the Crowd is Driving the Future of Business*, Crown Business, 2008); and Surowiecki's "wisdom of crowds" (James Surowiecki, *The Wisdom of Crowds*, Doubleday, 2004).

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Appendix A:
Experience in States with Commission Orders on Smart Grid Applications: Hawaii, Maryland, and Oklahoma

A. Hawaii

The Hawaii Public Service Commission (Hawaii PSC) dismissed an application from Hawaiian Electric Companies (HECO) and closed the docket pending the completion of Extended Pilot Testing and the provision of "an overall smart grid plan or proposal filed with the commission."[138] Initially, the utilities requested cost recovery approval before completing their ongoing pilot project. Following the order closing this docket, the Companies are completing "Extended Pilot Testing" in 2010 and 2011. After the pilot testing is completed, the Companies will then provide to the Commission a report of that testing and will file an overall smart grid plan or proposal, prior to proceeding further.

B. Maryland

Maryland PSC conditioned its approval of the proposed BGE smart grid program on eight major criteria:

1. "cost-recovery… [which] provides… an opportunity for recovery of prudently incurred costs, while synchronizing the cost to customers… with the onset of benefits;"
2. cost-recovery "at the time that the Company has delivered a cost-effective AMI system" following periodic performance reviews that "will focus primarily on whether the Initiative is being deployed properly and on schedule, whether and how it functions, whether and to what extent customers are receiving benefits, and how the costs compare to the Company's budget;"
3. "ongoing reviews… to gauge the progress of the project;"
4. future development, through a collaborative process, of metrics "designed to measure the progress of the project and the benefits to ratepayers, …customer education and communications, [and] operational and supply-side benefits" to be preapproved by the commission;
5. future development to address "critical privacy and cyber-security concerns;"
6. a future proceeding to determine cost recovery for "legacy meters" that are replaced by new smart meters;
7. provision of TOU pricing on an opt-in basis and "Peak Time Rebates for all BGE customers, even those who stay on Standard Offer Service;" and,
8. provision of a substantial, effective, and successful consumer education and communications plan, which "is an undisputed work in progress" subject to "further vetting, input and modification."[139]

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[138] Hawaii PSC, July 26, 2010 Order in Docket No. 2008-0303, pp. 7-8.

[139] Maryland PSC, August 13, 2010 Order No. 83531, pp. 32, 41-44, 48, 50.

C. Oklahoma

The Oklahoma Corporation Commission (Oklahoma CC) approved a *Joint Stipulation and Settlement Agreement* (JSSA) filed by all parties in a case involving an Oklahoma Gas and Electric Company (OG&E) application "for pre-approval of deployment of smart grid technology… and authorization of a recovery rider and regulatory asset."[140] Oklahoma CC capped cost recovery at the Company's "projected cost… plus a 2.5% variance allowance" prior to being "included in the revenue requirement in OG&E's 2013 general rate case…."[141] The Commission further conditioned its approval on the Company's assurances that it shall:

1. make available a "smart grid web portal… to all customers having a smart meter;"
2. guarantee a schedule of projected operations and maintenance (O&M) cost reductions, to be credited to customers;
3. hold a public workshop to consider and "evaluate the feasibility of implementing an hourly-differentiated fuel adjustment clause;" and,

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[140] Oklahoma CC June 22, 2010 Order in Cause No. PUD 201000029, Order No. 576595. Oklahoma Commissioner Dana L. Murphy issued a dissenting opinion (Order, pp. 20-21). Commissioner Murphy explains, in part:

> In my view, there is simply not enough data and evidence to support **pre-approving** cost recovery of the entire proposal today. As it stands, the request is for the Commission to **pre-approve** more than $220 million of ratepayers' dollars for a project that is, at present, largely unproven. Further, to get the full benefits from *that* investment, it is unknown at this time what significant **additional** expenditures may be needed in the future.
>
> I believe a more measured approach would be appropriate whereby any pre-approval of costs would be considered on a **limited** basis, in incremental **stages,** ***after*** OG&E has provided hard data substantiating that the technology works properly, that privacy and security are not compromised, and that the purported savings and benefits are real. While it is true approximately $22 million in savings has been guaranteed by OG&E, no concrete data or guarantees were presented to prove any additional actual savings or benefits will result. Estimates and assertions of benefits and savings associated with the proposed deployment were made, but I believe OG&E should be willing and required to prove by stages that these assertions are reliable and supported by actual, verified, relevant data before OG&E receives ratepayer dollars. [Emphasis in original.]

[141] Oklahoma CC June 22, 2010 Order in Cause No. PUD 201000029, Order No. 576595, JSSA, pp. 3-4. "The Stipulating Parties agree that to the extent OG&E's total expenditure exceeds the Smart Grid Cost, OG&E shall be entitled to offer evidence and seek to establish that the excess above the Smart Grid Cost was prudently incurred and any such contention shall be addressed in the 2013 OG&E rate case."

4. “provide… periodic reports regarding complaints and customer input received by the Company related to Smart Grid Deployment… [and] provide… the results of… 2010 and 2011 demand response studies.”[142]

[142] Oklahoma CC June 22, 2010 Order in Cause No. PUD 201000029, Order No. 576595, pp. 17-19.

Appendix B: Experience in States Developing Standards for Utility Smart Grid Applications: California, Colorado, and Illinois

A. California

California law requires each investor owned utility to apply to the California PUC, seeking approval of a smart grid deployment plan.[143] The California PUC is presently developing detailed requirements for utility smart grid deployment plan filings. The state's three IOUs are required to submit their plans by July 1, 2011, and those plans will be reviewed in a single, consolidated proceeding.[144] The California PUC is encouraging and facilitating collaborative processes, prior to utilities filing their deployment plans.[145]

The California PUC has determined that all utilities will "follow a common outline in preparing their Smart Grid Deployment Plans."[146] The outlines will include:

1. Smart Grid Vision Statement;
2. Deployment Baseline;
3. Smart Grid Strategy;
4. Grid Security and Cyber Security Strategy;
5. Smart Grid Roadmap;
6. Cost Estimates;
7. Benefits Estimates; and
8. Metrics.[147]

California is establishing a two-stage process. First will come development and approval of deployment plans. Later, implementation costs will be considered in either a general rate case

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[143] California Senate Bill 17 (Padilla), Chapter 327, Statutes of 2009.

[144] California PUC, June 24, 2010, Decision 10-06-047, p. 91, http://docs.cpuc.ca.gov/WORD_PDF/AGENDA_DECISION/119685.pdf.

[145] California PUC, June 24, 2010, Decision 10-06-047, p. 114, http://docs.cpuc.ca.gov/WORD_PDF/AGENDA_DECISION/119685.pdf.

[146] California PUC, June 24, 2010, Decision 10-06-047, pp. 3, 5, http://docs.cpuc.ca.gov/WORD_PDF/AGENDA_DECISION/119685.pdf.

[147] California PUC, June 24, 2010, Decision 10-06-047, pp. 86-87, http://docs.cpuc.ca.gov/WORD_PDF/AGENDA_DECISION/119685.pdf. CA-PUC is in the process of determining specific metrics to be included in smart grid deployment plans and annual reports.

or a special-purpose case. This two stage process is intended to address the fact that "technologies… used in the Smart Grid are undergoing rapid changes in capabilities and costs." The California PUC indicates that having a preapproved general implementation framework will:

> …provide a utility with guidance concerning Smart Grid investments and a rationale that can support a proposed investment during review of the project and help in the determination that the project is reasonable and consistent with the Commission's overall Smart Grid vision.[148]

The California PUC emphasizes customer education, stating:

> [T]he Smart Grid vision statement should address how a utility will enable customers to become more informed about the Smart Grid and allow customers to use electricity more efficiently and save money. The vision statement should consider the expectations of consumers concerning the Smart Grid and how to meet customer expectations and educate customers so that they can align their expectations with the realities of the technology. … In general, the Smart Grid Deployment Plans should demonstrate a proactive approach to consumer education and outreach and draw on consumer research and past experiences.[149]

B. Colorado

The Colorado PUC has begun an "investigation of the issues related to smart grid and advanced metering technologies."[150] In this docket, Colorado PUC has "reach[ed] some preliminary conclusions… [and] identified areas that require additional investigation." In its initial order in this proceeding, "stating preliminary conclusions and requesting comments," Colorado PUC, among other things:

1. notes its "long-standing practice of using cost-benefit analysis when evaluating the merits of utility investments" and identifies "a publication of the Electric Power Research Institute [EPRI, 2010]… that describes a complete framework for evaluating the costs and benefits of smart grid investments;"
2. finds "that the positive externalities potentially attributable to smart grid investments should be factored into the Commission decision-making… and may

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[148] California PUC, June 24, 2010, Decision 10-06-047, p. 125, http://docs.cpuc.ca.gov/WORD_PDF/AGENDA_DECISION/119685.pdf. The California PUC further explains, "[E]vidence that an investment does not comport with a utility's Smart Grid Deployment Plan or the goals of SB 17 should be considered a rationale supporting a determination that it is unreasonable."

[149] California PUC, June 24, 2010, Decision 10-06-047, p. 37, http://docs.cpuc.ca.gov/WORD_PDF/AGENDA_DECISION/119685.pdf.

[150] Colorado PUC, September 29, 2010 Order in Docket No. 10I-099EG, Decision No. C10-1077.

lend themselves to creating an overall cost-benefit 'adder' (percentage margin from break-even) for use in cost-benefit analyses;"

3. finds "there may be value in considering the technologies on a disaggregated basis… [which] may have stand-alone justification [and] believe[s] utilities should move forward to implement components that are clearly cost-effective… [with] no reason to insist that the entire suite of technologies be installed at the same time, or even at all;"

4. concludes it will be "most appropriate for the Commission to consider and adopt the NIST Interoperability and Cyber Security standards as they are released;"

5. concludes that "meter-supported time variable rates… should be pursued when and only when clearly beneficial to the system;"

6. identifies a need to consider how customer "diversity will likely influence how customers interact with smart meter technology" which leads to a need for further evaluation of "the pros and cons of converting all meters, and applying time-sensitive rates (as opposed to targeting conversions to specific types of customers)" while seeking to find "a balance between the benefits of upgrading all meters and the costs of upgrades that yield little value to specific consumers;" and

7. "recognize[s] that existing Commission rules may not provide sufficient guidance on what constitutes a complete application to implement a smart-grid project… [and] preliminarily support[s] adoption of a 'checklist' for the utilities to follow when filing a smart-grid related application."[151]

C. Illinois

The Illinois Statewide Smart Grid Collaborative provides "Utility Filing Requirements for Smart Grid Investments."[152] The Illinois *Collaborative Report* includes a quite detailed proposal for utility filings, which would provide for:

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[151] Colorado PUC, September 29, 2010 Order in Docket No. 10I-099EG, Decision No. C10-1077, pp. 3, 6-9, references omitted.

[152] Illinois Statewide Smart Grid Collaborative, *Collaborative Report,* September 30, 2010, pp. 30-31, www.ilgridplan.org. The Collaborative indicates, "For traditional (general rate case) filings, supporting information requirements are well established." The Collaborative also reports "general agreement on the scope and content of the filing requirements for non-traditional cost recovery of smart grid investments." The Collaborative further reports a lack of consensus whether its published "requirements" should be considered mandatory and legally binding or be accepted as guidelines.

1. cost-benefit analysis, including a Total Resource Cost (TRC) test,[153] with supporting documentation;

2. "a description of each smart grid application included in the investment and a discussion of [its] technical design" including details regarding, among other things, the application's: capacity; technical maturity and risk; openness, standardization and interoperability; security and reliability;

3. a review and discussion of each application and how it adheres to over a dozen specific criteria; and

4. cost recovery proposal details, including the review of over a dozen specific concerns.[154]

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[153] The TRC (Total Resource Cost) Test is an economic analysis method for evaluating the economic effectiveness "applicable to conservation, load management, and fuel substitution programs. … The TRC Test measures the net costs of a demand-side management program as a resource option based on the total costs of the program, including both the participants' and the utility's costs." It is one of a series of standard methods developed for this purpose. See *California Standard Practice Manual Economic Analysis of Demand-Side Programs and Projects*, October 2001, http://www.energy.ca.gov/greenbuilding/documents/background/07-J_CPUC_STANDARD_PRACTICE_MANUAL.PDF, pp. 18-22.

[154] Illinois Statewide Smart Grid Collaborative, *Collaborative Report*, September 30, 2010, pp. 249-255, www.ilgridplan.org.